Solar is the Solution

SOLAR IS THE SOLUTION

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Save the only living Planet in the Universe

Let us plan as to what we can do to save the creation, save the life on the only living planet of the universe and back home, make our own Indian economy stronger and vibrant.

Today, let us limit ourselves to some suggestions about what we can do to make Indian economy stronger-strong enough to save the humanity from destroying itself.

Size-wise our planet is too small, insignificant, even tinier than a particle-of-sand-in-ocean, in this expanding universe.

Yet we are unique!

Ours is the only planet which has life and perhaps the most intelligent one!

That is why we need growing amount of energy to lead us to progress, to energize us for creating new infrastructure and devices. The big question is why do we source most of this energy from fossil fuel which has a limited reserve. Let us look at the balance sheet of energy. We get almost 23000 TW of energy from the Sun against the global requirement of only 16 TW. But we draw this all from our million year old reserve of coal(900 TW), oil(240 TW), natural gas (215 TW). This is only because these limited reserves are either carbon or hydro-carbon. Burning them is easy to produce energy. This energy, however, is not only accompanied with green house gas but also is from a limited source, belonging to all the generations, down the line. At the cost of coming generations, who are not here to claim on the oil-wells or gas-holes or the coal-blocks, we are consuming an accumulations of billions of years. The net effect is that, in our lust for material wealth we are destroying the planet's life bearing system – leaving the world less healthy for our next generations.

In contrast to this solar is a source which is all capable. All it needs is efforts and research to develop practical means of harnessing it to execute our activities and provide ambience for comfort. In one hour more sunlight falls on the earth than what is used by the entire populatins in one year.

Forget the future. The world already is nearly five times as dangerous and disaster-prone as it was in the 1970s. This is because of the increasing risks caused by climate change and global-warming due to green-house effect. The first decade of the 21^{st} century saw 3,496 natural disasters from floods, storms, droughts and heat waves. That was nearly five times as many disasters as the 743 catastrophes reported during the 1970s – and all of those, the weather events are influenced by climate change.

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The widening ozone–hole, shown in Fig.1, is a comparison of the current state with that of the one that existed in 1979. The fossil-fuel burning is responsible for this enlarging hole in the protective layer.

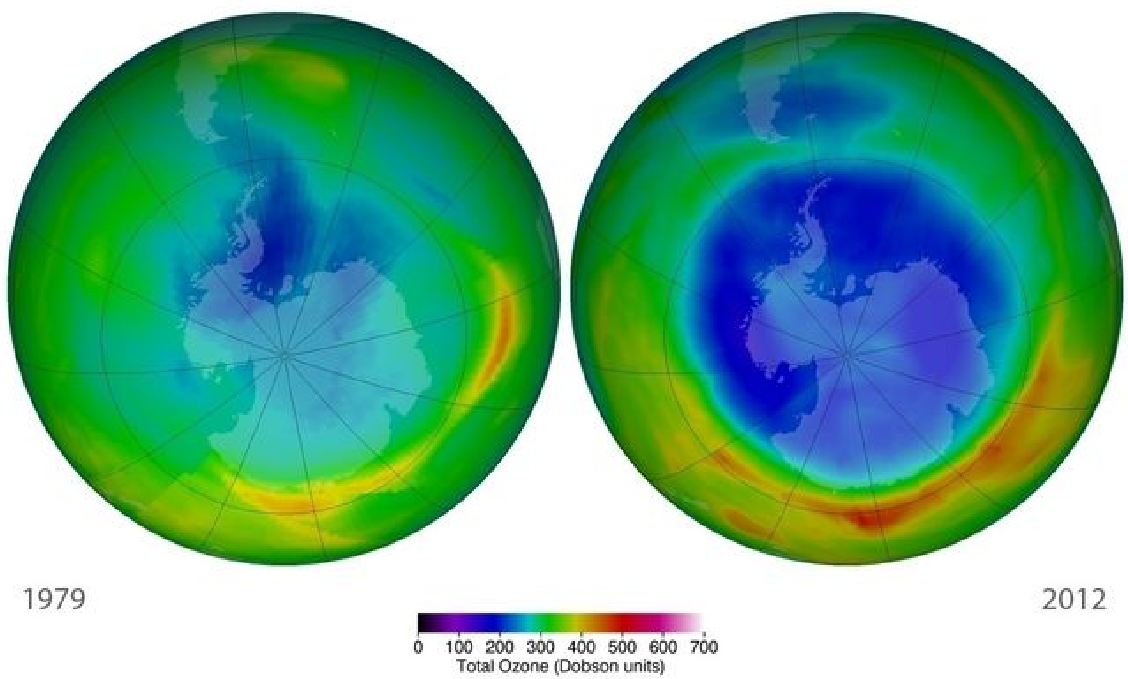

Fig.1 Ozone Hole [Courtesey "Physics World" Institute of Physics]

The bottom line is that natural disasters are occurring nearly five times as often as they were in the 1970s. But some disasters – such as floods and storms – pose a bigger threat than others. Floods and storms are also taking a bigger bite out of the economy. Heat waves are an emerging killer and the depletion in protective ozone layer is dangerous.

