

# Solar Energy - The Mother of All Energy

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Solar is a mother of all energy: beat thermal, beat hydro, wind, everything; solar is mainly responsible. In fact, if you remove some . will come, the . is the doom day, the final day. Average incidents solar energy received on air surface is 600 watts per meter square; it is going to lot of energy. And the beauty is it is free, you do not have to pay single paisa, single ., single dollar for that. It is non exhaustible, it is not the little stop coming after some time, it keeps coming all the time, and it is pollution free - absolutely pollution free. .There is no pollution; only problem is, as they said, not everything is plus is anything, there are cloudy days; for example, in England is hardly any sunny day, and when there is a sunny day, they become so happy; everybody goes towards you know beaches, enjoy; how it is a sunny day here? Every day is sunny day, hazy atmosphere, for example, place like Rajasthan if you get sun storm and wind storm all those things, then of course the visibility goes down. And on certain days, you have to start your headlights of your vehicle even day time, that reduces of course energy up level; it do not remains 600 watts per meter square on such days, when there are clouds, raining or there is a storm you know. There are challenging technological problems; it is not easy to harness solar energy; we must be reading lot about solar energy in other courses. So, again I will be giving only general idea, the detailed, you know, set of on solar sun. So, many people's must be talking their solar thermal photo will dry concentrators, you know, trackers, all this things, the manual trackers, semi automatic, automatic, all these things will be taught well by several experts there. How to collect this energy? The first challenge is energy is there, but you to collect it; so, it have a collectors.

Lot of physics, mechanical engineering you have to read to understand solar energy. Concentration of solar energy, you to have mirrors, then you have to concentrate on a point - solar concentrators - all convergent to electric form. Ultimately, what you need is electricity; of course, there are non electrical use a solar energy, as will be talking water heater, distilled water for your batteries, for so many other medical purposes, you can get it from solar energy. .. Of course, you want efficient power and comparatively economical. No person in the world wants to spend a single penny extra, if given a choice. Now, there have been several technologies to generate electric power using solar energy. 700 degree centigrade is the enough temperature to operate a heat engine, stalling engine or several

engine people have tried in many countries at reasonable efficiency to generate electricity. Let me tell you . has started a solar energy centre near Gurgeon; it is actually Gualpari village name is Gualpari. The terry campus is also there, its around 20 minutes drive from here towards Magroli, and you know, then you to go that side, and its worth, see again I will request to go there on some someday chosen by you; take a vehicle from institute. Tracking bowl, just to give an idea how big the bowl will be thirty meter dire, more than that in fact. And you can generate 200 kilo watt; 200 kilo watt is not a small power for small needs of villages, who even today live with their kerosene lamp or even candles or chimneys and so on. Well, you have to have a huge construction cost, is bowls, is mirrors. So, that is an initial cost, like hydro power; there also you need lot of initial cost, dam constructions, civil engineering constructions. So, huge capital out lay is required initially; running cost is absolutely free. A ten mega watt power plant solo power plant is there in California; California is a very important state in US, where you have a silicon valley, where you celebrated your 50 years of IIT .

System; it was again California and San Fransisco, your Hollywood, everything is in California. 1818 on 18 plane mirrors, look at the size 7 meter by 7 meter; direct radiation to the raised boiler and the steam is formed. All this energy is directed towards that raised boiler, water gets heated because of the solar heat, and gets steam. Once you can have a steam, then you know how to go about it; just pass it to turbine or turbine as you pronounce it and then there is a generator and power is there; this is solar thermal power station. There is a certified solar power station; what is the beauty of certified solar power station? Sun is there throughout 24 hours; there is no sunset, as indeed is now in sudden during summer, the night is only of 2 hours; 12 o clock sun is there, but 2 or 3 again sun comes back, and the reverse happens in winter, is hardly sun for 2 3 hours. Even in Calcutta, our country 4 PM, sun goes in winter time; its already dark by the time you come to... you even in IIT, our IIT in winter, you will see in 5.35 class or 5 o clock class, it will be almost dark, there is solar tower concept. In fact, solar chimney we are trying to have it in Jasalmaid by Imran, which was to produce 150 mega watt power using solar energy, image in tremendous amount of power 150 megawatt in Rajastan. Victoria is state in Australia, where their planning to have one kilo meter high solar tower, and that was enough to supply the needs of Victoria state; mind it the population of whole of Australia is just 17, 18 million, less than Delhi population, which is now 20 million - 2 crores. At least in day time, you will go and sleep elsewhere in . region in night time, Kajabad, Faridabad, Gurgeon, and they go up to Revadi, Panipat, Matura and so on. .. Are you heard of solar pond? This was first built in Israel. Israel is the country which is well known for energy research; there is a desert required intelligent people there.

