Design of an energy efficient house reports example

Technology, Internet

Introduction

In the design of energy efficient house, three key factors need to be considered. First is the materials and construction. The chosen materials should be durable, renewable and have high insulation levels. Second, the resource value unto which the construction is done is important. Finally, putting energy use at the centre of the design process is the key factor that surpasses all other factors.

Having realized that embedded systems in the distribution network could lead to great energy savings, especially in the domestic situations, it is feasible to come up with energy efficient house that can utilize renewable and carbon based fuels. Embedded generation is a phenomenon of connecting generators within or distributed along the distribution network instead of the transmission network. The benefits of this kind of generation over traditional centralized power stations include an increased overall energy efficiency. It is because of co-generation and tri-generation techniques and an opportunity for residential customers to generate their energy using sunlight, in the case of photovoltaic embedded generation, which can subsequently be injected into local distribution networks, eliminating the need for expensive energy storage batteries.

This paper details the design of energy efficient residential house that uses solar and biomass fuels to generate sufficient amounts of energy for its operation and inject surplus energy to local distribution networks.

Description

An energy efficient residential house desired in this case is designed to provide a sizeable reduction in energy consumption for heating and cooling, and this energy is independent of the equipment put into use. It can be achieved in the following way. First we design a bioclimatic architecture that puts into consideration factors such as orientation and shape of the house, utilization of solar systems, solar protections and wind power systems. Second, high performing solar envelope will be used. The will be achieved through maximum insulation, high performing windows and glaziers, air tightness and elimination of thermal bridges. Finally, a high performance controlled ventilation in the form of mechanical insulation and heat recovery is used. It is only when the building has been designed to minimise energy loss that it makes sense to evaluate the energy sources and heating and cooling elements.

Structure

Bioclimatic architecture

The shape of the house should be compact to minimize the edges in contact with the exterior. The house has a canopy and balcony that provides a cooling effect during summer while the openings are appropriately positioned in a south-facing direction to increase warming during winter. Interior spaces are determined according to the heating requirements.

Thermal insulation

Thermally insulated houses save significant heating and cooling costs and reduces emissions from the moment they are built. Thermal insulation is used in every part of the envelope such as ground decks, roof lofts, facades and walls. Insulation in this case serves two purposes, to keep the building warm during winter and reduces heating costs and keeps the heat out during the summer and reduces cooling costs.

The high level of insulation begins with the ground. A 9 inch type 2 and 3 polystyrenes is laid below the slab. The external side of the foundation contains 12” type II EPS. An Additional plastered finish is placed on the side of the foundation.

Walls

The walls are made of locally milled clapboards and trims. A strapping for 1. 5” rain screen is allowed. The wall system comprises of 16” truss that is sheathed with 1x8 boards and filled with densely packed cellulose. This wall system will ensure the same level of insulation as the foundation and provides zero thermal bridge. The interior sides of the truss are fixed with 7” oriented strand board. The products used gives a high thermal resistance consequently decreasing the amount of heat lost to the surroundings.

Air tightness is meant to decrease the leakage of warm/cold air out of the house. In order to ensure an air tight environment, due care is taken to ensure that every step of the construction is conducted with insignificant or no air gaps. Installation of insulation material is important as it guarantees excellent air tightness and efficient management of moisture. The consequences of air infiltration are increased energy use since infiltrations cool the surfaces of the interior leading to condensation. In the same manner exfiltration increases heat loss leading to waste of lost of energy.

Roofing

Roofing material is made of recycled composite material that is derived from polymers and resembles slate tiles. The material is supported on trusses with 30” loose fill and 32” raised heal cellulose. A 6 mil polythene barrier is inserted and sealed with tapes. After which, the roof is covered with low maintenance sedum plants that give maximum cover and excellent protection for the waterproofing system. The plants are first matured on a blanket like substance after which they are harvested like turf and installed on top of the waterproofing system. The blanket is light in weight, easy to maintain and provide the greening feature and aesthetic purposes. Sedum blankets are obtained from across the UK and are delivered to the sight within a short timed.

Sedum is used in the north-facing side of the roof where solar panels are not installed. In the south-facing sides, photovoltaic and thermal solar panels will be utilized to harvest sufficient energy for domestic consumption and probable distribution of excess to local networks.

Windows

Windows are made of cellular PVC material with optimal solar heat coefficient to ensure that large amounts of heat is absorbed during winter and blocked during summer. A double glazing is used to lock in heat energy and minimize losses.

Controlled ventilation

The rule of the thumb is to build tight and ventilate correctly. Heat Recovery Ventilators are used to salvage almost 80% of the energy from the stale exhaust air and inject it back to the fresh air entering from the heat exchanger device. A Zehnder Confoair 200 device is chosen with a heat recovery rate of over 90%. There is also a Thermolec 2000 Watt resistance heater that automatically converts heat output and keeps the indoor temperature at 20-23 degrees Celsius.