Energy strategies need to be drawn

Energy strategies need to be drawn such that the climate is not affected and we do not change the composition of atmosphere or sea. Clean energy neither emits the Greenhouse gas nor the ionizing radiation on an overall basis. India's per capita electricity consumption is expected to reach around 5000 kWh in 2020 from the current level of 1010. The human development index (HDI) is closely connected with the per capita electricity consumption. Our electricity need will thus grow to 518 GW. On a global basis, we will exceed 10 billion populations by the turn of the century. The decisions are normally weighed with the criterion of return on investment (ROI).

We have a great role to play

It is a matter to think and introspect. Can we perform all tasks that we do today with less green-house-gas (GHG) emission? Can we reduce global warming, floods, landslides and climate change? The Table 1 and Fig. 2 shows that we are the fourth biggest emitter of GHG surpassed only by China, US and EU.

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Countries/Group of Nations	Percentage of total Emissions
China	25.3
U.S.A.	14.4
E.U.	10.2
India	7.0
Russia	5.4
Japan	3.1

Table 1 Global CO2 Emissions Per region from Fossil-fuel use

We have a situation

1. Our fossil fuel reserve is very limited compared to our requirement. Fossil fuel import is the major drain on our foreign exchange. If crude price increases by USD one per barrel, the net import bill increases by Rs. 7096 crore and if exchange increase by Rs 1 to a USD net import bill increases by Rs 7440 crore. We import more than 190 million tonnes of crude oil annually and increasingly higher amounts of coal.

