NZEB (Net Zero Energy Building)

A Brief Introduction

Zero can be amazing. It has equally infinite numbers on both sides. Ah! The beautiful balance. Well then, how about a balanced home which can work all by itself with zero external input of energy? That would be mind-blowing, and indeed it is.

"In 2014, an electrified Indian household consumed about 90 units (kWh) of electricity per month on an average; enough to run four tube-lights, four ceiling fans, a television, a small refrigerator, and small kitchen appliances with typical usage hours and efficiency levels in India." *Source – cprindia.org*

That's a lot of energy. Just imagine the numerous ways in which the environment would have been damaged in the generation of electricity. In such a situation, a great option to reduce these damages would be to use self-sustaining homes.

Self-sustaining homes work on the concept of converging the different types of renewable energy sources we have. In such a home, the various functions are managed as follows –

i. Lighting – Lighting energy accounts for more than a quarter of total energy consumption in buildings. A great source for lighting is the almighty Sun. During the daytime, the interiors are properly illuminated by using walls made of glass,

which allow the light through alongside giving the home a modern look. For nighttime, the energy absorbed by the solar panels is stored in a battery compartment, which then redirects this energy to the lamps and all other lighting systems as and when required.

ii. Air Conditioning – The air conditioning system in these buildings utilize natural wind to cool down the temperature. No energy is required in this process. The cool breeze enters through the glass windows in the front of the building from the bottom. As the air gets heated up, it rises and flows out through the windows at the rear of the house on the top, thus forming a cross-ventilation system. Additionally, if required, fans are run using the energy stored by the photovoltaic cells and wind turbine.

iii. Other Electric Appliances – All the other electric appliances are run using the energy stored by the solar panels and the wind turbine. All common appliances are energy efficient and utilize less energy for more work.

Thus, one can conclude that if these houses are implemented properly, then one day we can completely make a switch to renewable sources and save our environment from further degradation.

SECTION I

Solar Energy: A Radiation Worth Harvesting

Introduction

Solar energy is the radiation from the sun capable of producing heat, causing chemical reactions, or generating electricity. In other words, it is the radiant light and heat from the sun that is harnessed using a range of ever evolving technologies such as photovoltaics, solar thermal energy, etc.

It is an essential source of renewable energy and its technologies are broadly classified as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power.

Our sun is a blessing to us. Reckless use of our precious natural resources is depleting them and that day is not far when we would be exhausted of the resourceful gifts of the mother nature. So, it is necessary for us to realize our wrongdoings and turn things around to save the planet. For this, the sun is an exceptional source that can be used to harness electricity while preserving our valuable innate minerals.

The Merits

1. It is pollution free and causes no greenhouse gases are emitted after installation.
2. Reduced dependence on fossil fuels and exhaustible resources.
3. Virtually no maintenance as solar panels, they last over 30 years.
4. Creates job employment opportunities such as solar panel manufacturers and solar installers.
5. Aesthetics are improving making the solar power more versatile compared to older models.
6. Local benefit: India is a tropical country blessed with abundant solar energy. So, harvesting energy using solar panels and implementing them on a wide scale can prove to extremely benefitable.

Answer to The Why Question

Bihar is a fast-developing state. As of February 2019, Bihar's growth rate was 11.3%, highest in the country. The economy, polity and society are thriving. Villages, towns and cities are proceeding towards a new and smart future. But do we care about the resources being used? The economically disadvantaged sections of society? The unnecessary capital being exhausted to fulfill the economic needs?

When we think about development, we only wonder about the future scopes of benefit and what is improving. In reality, we fail to understand that the innate resources are being carelessly used and that not all people are financially capable of keeping up with the pace at which the society is proceeding. The resource count of the state is depleting at a fast rate which an unfortunate situation. These and many more problems are quite concerning and are required to be worked upon.

All of this has a very significant impact on our lives and surroundings. So a solution is needed to rectify the past mistakes and sow seeds for a brighter future.