The jews are supposed to be very intelligent people, and they have done lot of work in solar energy. There in solar pond, I am sure they will teach you there in renewable energy courses or whatever; they create a difference temperature difference, something like similar to miami power plant, talked about 17.5 degree temperature difference in the sea. So, here also the salt etcetera, the use and they created difference, and then, that is used the gradient used - to generate power. It is . given that is right, 150 watt from 0.74 hectares at cost of 20 seconds per kilo watt hour, which is very cheap, 20 seconds is nothing. Even if you

convert in to rupees, it will be 4 rupees, and 2000 mega watt is planned using this. You should be enough for most knives of Israel; we do not have solar pond as such in India, but on experimental basis, we do have few, but not for commercial power generation; it only a pilot plant; of course, so, research, lot of research is going on. Solar cooker is very important. Many people have solar cookers in their houses; we have one in lab approved symbolic, you can go and have a look at that; you might have done lab, may be we will doing next semester. 4602000, what is the importance of solar cooker? No fuel is used, just a mirror, the black end surface, we can prepare rice, dhal, sabji, kier or anything, except chapathis. Earlier there was a joke, if you want to lunch, may be dinner time in ., but now it lets prepare lunch time itself. .Imagine how many people must be saving, saving of the LPG, saving of woods, saving of kerosene, is also indirectly helping reducing polisure, reducing cost, which cost? The import bill of petroleum products, that is the biggest check, the Indian government signs in dollars for payment, right; the oil import, product petroleum products import, that will be reduced if you use more and more renewable energy or indigenous energy, producing indigenously.

47 mega watts solar PV for ., that is a install capacity today. Do not worry about 47 is not a small amount, it is a big amount. 270 community lights, if you visit osmaniya university campus, the whole campus is lit by solo photo voltaic; anybody found money ., is it true what I am saying? And in our committee room, where you must got your welcome by the head that one samosa and one cup of tea, that room was lid earlier by photo voltaic, when there is no fourth floor; now, there is a fourth floor. So, all those photo voltaic things are gone behind sixth block; if you see there is a energy park, there is a you know wind station, then there is a green house effect, then this photo voltaic, and there is a mud house. Mud house is a technology by which you can build housing at a very low cost. We do have a solo houses in the campus; if you go towards new campus, then you get, you will find there are eight special houses made, and they are called solar houses. What is the specialty? There using solar active and passive, heating and cooling principles. What is that? The ground floor is roughly one third is in the inside the earth; it is the sort of, you know, the using the coolness, and the material use, insulation use, is cheap. And the houses will be 5 degree warmer in the winter and 5 degree cooler in summer; 5 degree is a very big range, as I told you, if you go from 30 degree to 25 degree, you may have to switch off your AC's, coolers and fans. 25 degree is perfectly fine; 30 degree is not than in to use the fans at least. 270 community lights, there is a lanterns called solar lantern; no kerosene all to be put there, no wax, no candles, just a small photo votaic panel and it burns for hours; and it is very cheap, it is not costly. You may ask me question where all these things are available. Now, the government of India through MNES - the ministry of non consumption sources have opened the outlets in 36 cities in India. And in New Delhi, it is close to .