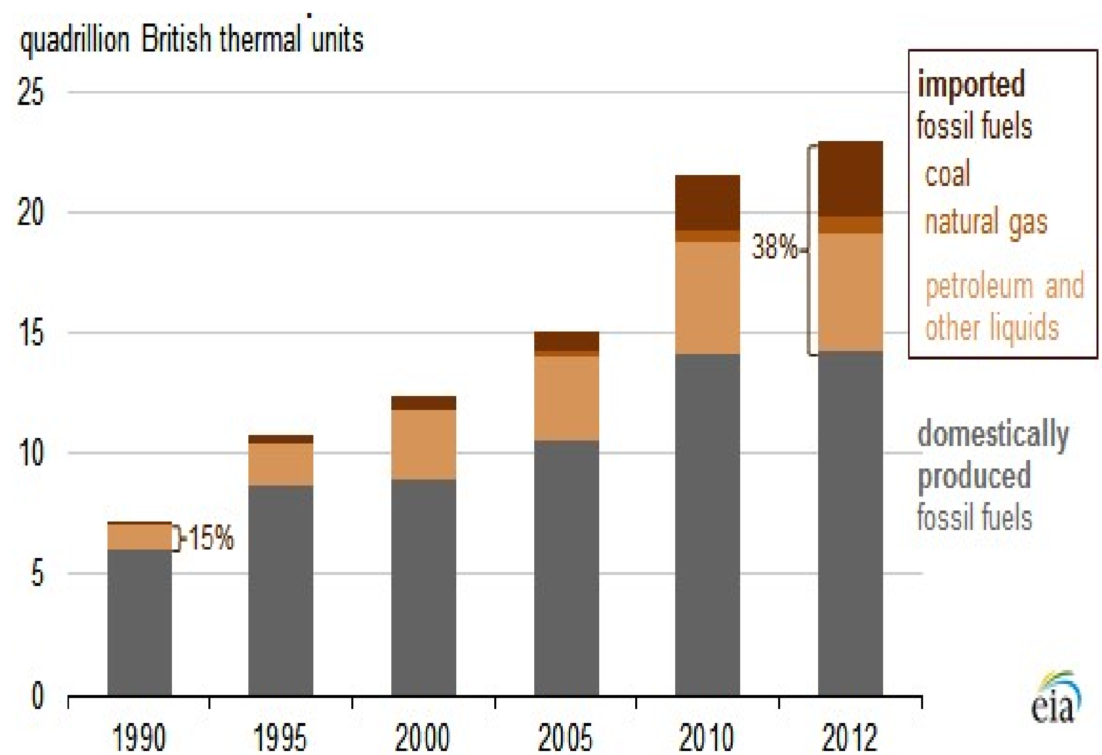

Fig. 2 India's Fossil Fuel Consumption

2. Even with this low per capita energy consumption the state of environment is quite pathetic.

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3. If per capita consumption of energy for India attains the same level as that of developed nations such as the United States of America, then we will be emitting additional 30 Giga tonnes of CO_2 annually into the atmosphere. You can imagine state of global warming and pollution under such condition. Therefore, while we have to advance in energy consumption to a per capita level of United States, we have to see that the new energy is completely emission free. This is possible only through renewable sources and focus of this article is on planning to meet our energy requirement by 100% solar and other renewable sources. The transition will not be simple as it would call for innovation and inventions for each of the applications such as lighting, air-conditioning, water pumping and transport. Each of the applications will need a separate methodology for converting renewable energy to the application sector in the most efficient manner.

The solution lies in going solar

Sun is the source of life on the earth. It is also the source of all energies including the fossil fuel ones. While renewable are replenished, the fossil fuel is a depleting reserve. The other and the more serious negative aspect of the fossil fuel is that it is mostly carbon based. The energy is derived mainly by burning carbon and emitting CO_2. How can we tap the energy that the sun gives us everyday. It is all renewable and inexhaustible and totally emission-free.

We the members of the current generation have great responsibility in reversing the climate change effect. The ultimate survival and strengthening of Indian economy depends on "*Harnessing Solar Energy*"

Energy drives our economy. The entire supply of energy required for growth and sustenance can be from the solar/renewable resources. For this we have to develop appropriate technologies for each of the application areas. The renewable energy-resources are mainly solar (inclusive of wind, tidal and micro-hydro).

Nuclear energy is not Safe

Nuclear energy is often pleaded as an emission-free source of energy. However, it is neither renewable nor safe. At every stage, from mining of nuclear fuel, its enrichment, handling and disposal after reaction is hazardous for several generations down the line. The hazard described in the previous line is during the normal and safe operations. It is severely more in case of an accident, explosion and uncontrolled reaction, as was recently observed in Fukushima in Japan in 2011 and earlier in Chernobyl (Russia) and Three-Mile-Island (USA).

Major hydro-power disturbs ecology, inundates large areas and settlements. It also involves large scale dam-construction causing land-slides and tremors.

A small fraction, less than 1%, of the sunshine on our barren land and deserts can meet the entire global requirement of energy. So why mine coal and import crude oil ? Fossil fuel burning is neither desirable nor sustainable. Stop mining of coal and switchover to solar on rooftop, canal-top, barren lands and deserts. This will be climate-friendly and economy-strengthening. All this will require appropriate application-oriented technology-development.

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Utilizing the sun does not mean only fixing photo-voltaic panels on the roof-top or unused area. It means developing appropriate technologies, specific to the use or application. A good example is solar water heater which doesn't involve generating electricity from solar panels storing it in batteries and then running geysers in bathroom through inverters. This would give 3-4% efficiency of harnessing in place of the present 20%. This is just an example. We have to develop application-based efficient technologies for each sector, if we have to switch over to 100% solar.

