

Comparative Study On The Efficiencies Of Self Sustaining Building And Conventional Building

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1. ABSTRACT

A civil engineer is a catalyst for the growth of the nation. The rising levels of pollution have made it a challenging task for the civil engineers all over the world to put a check on this pollution. Civil engineers all over the world have now understood that it has become important to deal with this issue as it is a great deterrent for a developing country as well as for human life. Civil engineering is a branch which can impact a great deal on the environment by smart construction. The rapid boom in the construction industry has led to the development of newer and much more efficient materials and methodologies which will greatly help in curbing the problem of pollution and raise the standards of human life without compromising on comfort.

2. INTRODUCTION

Civil Engineering:

“The art of directing the great sources of power in Nature for the use and convenience of Man.”

Sustainable Development

“Meeting the needs of the present without compromising on the ability of the future generations to meet their own.”

A self-sustaining building is generally detached from the normal buildings as it can generate its own electricity, food and also water. The wastage is also kept to a minimal by means of recycling of the wastes and utilizing the wastes to the maximum before disposing it off carefully.

3. OBJECTIVES

A self-sustaining building is one which is capable of providing the user with all the basic amenities with partial help from outside sources. In this report we would be focusing on five important topics of modern life i.e. Energy, Water, Food, Wastewater Management and Planning and use of Smart Materials.

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Focus is also put on the planning aspect of the building as an efficiently planned building drastically improves a buildings efficiency without the need to put greater efforts. The advancements in construction industry has enabled us to get in touch with newer and much

efficient materials commonly termed as smart materials. These materials have specific advantages and disadvantages but when used properly will enhance the overall usefulness of the building.

4. METHODOLOGIES

4.1. Solar rooftop PV system

Electricity generated through coal plants is becoming expensive by every passing day. Power cuts and increasing dependence on DG sets is causing a lot of damage to the environment. The demand supply gap for electricity is increasing in the country which makes it very important for people to start thinking of other ways of realizing their energy needs. Keeping this in mind Ministry of New and Renewable Energy (MNRE), Government of India is promoting off-grid solar PV systems under the Jawaharlal Nehru National Solar Mission in the country. Many people in the country have started feeling the need of installing solar PV system for their home, apartment complex or small office use, and with this article we would try to provide some information which can be a good starting point for a roof-top Solar PV system project.

4.1.1. What is a Solar PV cell and module?

Solar PV cell is the basic building block of a PV system. It consists of semiconductor material that absorbs sunlight to generate electricity through a phenomenon called “photoelectric effect”. Only sunlight of a certain wavelength can effectively generate electricity. Although a solar PV can generate electricity on a cloudy day, but it is not as effective as it is on a sunny day.

A basic PV cell produces a very small amount of electricity and multiple of them are connected together to form a Solar PV module that can generate 10W to 300W output. If more electricity is required, then multiple such PV modules have to be installed in an array.

4.1.2. Sizing a solar system

Before you buy a system, it is very important to size your solar system properly. Sizing will depend on the load requirements in your setup. It is important to note that a Solar system is good for operating low wattage appliances like lights, fans, TV, etc. High wattage appliances like Air Conditioners and Water Heaters cannot be operated using solar PV system (in fact solar water heaters and solar air conditioners are available separately). It is very important to make sure that your system is energy efficient so that you do need a bigger sized solar system. Please read our previous article: Before Renewables think Energy Efficiency. The connected load of your setup will help you determine the size of system that you need and that in turn will drive the cost of the system

4.1.3. Other considerations for installing a solar system

Although a solar PV system can generate electricity through direct or scattered sunlight but it is very important to assess the amount of sunlight available at the location where a solar PV system is being installed. To collect maximum sunlight the ideal orientation of a Solar Panel is towards south. However, a 45-degree east or west of south can also work. The system should be placed in such a place so that there is no obstruction of trees or adjoining building. In case these requirements are not getting fulfilled, an expert should be hired to do a detailed analysis on the amount of sunlight available.

The load carrying capacity of the roof where the solar panels are to be installed should also be done. Solar Panel structure typically weight 15kg per sq. meter and the roof should be able to handle the load.

4.1.4. System output or electricity units generated from a solar system

Although we talked about wattage capacity of a solar PV system, but that does not mean that the wattage will be available 24 hours a day and all throughout the year. The units or kWh output of a solar panel will depend on the panel efficiency and availability of sunlight in a location. The factor that defines this output is called CUF (or Capacity Utility Factor). For India, it is typically taken as 19% and the calculation of units goes as:

Units Generated Annually (in Kwh) = System Size in Kw * CUF * 365 * 24

So typically, a 1kW capacity solar system will generate 1600-1700 kWh of electricity per year (please note that this is just a thumb rule as the CUF will vary in different cities in India).