Place near sivaji stadium, from where 620 starts form your hostel gate or IIT gate; there this a big shop and that shop is called Athithya, is all called Athithya shop; Athithya means surya – sun - and their all these things are available, all sort of devices. .. If you happen to go to karna places, which must be going at times, do visit that Athithya shop and find out, what are the devices and what price they are available there, this solar lanterns and this community lights - community lights on streets - they are fixed, but the solar lantern, you

can carry like a torch from one room to another room. And if the power goes, which goes quite often in India, depending on 4 to 5 hours to 8 hours per day, you can use these solar lanterns, rather using your inverters or batteries or kerosene lamp or any other device. 640 TV are operated through solar energy, if you really want to see this things, either you to visit solar energy center or there is a Alipore, when while going to Panipat GT road, where there is a institute - Mahatma Gandhi rural energy institute - which is offering M. Tech course in energy; there also offering M. Tech course and quite number of peoples are doing M. Tech course. So, there all this things are displayed; it is not for all, you can also go take a one day vehicle, they are also. Street lights 3900, and 3370 water pumps, 3370 solar water pumps; you know how in villages they have to use bullocks to take water out of the well, not to maintain those two bullocks is not easy anymore, because your vehicles are also earlier they use to have a multiple users of those bullocks you know, that is in irrigation field, or even for travel, they use to have a cart, where you can use those bullets to come to the nearby town or city; now, there are buses or there are two wheelers. .So, where to use those bullocks now? Irrigation, now you will use to tractors, you do not use bullocks normally. So, instead of having those bullocks for taking water out of the well, you have water pumps; and these solar water pumps, again the design is very simple, and of course, there will be talk to you.

And the first water solo water pump was designed at bits Pilani in 1970 by professor T.S. Rao, who is not now no more. So, he is started this researches, then even to IIT Kanpur was D. P. Rao in chemical engineering department, of course, our center came in 1977 and since then they are also working on water pumps. Solar is going to overtake wind by 2040; all of you there to see that, of course, I will not be there, that is for sure. And another estimate is, the overall largest source will be 2050, not forty; 2040, it will overtake wind, and by 2050, that is the midpoint of the centenary current, 21 century, which were started or new millennium, it will be half over by that time, is of course the guess; estimate it will be the largest source to use for generating power by 2050. . So, you can take this futuristic, how much solar is going to be used more and more in future. PV, I am introduce to you roof top wind power station in last Friday if you recall, and I also told you now roof top is not used by anything else; if you do not sleep in the night, children no longer play there, because the roof top does not belong to one particular flat, and sometimes you do not know who is having the key to go to the roof. .There are so many flats there and you cannot go on all the 12 flats, to enquire about the key, and then nobody in the day time; everybody is gone for work. So, we have a roof top PV plant, and place understand there is the synergy building here, the sip and bite restaurant is there, you must visited that restaurant by now. If you go to the top, if you go to the roof, one crore rupee worth roof top PV plant is install there by energy center; it is worthwhile to go and to visit that plan, and see how it is generating power. And as I said that, that plant is supposed to feel plan and satisfy the needs of that building; we have n IIT office there, we have the two canteens: one is .

, another is government of India, that is the IIT canteen - the ground floor for employees and there are some other office is there. There is a bio technology also; now, there is a lift also there, and we can satisfy the needs of that building using that power - 10 kilo watt. I did written there, synergy building, IIT Delhi, one crore, 10 kilo watt, everything there. Solar cells efficiency, when they started solar cells, was hardly 10 percent; people are throwing

them, no use, 10 percent is very low; look now you have reached 25 percent theoretical, and practical 15 percent; it is good 15 percent. Solar cells are being manufacturing at CIL, Sahibabad. Sahibabad is close to Rajyabad; if you go to the metro train, use it, you will get Sahibabad after Shadra. So, you have to change it again. Now, what is happen in past so many years? That has bought the efficiency more improved, material technology. What are the four important areas which are made tremendous progress which is change the world in last 50 years? Instrumentation, energy, material science, computer science or electronics; electronics is, computer is nothing without electronics; there is no chip, there is no computer. So, these four areas, of course, bio, five, have five areas have change the world. Earlier doctors had nothing to do with mathematics. Now, they know mathematics, they have to learn mathematics because of computers; the engineers are to learn biology, because of bio sciences, bio technology, bio medical, bio chemical, bio mass, even energy, we have bio maintenance of cells is very important. In India, maintenance is the main causality; we even do not maintain our self's, forget about maintaining device or vehicle or house; how many of us take proper food? How many of take morning walk? How many of us go for jogging? How many of us do any you know the cycling, those gym sort of thing or the trade mill? Hardly any, we will get up so late, that is the .