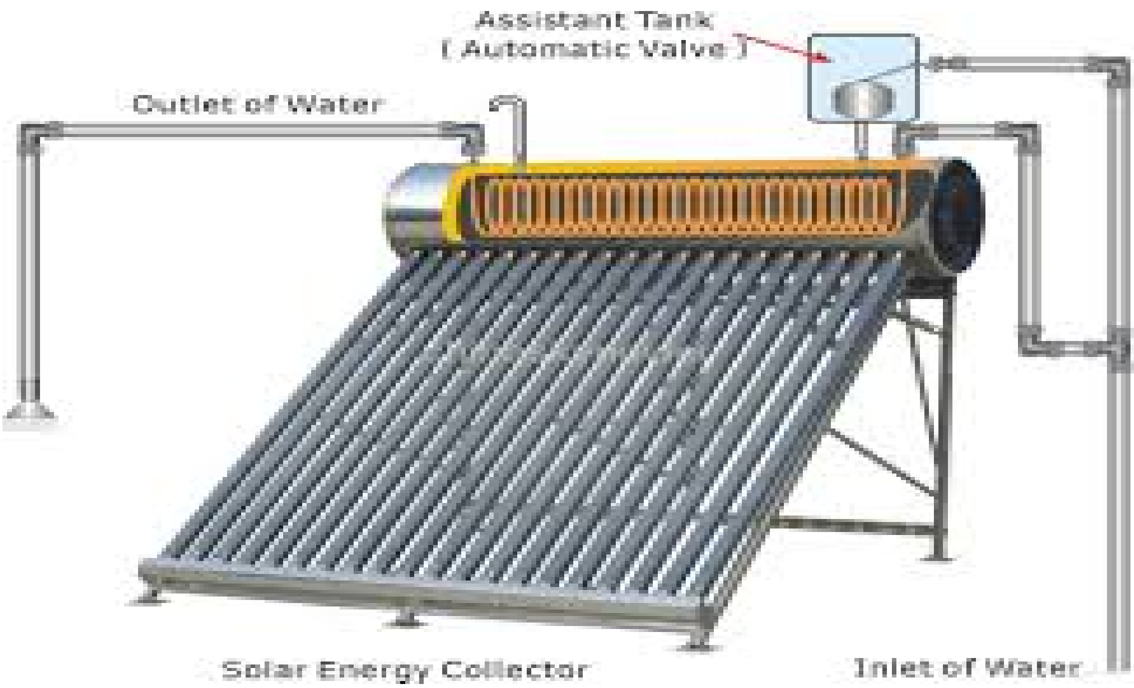

Fig.3 Solar Water Heater

Solar Architecture for the New Housing Complexes

Similarly an appropriate building architecture can give better air conditioning effect than the conventional window or split ACs powered by solar panels. Solar architecture would involve proper orientation depending on the latitude, altitude and slope of the place. In case of multiple stories, the architecture can improvise a solar chimney for induced draft. The in-built solar chimney can also accommodate the down comers the sewer-lines, cables and ducts, when appropriately designed. The draft so induced can effect fountains and cool air for circulations in the habitats. We have to develop and showcase such technologies so that these can be adopted, scaled up and multiplied. Such architecture will differ from low-rise houses to multi-storied ones. Similarly the pumping of water can be effected by solar energy during the sunshine hours and stored in over-head tanks.

India is rich in solar energy:

India is endowed with so much of Solar Energy that we can stop a major part of our petro-fuel import. This will stop the biggest drain of our foreign exchange and make our economy strong enough. Solar energy on 1/400th of Thar Desert can power the entire nation. Delhi's rooftop is sufficient to meet the electricity need of the capital.

Incidentally, we can find from solar map that our remote areas such as Ladakh and Sunderbans, which pose difficulties in obtaining grid electricity is endowed with higher solar intensity. For example, Ladakh and remote Himalayan region has higher solar intensity than most of areas in the Indian sub-continent. Ladakh gets around 8-9 kWh/m^2/day this is much more than our requirement. The rooftop areas in such region are sufficient to meet the energy requirement including the heating requirement in Himalayan region. The picture below (courtesy: Solar Energy Centre), maps the solar resources of our country:

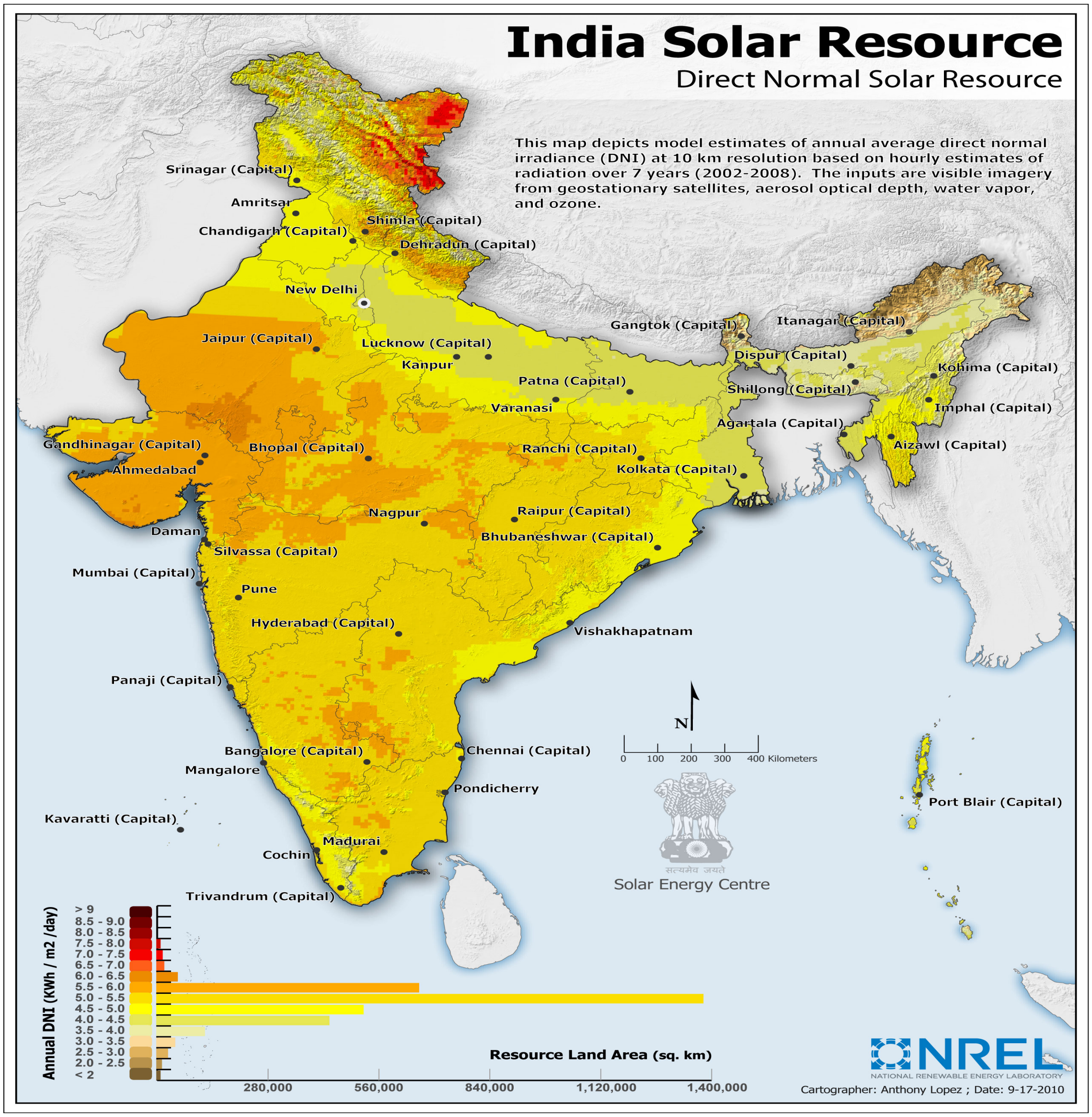

Fig. 4 Solar-Map Of India (courtesy: SOLAR ENERGY CENTRE, Government of India)

Renewable Energy can sustain Our Requirement

While planning to make our nation economically strong and safe to live in, it is necessary to transit to 100% renewable energy by developing a set of application-oriented technologies for harnessing solar energy. Photo-voltaic is suitable for electrical end-applications. However, there are two challenges-(i) poor efficiency and (ii) the storage aspect as the demand does not follow the sunshine hours. Solar-thermal (for thermal applications) and solar-architectural are the other two major routes for harvesting the solar energy. The broad plan is shown in the graph below where we

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conclude that a conversion of 300 GW of solar energy can make us totally self-reliant on energy matters, today. As we are in the beginning of the S-curve of solar technology with immense amount of renewable energy remaining to be harnessed through newer technologies, we see a good prospect of meeting our growing need of energy through the solar sources. This plan is shown in the graph below where we conclude that a conversion of 300 GW of solar energy can make us totally self-reliant on energy matters.

Thus we are making our climate sick and sick for the next generations.