Cost estimation

The anticipated surface area of the house is 1900 square feet. It cost a total of £90 to construct one square feet. A provision is made for a 155 increase in costs, as a result, of regulations to achieve a passive house energy efficiency. Thus, the total cost of the house would be £171, 000.

The house costs £1248. 82 less to maintain in a year that the house of the same kind built on the same side except the code. The passive house specific heat demand in 7kWh per metre square while the primary energy demand is equal to 100kWh per metre square. Heat loss is determined to be 7W/m2 while air tightness is approximated at 0. 2ACH at an operational pressure of 50Pa.

It translates to a saving of £109. 1 savings on energy, a value more than the £88. 66 stated mortgage value for the property.

Other features of the house include:

Floor surface area = 161 metres square

A two panel flat-plate collector system is used to collect water

Photovoltaic solar panels and solar water heaters

The roof is chosen as the appropriate place to install photovoltaic water heater solar panels. These panels will be installed on a greater surface of the roof facing south direction for maximum sunlight. A solar panel is approximately 1. 6m long and 0. 8m wide. In this case, 1. 5Kw solar system is preferred covering an average area of 12m square.

Photovoltaic solar panels will be mounted on the roof with specialized non-penetrating strapping to eliminate instances of roof leaking. They will generate electricity during the daytime which is stored and used for lighting purposes during night time.

On the other hand, solar water heater is used for heating water. The panels have a dark surface that fetches heat directly from the sun and transfer it to the water or circulating fluid inside the insulated tank. During cloudy days, heat conversion is minimal hence the system is less effective in heating water. An alternative electric booster is installed to keep water hot.

For a period of 1 year energy used for heating is equal to 702kWh. The total energy consumption for the house is equivalent to 4, 020 kWh, a value much less than the total energy consumption the total energy used for a code-built house with the same design and structure standing at 28, 427 kWh. The monthly savings derived from the house is much more than for a code-built house with the same design and size and situated in the same location.

For the 1. 5kW photovoltaic solar system, the supply slightly surpasses demand for a very period usually between 11am to 3pm. In total, the system produces 7. 3 kWh of energy against a consumption of 11kWh per day. Hence in this situation, virtually zero energy is exported to the grid from the photovoltaic system except between 11am and 3pm. However, a significant amount is still saved that would have been used to pay for power from the grid. During the winter, generation is much less than expected due to low sun intensity. The production would fall to 5kWh against a consumption of 11kWh, and in this case, no power is exported to the grid.

According to the UK guidelines, generations less than 3. 68Kw can be connected to the distribution network after completing and approval of an Installation Commissioning Confirmation Form. Thus, the first step towards getting connected to the local network involves inquiry and approval from regulatory authorities such as Northern Power Grid. Independent Connection Providers will carry out contestable work, but non-contestable activities will carry out by distribution network providers such as NP. Other technical details such as indicative maps of connection will also be provided prior to connection. It is because electrical networks exhibit a limited ability to accept voltage change, fault level headroom or thermal capacities. For small-scale connections such as this, the provider charges according to the amount of work conducted to accomplish the process. An estimate is usually available after 10 to 20 working days.

Micro wind turbine system

40% of all wind flows in Europe is over the UK, qualifying it as an ideal candidate for wind power generation. A small wind turbine system known as micro wind turbine is installed on the roof of the building to supplement solar energy. The building mounted turbines are strategically located at the top of the roof where wind breaks are minimal. In this case, a 2kw system is installed. On an average, a microwind turbine will generate 10-40% of the rated capacity. Hence, power generation on a day ranges between 4.

8kWh/day to 19. 2kWh/day. These energy amounts are sufficient to replace the demand that solar power cannot provide especially during winter. The cost of installing a 2kW turbine on average is equivalent to £10, 000 plus applicable taxes. The cost of maintenance ranges between £100 and £200 per annum with the need to replace the inverter after some years.

Before being connected to the grid, a Microgeneration Certification Scheme accredited installer must be used to be eligible for Feed-in-Tariff program.

Conclusion

This paper has discussed the design of energy efficient house purely dependent on renewable energy sources. Energy efficiency is achieved by first minimizing the loss of energy to external environment and second, using renewable energy sources. Solar panels for both water heating and electricity and micro wind turbines produce enough energy for domestic utilization as well as extra energy exported to the local grid.

References

Castleton, H. F. (2010). Green roofs; building energy savings and the potential for retrofit. Energy and Buildings 42, no. 10 , 1582-1591.

Spiegel, R. a. (2007). Green building materials: a guide to product selection and specification. . John Wiley & Sons.

Stavins, R. (2013, August 06). " Thinking About the Energy Efficiency Gap". The Energy Collective .