Time to take breakfast, .running, you take, why? I do not understand; why cannot we plan our life better? Such a beautiful time campus, you should take morning walk, should go for jogging. Play fields normally wear a deserted look, only when there is some competition or something, then some people visit that too with a half mind, half heart. Maintenance in India is a casualty in more than one ways; what are the different types of that? The big different center maintenance; this is next door to you, Tibolagiam maintenance center; we have plan maintenance, we have schedule maintenance, and then we have a break down maintenance. In India, we have only break down maintenance, because we have no time for scheduling maintenance for plan maintenance, why? We need to run that machine all the time; is only one machine, is only one unit power plant, is only one car, if you give it, then how do I go an work to work, if I give this car for maintenance? So, when you take your car from this thing to workshop? When it fails, not before that, and that is why it is called break down maintenance. I do not know how many of you know there is a bath tub curve; it is bath tub is seen in movies, in TV serials, where most of the murder takes place; we cannot to bath in bath tub in normal house, it is a bath room itself is so small, that you would not allow in bath tub enter there, but if you see movies in five star hotels, it is a bath tub; this curve is between lambda and t, what is lambda? Failure rate. Those of you have done reliability engineering or may be in energy somebody missed out to talked about it. It is consist of three parts; this is debugging period, this is a normal running useful life span, and this is wear out period. Why it starts with higher lambda, higher failure rate? It is nu; how do you test your bulb when you purchase from the market? Rather the shop keeper themselves will test it before you take it; you remember, two shops in your . or there are now there are many he he checks it and then gives you, then it is not his responsibility, why? If the bulb has to fuse, that is the first instance when it will fuse; if it does not fuse at that time, it will work for some time, even if it is Indian made.

A baby you must have all your self's are baby once. First year of baby is very important; your grandmother, your grandfather, first summer, first winter, closes ears, you will get catch cold; summer, you will get flu, why? The guys new to the world; he is not, he or she has not face summer or winter. .So, it is the first time he is going through; however, big players may be, where is a Gavaskar or Tendulkar, very first ball of their test carrier, it must be shaky, because it is an unknown commodity. Ranji is different and test is entire different ball game, but now, there is no problem, they are season; that is why the failure rate starts our way, then it is settles down, then there is a useful life span; this is having constant lambda, the assumption is you are maintaining it, but in India, you do not maintain it. . So, you do not get . at all, and then there is a wear out period. Once your useful life span is over, once your ink is finished, you throw the pen or you take a refill. Nowadays, nobody cares for refill, just threw away and take away, take another; yes these are the material of stock. The amorphous silicon, this has reduce the cost of the cell and increase the efficiency of the cell; then, all we have cheaper, solar cell level available in the market. There is a solar car, of course, you need lot of space, and to promote solar energy, Australia is one of those countries which is very much for renewable energy; you you can all go for PHD doing in many Australian university; there is a very strong energy program in Australian universities, and Perth, Melbourne and Sydney, and Canberra, of course, the capital of the Australia. So, there is a solar car race every year organized in Australia from Sydney to Perth, and the road is straight; you do not have to use your steering wheel just to promote.

.Only thing is, only two persons can sit in such a big car, the space is a broad; just to give an idea how much space is required to generate solar power, 0.1 percent of US area is required, if you want to generate 10 raise to 12 power kilo watts hour per year. And please understand 1.5 percent of area is used for highways in US; there are highways in freeways; you do not have a freeways in our country. Freeways means, there is no signal there, just you start and go quickly anywhere in the world, I mean, in that city. Solar thermal you need storage and back up in any renewable energy, why solar? As I said wind is there and wind is not there, water is there and water is not there, sun is there and sun is not there, but you cannot stop your working, your machine, your studies, just because sun is not there. So, you have to have a storage or a backup. What makes energy engineering a challenging field? The load is also fluctuating, and our renewable energy sources are also fluctuating. So, it is a very deadly combination; both things are fluctuating, your job is to keep a balance. Now, with this, we finish solar energy, of course, it is only a general idea; if you want to have the full, I think there are courses in solar energy, and energy program. And I am sure all of you must be going through that; this is just to introduce to that, and mainly from power generation point of view. I can only tell you few more things about solar energy. The solar housing, the buildings nowadays they are using solar passive and active principles, and Himachal Pradesh is the first state in the country, where if you want loan for house building, the condition is you will use solar energy, and the whole construction will be such that, you will be having more and more solar energy available in the house. The tragedy in the five star hotels are, even a houses are, we put thick curtains and do not allow the natural light to come in and then you starting the artificial lights.