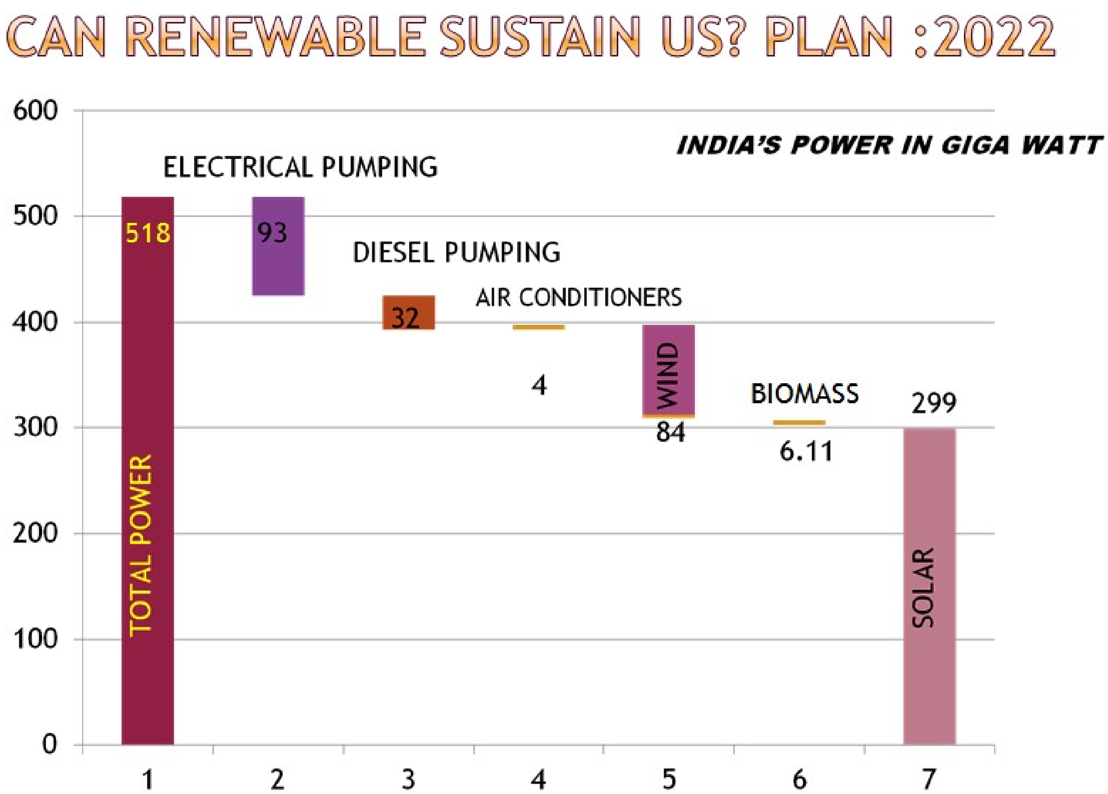

Fig. 5 The Solar Solution

This is equivalent to solar panel of 3600 sq. km. which is less than 1.5% of Indian Thar desert.

Some of the technologies that we may undertake to develop are:

- Solar thermal siphon pump with no moving parts for multi-storey buildings
- Solar thermal siphon pump for irrigation
- Solar melting furnace for metal melting and refinement
- Solar Hybrid Vehicle
- Solar Inverter like TESLA's wall charger
- Solar Kiln
- Solar electrolysis for generating Hydrogen from water for running IC engines
- Solar drying of grains
- Solar fabric dyeing

- And many others as identified by our team.

Let us save the globe by our action

This will not only engage us in new technology development but will also showcase our strength and offer new technology for adoption and multiplication.

A brief write-up on the first three of the nine technologies identified for development and mentioned above are given in the following paragraphs:

(i) **Solar thermal siphon pump with no moving parts for irrigation and multi-storey buildings**

This invention is the development of solar energy based pump for irrigating agriculture fields by lifting ground water. The most attractive part of the pump is the absence of any moving component, which makes it almost maintenance-free. Solar thermal energy is used to create a pressure higher than the atmospheric pressure over the water table of the ground water. This pressure(higher than that of atmosphere) lifts underground water through a tube dipped in ground water and delivers at a head H given by $H = (P_c - P_a)/\rho g$. Where Pc is pressure created by solar energy, P_a is atmospheric pressure, ρ is mass density of liquid and g is acceleration due to gravity.