The Ultimate Solution

Solar power is an excellent way to harvest energy without harming the mineral resources of the state. Bihar is blessed with the precious source in the form of solar energy. Proper use of the abundant sunlight can result in very fruitful returns.

The best way of harnessing solar energy in Bihar is by using solar panels. These can be used by people living in individual plots or even people living in rural and remote areas. These require just a one-time investment and will yield returns for a long period of time. Maintenance requirements are virtually non-existent as the solar panels last for over 20-30 years. This addresses the problem of poorly electrified regions.

Also, the advent of solar power would create a lot of employment opportunities which directs the issue of poverty and unemployment. These include suppliers, solar electricians and solar installers.

The Path Towards Implementation

We decided to develop a model solar paneled home to showcase the working, ease of installation and effective use of the solar energy to the people. The live working model will enable people appreciate the use of solar power and motivate them to install it in their respective homes and workplaces.

We have made a wooden house on platform measuring 1 square meter. The house has a slanting roof having clear surface area of around 2 square feet.

We have affixed one solar panel of 12 V – 1 Ah in center of the roof along with 10 smaller solar panels of 6V – 100 mAh each around the main 12V solar panel. All the panels have been interconnected through electrical wiring by soldering, with a blend of parallel connection (to increase the current) and series connection (to increase the voltage).

The main wire coming from the solar panel has been connected to a Solar Charge Controller, which regulates the flow of energy to a battery bank, which can store the power to be used when there is no sunlight. Alternatively, the panel can directly be connected to the lights, but they will work only during the day time.

Now the wire from the battery are connected to various forms of electrical fittings like LEDs, fans, etc. to power them.

We will expose the house to sunlight for a day to fully charge the batteries.

The model demonstrates how the sun's rays can effectively and cheaply be used to electrify a home for round the clock use and be a self-sustaining and an environment friendly initiative.

The Optimal Implementation

Bihar, having advantage of tropical climate having almost full year of good sunlight is appropriate for adoption of solar energy on a large scale. The state government is also sensitized towards it and has announced a slew of incentives and support for fast and massive installation of solar panels across the state.

The solar energy can almost be generated and used everywhere, starting from individual homes, apartments to commercial complexes, government buildings, factories, warehouses, airports, railway stations, hotels, hospitals, vehicles, etc.

Individual homes can be electrified with solar energy by installing roof top solar panels to warm water, run all or some electrical equipment, fittings and appliances. By having a good battery bank the solar power can be used round the clock, throughout the year. The state government can incentivize the common man by providing subsidy in installation cost and/or rebate in grid power bill.

Government buildings, factories, warehouses, hotels, hospitals, etc. have huge un-utilized roof top areas. With some initial investment, the same will drastically reduce their power bills and also make them self-sustaining and green buildings.

We have large tracts of open un-utilized lands. Solar panels can be installed in these lands as viable commercial projects and solar energy can be exported to the grid to supplement the state's energy deficiency. Banks are eager to fund such projects.

Admitted, that at present the initial cost of solar power system is on the higher side, but the power bill savings, ease of operations, self-sustainability and environmental friendliness, justify promotion of solar energy on large scale. Once installed, these systems work uninterrupted, without much maintenance for long period like 30 years.

SECTION II

Wind Turbines: The Blades of Electricity

SECTION III

Water: Collection and Utilization

Introduction

Certain problems have beset the use of groundwater around the world. Just as river waters have been overused and polluted in many parts of the world, so too have aquifers. Developmental works have restricted the seepage of water. This has led to the depleting of water table. It has drawn concerns of the whole world.

Understanding the seriousness of the problem, our group has prepared a system of rain water harvesting in the NZEB model.

The first 5 to 6 hours of Rainwater has very low pH level, which is too acidic for the soil health. The NZEB house has a slanting roof, attached with PVC pipes which bring down the water to the soil area. The PVC pipe has limestone powder which reduces the alkalinity of water and increases the pH level of the same. The water brought down by the pipes helps in generating hydroelectricity (This will be discussed later).