So, loosing on two accounts. Excuse me You are wasting energy or paying for extra energy, and the natural energy which is very good, you are preventing, especially that can help you warm also in winter, rather than starting heaters or gas heaters or whatever heaters or air condition. Well, wave energy is another renewable energy; the energy content is very high; look at the Indian map, we have several thousands of miles or kilo meters of costal lines in India - South India, right from Calcutta, coming to down to Trivandrum and going up to Bombay. .. If you can use this solar sun sea sea energy or wave energy, you can generate lot of power; the power is proportional to amplitude whole square into period of motion; this is roughly ten seconds, and this is of the order of two meter, which is enough. There are two institutions in India, where lot of work is going on, on wave energy, sea energy, tidal energy; one is in Goa ., just have selected as the city for your film festivals; . world over they are known by the cities, dances, film festival and so on. So, Goa is also known for institute of oceanography, where this ocean and thing. Similarly, IIT madras, how did this energy center is started in IIT Delhi? There was a committee chaired by Noiduma - late professor Noiduma, who was director general CSIR, . is mashalker; previous to that will be professor Joshi, who is currently chairman board of governors Rudki IIT, is whether is in energy centre, doctor j c Joshi. Now, this Noiduma was given a task of creating centers; one centre each in all IITS, at those time only five IITS, that should be a national centre - centre of prominence, imminence, the whole world should look towards those centers for good work. IIT Kanpur got material science, IIT Bombay got resource center, Madras got this oceanography. So, there is a center their; the Kharagpur got cryogenic center, and energy center was given to IIT Delhi, other centers are also there, but this is a center of national .

. . . So, that is why you see thirty percent there, their thirty professors or faculty members, reserve is five ten in other centers. Energy flex is too high - 50 to 70 kilo watt per meter width of oncoming wave; potential is 20000 mega watt, but there are engineering problem; it is not that easy, otherwise they would have done it by now, with wave power are formidable; however, they are trying fuse parts. . And, let see they can success, then they can repeat it elsewhere; I tell you the name of parts in few minutes time. Have you heard of OTEC? Ocean thermal energy conversion. . This is world's largest solar collector ocean, three fourth of the earth is water, only one fourth is land. The temperature difference of 20 degree centigrade it will warm solar absorbing surface water, and cooler bottom water can occur; as I told you, in earth if you go below, you will be hotter and hotter; if you go up in air, higher you go, cooler you feel, there is an proverb. Similar thing happens in the ocean, see, if you go down, it is cooler; the surface water is bit warm; those of you take dive, they will understand this much better. Do not go and take the lesson to you know how to swim. Temperature difference of 20 degree centigrade is big enough, to create a gradient and generate power; thermal energy can be converted into other energy forms; again the potential was vast 50000 mega watt. . And US Miami, I was talking to you temperature difference is 17.5 degree centigrade and they are generating power. In India, we are considering Koalam beach as a probable site; this already talk to you, Goa - IIT madras are oceanography centers; where is Koalam? it is 48 kilo meters from Trivandram, as you go towards Kanyakumari from Kerala to Tamil Nadu; Kanyakumari is in Tamilnadu, the Trivandram is of course the capital of Kerala, and Koalam beach is very world famous beach.

The tourist government, go they are, and there they are trying to develop the power station; still they are trying, if it become a success, they can repeat it.