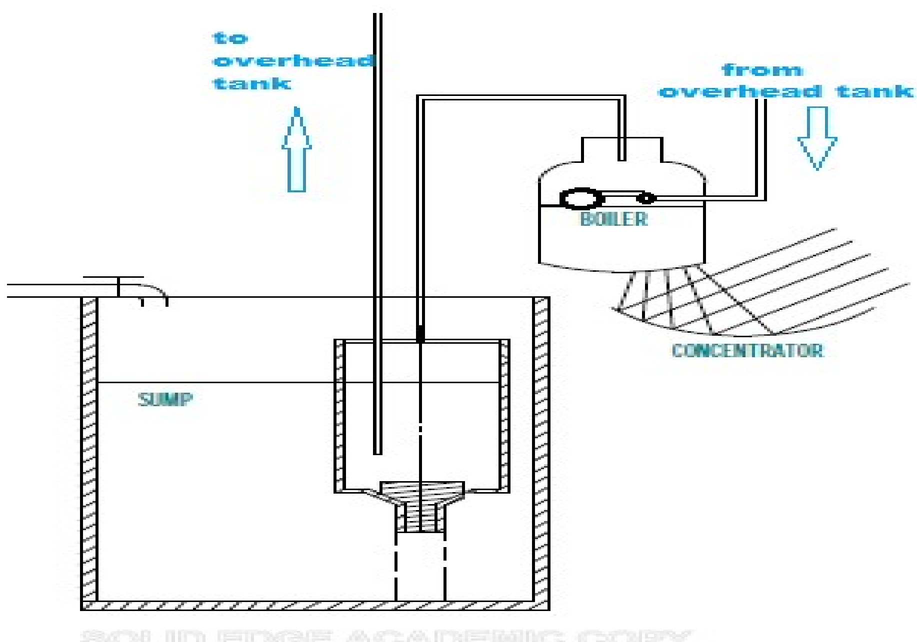

Fig. 6 Solar Thermal Siphon Pump For Multi-storey Building

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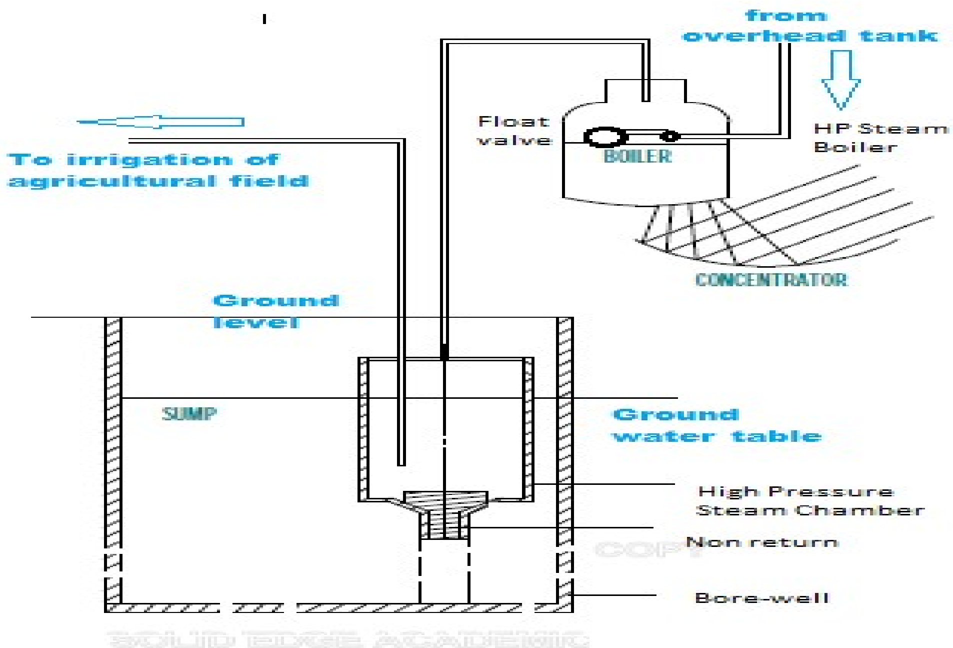

Fig. 7 Solar Thermal siphon Pump For Lift Irrigation

The following specifications are given below.

1) **Pressure, Discharge, Height and Solar Power Required,**

Head of Discharge = H in meter

Mass density of water, ρ= 10^3 kg/m^3

Acceleration due to gravity, g= 9.81 m/s^2 or say 10 m/s^2

Atmospheric pressure = 10^5 Pa.

Pressure head= ρ.g.H

= 10^3.10.H

= 10^4.H Pa

Pressure required on water table for achieving the discharge head = Atmospheric pressure+ Pressure head

= 10^5+10^4 H in Pascal

Assuming no friction loss.

Exerted Steam Pressure = Pressure required on water table = 10^5 + 10^4 H in Pascal.

m= flow rate in kg/sec

1 gallon=3.785 liter=3.785 kg of water

The average discharge rate for a 1H.P conventional pump is 2200 gallon per hour

Average discharge rate taken for unit pump is

= 2200*3.785 kg/hr

= 2200*3.785/3600 kg/sec

=2.313 kg/sec

Average head of water pumping for Delhi (average depth of water level in delhi) is= 20 m below ground level (bgl)

Power required maintaining the delivery rate of 2.313 kg/sec (m) for a head of 20 m (H)=m.g.H=2.313*9.81*20 in watt

Solar energy required to deliver this power is = Effective Aperture area* solar constant

Pressure required on water table for achieving the discharge head= exerted steam pressure

= $10^5+10^4.20$

= 300 kPa

Boiling temperature of water for exerted steam pressure ($T_{boiling}$) = from steam table

= 134 ^{0}C at 303 kPa.

2) **Specifications of Solar Concentrator (SC).**

Projected area for heat required = Effective Aperture area of solar concentrator = A_a m2

Diameter of solar concentrator =D

Eff. Aperture Area, $A_{ea}= \pi D^2/4$

Solar Constant = 1000W/m2 (Standard for India)

Efficiency of conversion of solar energy is taken as 50% thus (including losses), solar constant taken as = 500W/m2.

Eff. Aperture area of SC = A_{ea} m2

Solar Power converted = Eff. aperture area*solar constant*efficiency

2.313*9.81*20=A_{ea}*500

A_{ea}= (2.313*9.81*20)/500

= 0.9076 m^2

Eff. Aperture Area, $A_{ea}= \pi D^2/4$

=0.9076 m^2

Diameter of solar concentrator, D= 1.07499 m

Or

D= 1.2 m

Eff. Aperture area = Aperture area – boiler's projected area.

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3). System Efficiency Estimation.

Optical Efficiency = $\eta o = \text{þ}m * \alpha a * \gamma * Ƭc\, [(1 - \tan \Theta) \cos \Theta]$

Where þm = SC material reflectivity.