The soil is splashed by limestone powder which reduces the alkalinity of water and increases the pH level. The water falling on the rest of the area is brought into the soil area by the holes made. The water is filtered by the limestone powder that is splashed in the soil.

The normal pH level of water is 7 and by the experimental results it is found that the contact time of water with the provided limestone powder, in the NZEB model, we can increase the pH level nearly to 6.5. When this water will seep into the soil, it will also get filtered by the natural methods.

Hydroelectricity

The name of our project is Net Zero Energy Building which means that all the energy required in the house will be generated by itself. We have made a system to generate hydroelectricity from the rainwater.

In the model, it has been represented in the following form:

Structure

In this system there is a circular wooden structure attached with many spoons. This circular structure is attached to a dynamo motor (9V). This dynamo is further connected to the Battery.

Working

When water falls on the spoons, the wooden wheel starts rotating. Electricity is produced and stored in the battery. The electricity production depends on how fast the water can rotate the wooden wheel.

Water, Water Everywhere but How to Obtain a Single Drop to Drink?

In our model, we have just increased the pH level to such an extent, where it will not harm the soil health much. But there is another way by which the rainwater can be made drinkable.

The method is mentioned below:

Neutralizing filters are point-of-entry devices that raise water pH to neutral levels (around 7) which reduces or eliminates plumbing corrosion problems. Calcium carbonate treats water with a pH greater than 6 and synthetic magnesium oxide will treat water with a pH below 6. Untreated water flows through the filter, which is filled with calcium carbonate (limestone) or a synthetic magnesium oxide medium. This material dissolves in the water and raises its pH level.

The neutralization process takes time and in general the flow rate should not exceed 3.0 gallons per minute per square foot of filter bed area. A bed depth of 32 to 36 inches is necessary to provide adequate contact time; shallower beds will not provide sufficient neutralization.

Installing a cartridge filter prior to the neutralizing filter will remove solid particles from the water and can help to prolong the life of the neutralizing filter.

The biggest drawback to neutralizing filters is that they may increase or cause water hardness if calcium and magnesium are used in the filter. If hard water becomes a nuisance, the neutralizing filter should be followed by a water softener.

Water softeners consist of a corrosion-resistant tank that is filled with resin beads that are saturated with sodium. The resin prefers calcium and magnesium (the principle components of hardness) over sodium. As water passes over the beads, sodium is released and calcium and magnesium are adsorbed to the resin beads. A distributor disperses the untreated water throughout the resin. This assures that all the untreated water contacts the exchange material instead of passing directly through the column without contact.

Acid injection treats water with a high pH by lowering the pH of water to around 7, which eliminates the soda taste and can improve the effectiveness of chlorination. This method also reduces the potential of pipe corrosion as water with a pH above 9 can corrode metals such as brass, copper, zinc, aluminium and iron. Acid injection is a point-of-entry system. A chemical feed pump made from corrosion-resistant materials injects a solution of acetic acid (white vinegar) into high pH water. Citric acid and alum can be used instead, although they are more expensive. Weak solutions of hydrochloric acid or sulfuric acid also lower pH but these are more hazardous and require special handling. They are recommended, however, if the pH of untreated water is 11 or higher. After adding the acid solution, the feed rate should be adjusted until tap water reaches a pH around 7.

This way the water can be neutralized as well as disinfected.

But such a system would be extremely complex and costly to miniaturize so as to fit our model. So we were not able to show this in our model.

SECTION IV

Battery: The Mighty Accumulator of Electricity

But Why?

As mentioned earlier, solar panels can't provide solar energy in the required constant amounts 24x7 or throughout the day.

"In New Delhi the number of average daily sun hours is 5.5 for modules mounted horizontally and 6.2 when the modules are mounted at the latitude angle of Delhi which is about 28 degrees."
Source – WordPress

Although we have substitutes in the form of wind turbines and hydroelectricity generators, they might as well turn out to be not as fruitful as required in some areas. Only those areas which receive proper rainfall and those which lie in the path of strong winds would be able to completely take advantage of these.