4.1.5. Warranties and Maintenance requirements for a Solar PV system

If purchased under NSM a Solar PV module comes with a warranty of 25 years from the date of supply. A solar home lighting system (with inverter) comes with a warranty of 5 years and the batteries if sealed maintenance free come with 2 years warranty and lead acid flooded type battery comes with 5-year warranty.

It is important that the manufacturers provide an operation, instruction and maintenance manual in English and local language along with the system. As with all electrical and mechanical system, solar PV system also needs regular maintenance. An efficient long-lasting system is one that is maintained properly and regularly. A solar PV system does not require a lot of maintenance but it is good to clean the system of dust and bird droppings regularly to maintain its efficiency. If you choose a maintenance free battery then you need not worry about the battery, else the battery will need regular maintenance. Make sure that the system is getting adequate sunlight and is not getting shaded by nearby trees, etc.

4.2. WATER

4.2.1. Rainwater Harvesting

Rainwater harvesting has been used throughout history as a water conservation measure, particularly in regions where other water resources are scarce or difficult to access. In recent years, researchers and policy makers have shown renewed interest in water use strategies due to rising water demand, increased interest in conservation (both water and energy), and an increased regulatory emphasis on reducing storm water runoff volumes and associated pollutant loads. In the last decade, as interest in the practice has grown, numerous state, municipal, and regional agencies have adopted or amended codes and guidelines to encourage responsible and effective rainwater harvesting practices. In addition, researchers from universities and non-government organizations, as well as industry consultants, have published papers and articles addressing a broad range of topics related to the installation, maintenance, costs, and performance of harvest and use systems.

Methods and Techniques:

The methods of ground water recharge mainly are:

Urban Areas:

Roof top rain water/storm runoff harvesting through

- Recharge Pit
- Recharge Trench
- Tube well
- Recharge Well

Rural Areas:

Rain water harvesting through

- Gully Plug
- Percolation Tank
- Check Dam/Cement Plug/Nala Bund
- Recharge Shaft
- Dug well Recharge
- Ground Water Dams/Subsurface Dyke

4.2.2. Water-Efficient Fixtures And Equipment

Fixtures that save water include low-flow shower heads, sinks with auto-shutoff mechanisms, and water-saving toilets and urinals.

Equipment that saves water includes dishwashers, clothes washers, other commercial kitchen equipment such as sprayers and steam cookers, as well as industrial process equipment.

Reducing water use from fixtures and equipment is perhaps the easiest method to reduce total potable water use. It does not require extensive design solutions, just specifying certain products. Avoiding large fountains, pools, and other water features will also save water use.

4.3. Wastewater treatment

There are many ways by which to treat grey water so that it can be re-used. The various methods used must be safe from a health point of view and not harmful to the environment. These types of grey water systems rely on plants and natural microorganisms to treat the water to a very high standard so that it can be safely re-used. The main advantage with these types of systems is that they treat the grey water naturally, and also enhance the local environment because of the attractive plants used and the fauna attracted to them. It's estimated that just over half of household water used could be recycled as grey water, saving potentially hundreds of litres of water per day.

There are two types of systems to recycle grey water:

Diversion devices

Diversion devices simply carry grey water from your bathroom or washing machine directly to your garden or toilet, without treating it. Components may include:

Hose

Grey water is diverted from its source to the garden using a simple flexible hose.

Grey water Diverter valves

In this you can install a switch that allows you to choose when the water flows to your garden and when it flows to the sewer.

Closed-loop system

This diverts grey water to your toilet rather than your garden, but isn't approved in some states.

Surge tank

This stores the brunt of the outflow so your grey water won't flood the garden, or worse, the house. You need to remove sludge from the tank every six months or so, and it should also have an overflow device to divert excess water into the sewer.

Filters

These remove hair and other large particles from the water so they don't clog up your irrigation pipes. Filters need regular cleaning and need replacing every 6 to 12 months.

Pump

This may be necessary to get water to all parts of your garden, especially if gravity's not on your side. You'll need a power source, which may mean getting an outdoor power point installed.

Cost

The more complex grey water diverters range from several hundred to several thousand dollars, depending on what you need in the way of pumps and surge tanks, irrigation equipment and the suitability of your existing plumbing. You'll also need the services of a licensed plumber, and will most likely need to alert authorities that you have a grey water system in place.