.. Bio fuels, we are talking about bio; some time back the material of plants and animals is called BIOMASS, transform by chemical and biological processes, intermediate bio fuel such as methane; I hope you are not forget in your chemistry, CH<sub>4</sub> is methane, this was the you must have written this formula in your chemistry course, carbon has valency four. So, there are four hydrogen atoms, and then . was to if you recall; ethanol liquid or charcoal solid, I am sure if you visit villages, in cities, it is stop down. People will go and collect those cow dungs; they are not mad there collecting, and there is not that there would not do not have any work to do that; they bring it back to the house and prepare that, you know, cake . cake, and that can be burn as a fuel and it is free, because you are just then form, you know, walk, and on the roads, you found this this thing and you collect it. i do not whether you know, there is a god also to be created using this cow dung on next due to the value, that is . than pooja; there also prepare that god using this cow dung, you worship it. And then, second thing some people mixed with water, and sprinkle it in front of the house; I do not know whether you have seen it, and it seems that keeps, you know, environment cool and clean; this still happens in villages. Yes, it gives you heat for cooking; there are few colony's in Delhi, there biogas is being supplied rather than LPG for cooking and it is very cheap. There are biogas community plants in villages, .there are individual plants also, which can give you light, which can give you gas to cook and so on. So, this is very important fuel for villages. It will give comfort heat, space heating, . drying, you know, have to use this drying. The solar dryers you might read in your solar energy courses; factory process is raising steam for electricity production and transport.

. D K Sharma, this are all guys who are exports in biomass, so called chemical engineers, they are chemise. . Potentially 17000 megawatt, it is worth . it, worth it tapping it. Agriculture waste, the waste I have been repeating it earlier on also, should become our primary source and we have to use it. What is cow dung? It is supposed to be the bio wasting, which is been converted in to flow. Agriculture waste is 6000mega watt available; the total biomass power harnessed so far 222 mega watt, very good figure. 2000 community biogas plants and family size biogas plans are 3.1; we have biogas plant in IIT campus itself in mechanical engineering department, that in between block three and two are something like that, you can go and will look at that. .. Rural energy scene, why should we worry about rural? Why government of rural all the time? It is not only for votes; the facts is India lives in villages, Mahatma Gandhi also said that. How many villages are there in India? Anyone 7 lakhs, that is 700000; how many of them have been electrified? Only 85 percent; that means, 15000 villages is still there, there is no light, no grid power, they are inextensible, they are hilly areas, and there is no chance of grid been taken to those areas. There is no money; even though 85 percent which have been electrified, the government definition is or CA definition is if a try in a lighter wind, if a transmission line passes through village the declare it to be electrified; that means, the transmission line is also not passing in those 15 percent villages, and is unlikely you to pass in coming ten years, fifteen years. For them, the only hope is this decentralized energy sources, the hybrid energy sources. The integrated energy of decentralized energy sources, integration of that, what will happen? If there is a electricity in village, what will

happen? They would not rush towards cities for job opportunities for better living conditions, because once energy is there, you can have rural industries, cottage industries, because engineering college is there anywhere, now everywhere, in every corner of India; thanks to ICTU, thanks to private engineering colleges.

So, education is there, electricity is there, jobs are there, so there will be reverse migration, because the village life is definitely cleaner, less polluted, less costly, nobody will visit you in village, no guest, no going to Delhi every alternate days, to receive somebody, to see of somebody or list from somewhere. It is going to bank purchase, this bill purchase, this send it, smooth we want this migration from cities to rural India. Now, it is everybody coming to Delhi, nobody wants to live there, it is one way traffic or such Meteros; we want smooth transition from fossil fuel economy to sustainable renewable energy based economy, that is our future plan, so that we give energy for all and energy forever. There are very good sounding words, whether they will be converted into reality; I do not know, because I am not a politician, I am not to suppose to say this 2012 I will do this, and 2020, you will developed country; who knows who will be there by 2020, but it is a good laudable goal; it is no doubt about it; if you can do it, and yes, we can do it, because we have the second largest scientific and technology for man power, we have resources, we have everything; only there what is liking is the will to do that. What will happen if this happens you will have a equitable and environmental friendly sustainable development. So, anyway it will be poverty elevation; all is poverty, because there is no opportunity, there no job; once you have no power, once you have education, so you will get opportunity to work. You do not go to unnecessarily go to cities or outside India or wherever, one is free to go of course, but does not have to go necessarily for making both and sweet. I think with this, I want you to ask some questions on today. Today, we have done solar energy, we have done wave energy, we have done biomass, biogas, all these things; and tomorrow, we have a class, will start with energy storage.

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