Thus, to power the building throughout the night and at times when the minimum energy requirement is not met, some sort of storage mechanism is needed.

Solution to The Problem

A pretty simple solution to this problem is a battery compartment. This battery compartment would allow the building to store the excess amount of energy it generates during the peak hours of the day or at the times of heavy rainfall or even during a windy day. Just like most of the conventional inverters, we decided to use Lead Acid batteries. An intelligent battery charge controller would allow us to charge multiple batteries using the excess energy produced through the electricity provided by the solar panels, the wind turbines and the hydroelectricity generators. At the times of deficit in energy levels, a common example being during the nighttime, or when sufficient sunlight isn't available, the charge controller would automatically connect the charged batteries to the main power supply of the building. Thus, a sustainable system of electricity generation and utilization can be created, wherein no external power source is required.

Implementation in The Model

To create a miniaturized representation of the actual energy storage system, we have put Li-ion batteries to use. To create a single battery which can output a constant current of 3.7V (minimum) to power the various loads, we joined 3 18650 3.7V cells in parallel so as to provide proper current and to charge them properly. 2 such battery packs have been prepared and attached to all the renewable power sources in our model. A simple switch stops the flow of electricity by breaking the circuit when it is not needed. As an intermediator and to protect the batteries from a power surge, over discharge or over charge, a 5V 1A charge controller named “TP4056” has been placed in each of the charging circuits. The charging module has two LED indicators built-in:

i. Red LED – when on, indicates that the battery is being charged.
ii. Blue LED – when on, indicates that the battery has been charged to its full capacity.

Thus, the working of the battery compartment is demonstrated in the model.

SECTION V

Lighting and Ventilation: Making the Environment Livable

Lighting...

Most of the modern houses which are not properly constructed are forced to use a LOT of lighting systems in order to properly light the whole house. The many houses which use old filament bulbs waste a major part of electricity supplied in the form of heat energy.

To address this problem, we decided to use a naturally-lit system so as to not only boost the aesthetics, but also to prevent wastage of electricity. The building structure includes huge panels of glass windows which successfully input enough sunlight to light the whole house during the daytime.

During the nighttime, due to the lack of sunlight, a lighting system is required. Since the modern LED lights are not only extremely cost-effective but also utilize extremely small amounts of electricity, we decided to use LED bulbs, LED strips, and other sorts of LED panels to light the house during the night.

In the model, this has been represented using LED strips connected to a solar panel, which can alternatively be connected to a battery as and when required.

Ventilation...

Apart from lights, the present generation of houses also use a lot of energy-consuming fans and air conditioners. During the summer months in the tropical areas, these can amount to a major part of the combined electricity consumption of an average building.

So, we decided to use another natural resource – natural wind system of Earth, to make a cross ventilation system for the building. For this, we decided to use the same glass panels used in the lighting system by making them of the flip-to-open type. The cool breeze enters through the glass windows in the front of the building from the bottom. As the air gets heated up, it rises and flows out through the windows at the rear of the house on the top, thus forming a cross-ventilation system. Additionally, if required, fans and air conditioners with five-star energy ratings are run using the energy stored by the photovoltaic cells, wind turbines and hydroelectricity generators.

Conclusion

In the recent years, there has been a lot of development in the field of renewable resources and it might continue forever. Many buildings in various parts of the world have tried to cut-down our dependency on the natural resources of our Earth by using all sorts of renewable resources including the ones we have used – solar panels, wind turbines and hydroelectricity generators. But the individual use of these resources makes it extremely hard and costly to make the buildings completely self-sustainable.

But through the course of this project, we have tried our extreme best to develop a method to combine these all valuable resources which would have just gone wasted otherwise. Just like the convergence of multiple forms of technology made it possible to get a beautiful piece of machinery we call computers, we hope that our experiment with this convergence of all the major renewable resources plays a role in the buildings of the future and thus, one day we might achieve a network of interconnected self-sustainable homes all over the world.