Safety

- There are limits to what you can do with untreated grey water because of the chemicals and bacteria in it, but treated grey water is somewhat safer to use.
- Untreated grey water should only be used for sub-surface garden irrigation — that is, through a network of pipes buried at least 1m below the ground – to reduce the risk of human or animal contact.
- Pipes carrying untreated grey water must display relevant warning labels.
- You can't store untreated grey water, because the bacteria and other pathogens could multiply to dangerous levels.
- Use it immediately (or within 24 hours), and if it's raining, divert it to the sewer.
- If someone in your family is sick with gastro or flu or another contagious disease, stop using the grey water.
- Don't use grey water if you've been washing nappies or using bleaches or dyes.
- Don't water herbs, vegetables or pot plants with untreated grey water.

Your grey water shouldn't escape from your property into a neighbouring one, into storm water systems or aquifers used for drinking water — in fact it's illegal

4.3.1. Aerated constructed wetland (ACW) unit:

Aerated constructed wetland is naturally aerated unit consisting of coal, stone grit, aeration system and vegetation. The unit has same dimension as previous units. The bottom half of the tank is filled with coal of size 10-20 mm and top half is filled with stone grit of 10-20 mm size. The vegetation *Typha latifolia* is planted in stone grit medium. The initial height of plant was 25 cm. The

combination of stone grit and *Typha* acts as a secondary treatment and coal media acts as tertiary treatment. The inlet and outlet are provided at the top and bottom of tank respectively. The inlet is provided at 10 cm from the top where outlet is provided at 3 cm above the bottom. For measuring water level piezometer is provided at the bottom of the tank. The valve 2 shown in Fig 3.2 is used to regulate the flow into ACW.

The specific feature of ACW is aeration system which works on the principle of natural aeration. The system has five perforated vertical pipes interconnected by seven perforated horizontal pipes. The total height of each vertical pipe is 60 cm. The pipes are 3.3 cm in diameter and perforation have 0.5 cm diameter. The CWs worked like a trickling filter. The circulations of air are occurring during filling and draining. The air set sucked inside the system during period of draining effluent.

4.4. FOOD

- Sustainable agriculture is the production of food, fiber or other plant or animal products using farming techniques that protect the environment, public health, human communities and animal welfare.
- The most important factors for an individual site re sun, air, soil, nutrients and water.
- Methods of Sustainable agriculture that we are using in our paper are as follows:
 1. Rooftop Agriculture
 2. Kitchen Garden
 3. Plantation of fruit bearing trees surrounding the compound

4.4.1. Rooftop Agriculture

- A roof garden is a garden on the roof of a building. Besides the decorative benefit, roof plantings may provide food, temperature control, hydrological benefits, architectural enhancement, habitats or corridors for wildlife, recreational opportunities and in large scale it may even have ecological benefits.
- The practice of cultivating food on the rooftop of buildings is sometimes referred to as rooftop farming.
- Rooftop farming is usually done using green roof, hydroponics, air-dynaponics systems or container gardens.
- Roof gardens are most often found in urban environments. Plants have the ability to reduce the overall heat absorption of the building which then reduces energy consumption.
- If widely adopted, rooftop gardens could reduce the urban heat island, which would decrease smog episodes, problems associated with heat stress and further lower energy consumption.

4.4.2. Kitchen Garden

- The traditional kitchen garden is also known as potager or kailyard.
- It is a source of herbs, vegetable and fruits and is often a structured garden space with a design based on repetitive geometric patterns.
- Plants are chosen as much for their functionality as for their colour and form. Many are trained to grow upward. A well designed potager can provide food as well as cut flowers and herbs for the home with very little maintenance.
- A vegetable garden (also known as a vegetable patch or vegetable plot) is a garden that exists to grow vegetables and other plants useful for human consumption, in contrast to flower garden that exists for aesthetic purposes. It is a small-scale form of vegetable growing.
- The herb garden is often a separate space in the garden, devoted to growing a specific group of plants known as herbs.
- The herbs are used to flavor food in cooking. Though they may also be used in other ways, such as discouraging pests, providing pleasant scents or serving medicinal purposes.
- Rosemary, sage, parsley, mint, catnip, henbane, marjoram, thyme, rue, angelica, bay, oregano, aloe, arnica, chives and basil. Basil is especially common in these gardens, not just for its culinary use but as a strong protection herb.
- Water can be used from all the sources of water harvesting like rainwater harvesting or ground water replenishment.
- Methods like drip irrigation and intermediate irrigation can be used while doing rooftop farming. A lot of water is saved and hence is a very sustainable way to farm.
- Green leafy vegetables can be planted and cultivated successfully by the rooftop farming methods.

4.4.3. Plantation Of Fruit Bearing Trees Surrounding The Compound

- Plantation of fruit bearing trees can be done on the periphery of the plot which provides with fruits shelter as well as fresh air.
- These trees form a shield around the property which protects the privacy of the plot and also gives a feeling of security.