αa = Receiver boiler absorptivity.

γ = Intercept Factor.

Ƭc = Transmittance of cover material.

(All above efficiency parameters based of standard value of used material)

"Solar Furnace"

This invention is development of solar energy based metal furnace for the purpose of casting and foundry practices. The most attractive part of invention is use of solar energy for the foundry practices which has not been practiced so far.

The basic principle of this furnace is use of concentrated solar thermal energy focused on the solid metal pieces for recycling of metal scrap using 100 % green energy. This furnace will not need any fossil fuel and it will be completely emission free.

Specification:

1. Biconvex lens is proposed to focus the solar energy on metal pieces for melting.
2. The melting vessel is provided with an adjustable fixture to align and focus the solar energy.
3. The molten metal can be evacuated through a discharge mouth in the middle of the melting vessel.
4. Shutter is provided to protect the lens during the pouring of molten metal.

Calculations:

The area of lens required to focus the solar energy to melt the metal is given as

$$\Delta h = S_c.A.t$$

The model of proposed furnace for Lead and Tin melting is under fabrication with specification. However furnace for other metal can also be developed with due consideration of their melting point.

Specifications for solar furnace:-

A. Total heat required for melting of metal

$$Q_{total} = m.C_p.(T_{melt} - T_{min}) + LH.\ m + m.C_p\ (T_{max} - T_{melt})$$

Where,

Q_{total} = Total heat required for melting of metal (KJ)
m = mass of metal (kg)
C_p = Specific heat of metal (kJ/kg.K)
LH= Latent Heat of fusion (kJ/kg)
T_{melt} = Melting temperature of metal (K)
T_{min} = Temperature below ambient for

T_{max} = Temperature above meting Point of metal for maximum capacity of furnace (K)

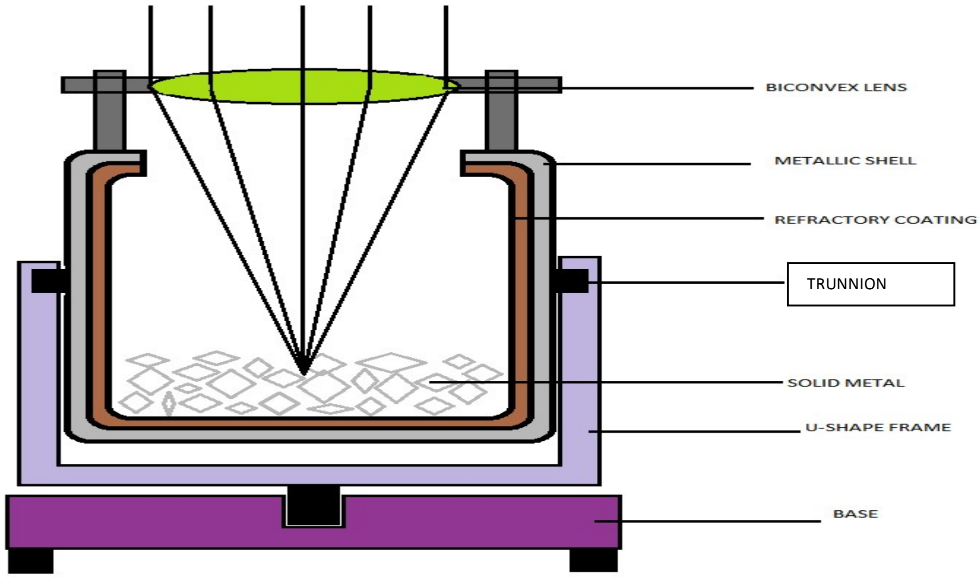

Fig. 8 Solar Furnace for Melting and refining Metals

B. Specification of Bi-convex lens

a. Area of Lens (A_{lens})

$A_{lens} = Q_{total} / t.S_{c.}$

Where,

A_{lens} = Area of Lens (m^2)

Q_{totsl} = Total heat required for molten metal (kJ)

t= time taken by furnace for melting 'm' mass of metal(s)

S_c =Solar constant (1 kW/m^2 average for India)

**** The value of Solal Constant varies place to place.**

b. Focal length of lens

$$\frac{1}{f} = (n-1)\{\frac{1}{R1} - \frac{1}{R2} + \frac{(n-1)d}{nR1R2}\}$$

Conclusion :

Solar-energy has the capability to perform all activities needed by us. However, each of the activities will require separate technology development as the electo-magnetic radiations carry energy in different form than the fossil-hydrocarbons that we have been burning to get energy in our power houses, automobiles and kitchens. The challenge before all of us, the engineers today is to develop such appropriate technologies.