A case study of energy-saving and water-conservation technology in the “N.T.U. Smart-Home”

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Abstract

When the energy and water are scarce, countries all over the world look and develop for alternative source of that, for meeting with the future demands. So, the concept of architecture: ecology, energy saving, waste reduction and health become an inevitable trend of development in Green Building evaluation system in Taiwan. This paper introduces the energy-saving and water-conserving technology in the National Taiwan University-”Smart-Home “. The energy-saving technologies include: stratified insulation PVC wall, Low-e glass, PVC window frames and a passive solar housing to reduce the energy consumption of buildings. The water-conservation technologies include: landscape Pool, ecological reservoirs and underground storage tanks technology to reduce water wastage, but also to create a friendly environment and eco-garden environment. Some suggestions about architecture design and water management for Taiwan are put forward.

Keywords

Energy Saving, Water Conservation, Smart Home, Green Building, Technology

1. Introduction

Since the oil crisis occurred in 1973, building energy-saving design become the western countries to attention. Another important issue is the lack of water resources of modern. Therefore, these two questions are primary consideration to create a sustainable
environment. Although a residential building space is only save a less of energy and water. However, if these green concepts apply in the city or rural areas which will to reduce the urban heat island effect, mitigation of flood overflow and reduces the destruction ecological environment. Therefore, this article notes examples of the construction area with a single residential house built on water-saving and energy-saving practices on the practical application. This research case: "Smart-Home" (Figure 1) at the National Taiwan University. The purpose is to let more people understand the construction of energy-saving technologies and water base for the application of technology. The basic concept is looking forward to work together to create a carbon reduction and energy-saving environment-friendly green living environment.

Fig. 1 National Taiwan University's “Smart-Home”

2. Energy-saving technologies of Smart-Home

2.1 Passive solar sunroom
The passive solar design in "Smart-Home" is to use of convection of heat to reduce heat air, and reduce energy consumption. Proper use of the sunroom in winter can save a lot of energy consumption. Taiwan is not a very cold winter, but in winter the sun formed housing thermal hysteresis phenomenon of natural convection by a warm air of the
adjacent main house, in order to bring users the feeling of warmth, and to achieve the purpose of dehumidification.

Passive sunroom (Figure 2) is located in the north of Smart-Home. It is high of about 8 meters, wide of about 6 meters and close to the ground layer set a air intake. In the sunroom indoor on the roof top has designed exhaust for heat air naturally rise since circulatory system into ventilation.

Fig. 2 Smart-Home attached passive sunroom design and flow diagram.

2.2 PVC-Wall
The wall, window and roof are a building design mainly consider of heat insulation. Building shell is main transmission medium of temperature that like human's skin have permeability and respiratory. Therefore, a thermal insulation of the building's exterior features by new technology has become an important revolution in housing construction. Smart-Home used by the external wall is PVC-Wall (Figure 3). The thickness is 60mm and U value is 0.72(w/m²•k). The building energy consumption is 3383.69Kwh of a year which is only consider the first floor of Smart-Home by use ENERGYPLUS to simulation. If only comparative 70mm PVC-wall and 120mm concrete wall, the total heating and cooling Load of one year is 15065540 (wh) and 20787824 (wh) (Figure 4).
2.3 Energy conservation of windows system

The window frame uses the lower thermal conductivity by the PVC material. The glass is a double Low-E glass. At the same time, installed the auto rolling shutter at outside on the window to prevent the heat and provide the home of security. Smart-Home use these technologies to build an energy conservation of window group (Figure 5).

The first layer (outdoor): Total thickness is 3.2mm PVC+63.6mm air layer+3.2mm PVC. Total width is 600mm (concave mortise 30mm).

The second layer (middle): Total thickness is 60mm air+50mm 10mm Calcium Silicate Boards. The structure is use light gauge steel and filled with insulation material-glass fiber.

The third layer (indoor): The material has a wide range of choices like wood and wallboard. In this case are used sound-absorbing materials that thickness about 25mm.

Fig. 3 This wall like a sandwich that have PVC-wall, air layer and sound-absorbing wall.