4.5.Planning

Planning is an important aspect in building design. A well-planned building helps in utilizing the natural resources to the fullest thereby reducing the reliability on the fossil fuels.

Aspect:

The aspect of the house should be such that it enables the family members to live comfortably. Aspect is concerned with the orientation of the building. The arrangement of the doors and windows in the outside walls of the house should be in such a way that plenty of sunrays, breeze can enter into the house. All the rooms should be well ventilated and well lighted by the proper placement of doors and windows. Aspects of a building provide comfort, hygiene and pleasant views.

Prospect:

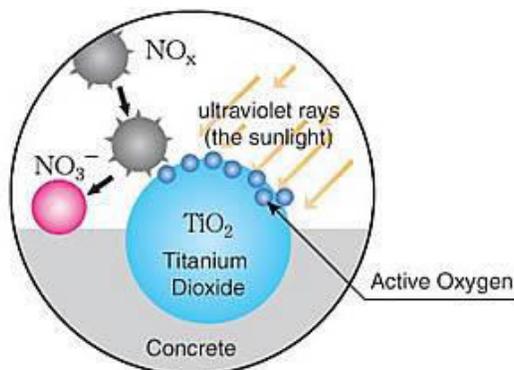
Prospect is the view from outside of a house. The house should have a proper prospect so that it can give a feeling of cheerfulness to the people living in it. It should create a good impression on a person who views it from outside. Prospect should reveal pleasant features and hide unpleasant and undesirable features of the house.

4.6.Smart Materials

4.6.1. Self-Cleaning Concrete

- Self-cleaning buildings and pollution-reducing roadways: These may sound like futuristic ideas, but they are the realities of some of today's concrete. Recently introduced formulations of cement are able to neutralize pollution, turning harmful smog into harmless compounds that can be washed away. Anything made out of concrete is a potential application as these cements are used in the same manner as regular Portland cements.
- On the surface of self-cleaning cement, the cleaning happens without any scrubbing involved. The secret? The power of *the sun*.
- When light and heat strike the concrete's surface, catalysts (usually titanium oxides) use that energy to break down the dirt into molecules like oxygen, water, carbon dioxide, nitrates, and sulphates. Gases float away, while liquids or solids are left on surface to be washed away by rain.
- Through a similar process, concrete can also break down pollutants in the air around it: if a pollutant strikes the surface, the titanium oxide reacts with it in the same way.

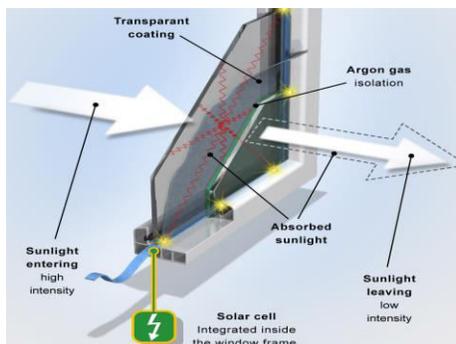
This diagram shows a nitrogen oxide hitting the surface and being converted into a nitrate:



Reaction of titanium dioxide with NO_x in the presence of ultraviolet rays and oxygen

- Photo catalysis is initiated by titanium dioxide (TiO_2), which is added during the cement's production. Typical properties (i.e. strength) of cement applications (such as concrete) will be added to clean the air around the photo catalytic surface. Nitrogen dioxide (NO_2) will be particularly abated when daylight activates the photo catalytic surfaces.

4.6.2. Smart Glass



Working of Smart Glass

A luminescent coating on newly produced windows using a technique called magnetron sputtering is applied. This technique is also used to make tinted windows for cars and offices. Because production is similar to existing techniques and the tinting of the glass is similar, Power Window can directly compete with regular office windows, especially because the product has the huge advantage of being able to convert sunlight into clean energy. After the glass is coated, we install the CIGS PV solar cells in the form of strips at the edges of the window in the window frame. These solar cells consist of mainstream thin-film PV technology and can therefore be easily customized and produced to fit many types and shapes of windows.

5. CONCLUSION

In conclusion it can be said based on the various findings that the operating cost of this self-sustaining building is very less while the construction costs are considerably high due to the application of various special equipment's for the conservation and utilization of the natural resources efficiently. In the long run the operating costs shall eventually turn into profits but it may take a long time for that. From the environment point of view, such buildings shall be common in the near future as these structures leave a far lesser carbon footprint and are in sync with the local environment thus causing less hindrance to the environment. The self-sustaining building makes it possible to synchronize the natural environment with that of the human beings with minimal discomfort to both the users. It utilizes the available resources to the fullest and in the best possible way.

With the emerging technologies and materials and equipments it has become very convenient and easy to install and operate such structures. Eventually the Self-sustaining structures shall be a common type of construction in the near future

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