Fig. 4 70mm PVC-wall and 120mm concrete wall energy consumption diagram.
2.4 Other energy-saving equipment

Green energy-saving technologies in addition to the house from the planning, design and material selection also can with energy-saving equipment to reach Green Building. In the Smart-Home, Auxiliary equipment have machinery and equipment, have:

- Solar photovoltaic and wind power generation system
- Solar fiber-optic lights
- Inverter air conditioner heating and cooling systems
- Heat exchanger heat pump hot water system
- LED lighting
- Solar power heat water equipment
3. soil-water conservation of Smart-Home

The average annual rainfall of Taiwan is about 2510 mm, but due to steep topography and short rivers, rainfall is not easy to accumulate resources. Taiwan's use of rainwater by storing only the total annual runoff of about 18%, others 82% go to the sea. Smart-Home area is limited which using the terrain, materials, planning and design integration to creating a water conservation, ecology and environment-friendly green space in the yard also called the rain-garden. According to water-retention strategy and storage technology is divided into three types. It includes: the front yard (creating water features), backyard (rain water conservation) and side yard (ecological and infiltration).

3.1 Natural infiltration materials

Nature infiltration of environment is the use of soil, vegetation and other elements so that the most direct infiltration of rain water way. Smart-Home's yard has much area for natural infiltration of surface water, such as: grass (Figure 11), soil-mound (Figure 12), and woods (Figure 13) ... etc. In addition, it’s also used artificial materials such as bricks, blocks water, wood and stone. Let rainwater can through the pores of the material or seam between to achieve the efficacy of infiltration.

![Fig. 11 Grass in backyard](image1)
![Fig. 12 Soil-mound in backyard](image2)
![Fig. 13 Woods in front yard](image3)

3.2 Infiltration trench

Smart-Home applies the natural and artificial materials to build infiltration ditch that include soil or gravel. those are mainly to distributed in the courtyard and to depend the terrain of difference, so that rainwater could natural infiltration and flowing to the pond. Another infiltration ditch material is gravels. It have high porosity could be rapid infiltration of rainwater because that have friction coefficient and contact area. So, the rainwater will be slowly flow velocity and extend the set time. This technology will to reduce the soil erosion and promote the rainwater to infiltration of function. In the Smart-Home, there are three kinds of ditch in the yard. Figure 14 is a soil ditch with flowers near the sunroom in the front yard. Figure 15 is a garden ditch along the
building side. Figure 16 is a gravel ditch as a surface of the water channel.

![Fig. 14 Soil ditch with flowers](image1)
![Fig. 15 Garden ditch](image2)
![Fig. 16 Gravel ditch](image3)

**3.3 Terrace garden**
Taiwan rainfall is urgent, strong, crazy and other characteristics. When has a heavy rain, the inevitable cannot be immediately infiltration. So, in this case design a terrace gardens (Figure 17) to drainage for the delay time as use of to slow down and reduce the courtyard the burden of the land water (Figure 18).

![Fig. 17 Terrace garden](image4)
![Fig. 18 Terrace Garden appearance](image5)

**3.4 Water ponds**
There are three ponds of rainwater storage: eco-pond, landscape pool and rainwater collection wells in Smart-Home.
- Eco-pond: It’s through the terrain of design lead rain water flowing to pond and infiltration. It cans extension of time in order to enhance infiltration of water security (Figure 19).
- Landscape pool: This pond set in the front yard. It is a landscape pond that has fish and aquatic plants. In the pond use the cycle equipment to maintain water flow and quality, not only to create a green view also has water conservation function (Figure 20).
- Rainwater harvesting wells: It is mainly to collection rainwater in the backyard. This well use the situ conservation of water resources of the storage concept, making the backyard more functional land use diversification (Figure 21).
4. Conclusion

Domestic green building development has matured and wants to promote to the community and the urban areas. Thus the domestic construction industry should not follow the traditional layout of imitation, ideas and patterns. They should think how to use the local existing building materials, green building concepts and eco-technology to create the future "Green Environment" for the sake of future generations to create a sustainable living environment-friendly.

Energy, health, nature and waste reduction is a common pursuit of the green building objectives. The economy, environmental protection and sustainable eco-city must be more in the future planning and design of integrated into consideration. To build “Green” reduces the urban-rural gap and low-carbon energy with to create a sustainable global village.

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