483: San Pedro National Park Visitor's Center Zero Energy Plan

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Abstract

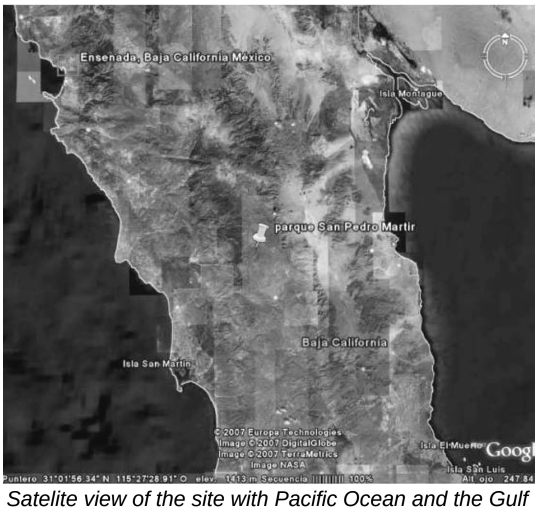
The Mexican federal authorities have decided to rehabilitate a 400 m2 existing structure adding 320 m2 to function as a new facility for visitors and park officials. The goal is to develop it as a Zero Energy Building with an autonomous photovoltaic system, water saving and treatment devises and full passive design. This will provide a double function as a "hands on" demonstration project for self sustainable buildings and the park's educational facility

San Pedro National Park is one of the very few untouched natural sites in Mexico, due to its remote location and difficult access. It is an excellent opportunity for an autonomous building because the site is in the middle of the park with an extension on 70,000 hectares. There is not any town or village in a 70 Km ratio and the permanent population is composed only by the personal of the Mexico's National Observatory and the park's guards.

Keywords: autonomous building, air heating roof system, photovoltaic

1. Introduction

The site is located at an altitude of 2400 meters above the sea level in the Sierra of San Pedro in a northern area of Baja California's Peninsula. It is one of the highest points in the San Pedro mountain system. In a straight line it is less than 70 km away from the Pacific Ocean to the west and the Gulf of Cortes to the East.



Satelite view of the site with Pacific Ocean and the Gulf of Cortes
Source: Google Earth, 2007

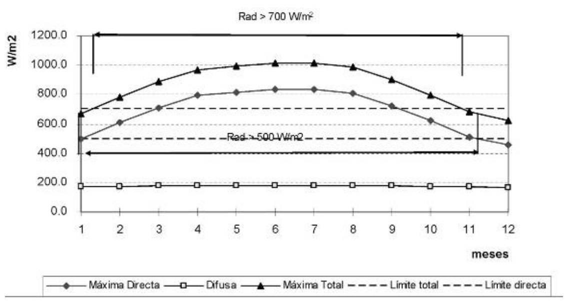
Most of the park is a very well preserved but not very dense pine forest. The park houses several research and wildlife preservation programs including the successful North-American condor reproduction program and the National Astronomic Observatory. Due to this reason, it is particularly sensitive to construction and services.

It is required to develop a minimum impact and zero energy building that will not need service lines or external support in terms of fuels, maintenance and operation.

2. Climatic Conditions

2.1 Solar Radiation

Due to its altitude and location, San Pedro has very particular climatic conditions. It is one of the very few sites on Mexico with high snow fall (max 1000 mm) on winter. However, rainfall is limited to only 250 mm per year due to its closeness with the Baja California and Sonora deserts and the cold Pacific Stream. These conditions produce a clear sky all year around with intense and constant solar radiation. As a matter of fact, San Pedro is one of the sites with the highest maximum direct radiation in Mexico.

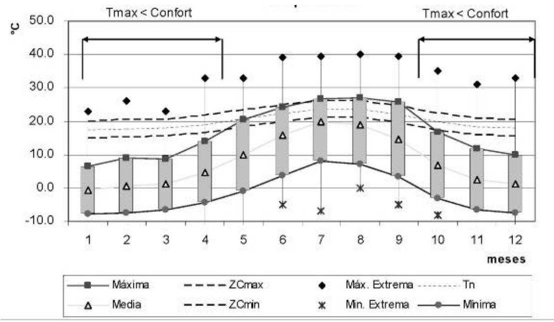


Monthly total, direct and diffuse solar radiation from 1980 to 2000
Source: SMN, Mexico

2.2 Outdoor Temperature

Maximum outdoor temperature is under comfort for seven months (October to April) making it necessary to provide all buildings with energy conservation measures and passive solar heating devises.

Summer months are generally comfortable; however, they can present sudden and extreme variations. For example, extreme maximum outdoor temperature in July has been 40°C and extreme minimum for the same month is -7°C. Therefore insulation and thermal mass can provide significant energy savings and a comfortable indoor temperature.



Monthly mean, maximum, minimum and extreme temperatures from 1980 to 2000
Source: SMN, Mexico

for air heat collectors, adding extra green houses to improve direct heating.

Air Heat Collectors are proposed with a 300 m2 metallic roofing situated 10 cm above the wooden insulated roof. 15 cm Polyurethane panels will be used, because of their light weight, easy installation on an existing roof. In sunny days, fresh outdoor air will circulate between these planes, moved by slow speed fans, turn around the chimney shafts and ducts and enter the main hall. Another convection circuit will distribute warm air within the space with the use of an inverse ceiling fan.

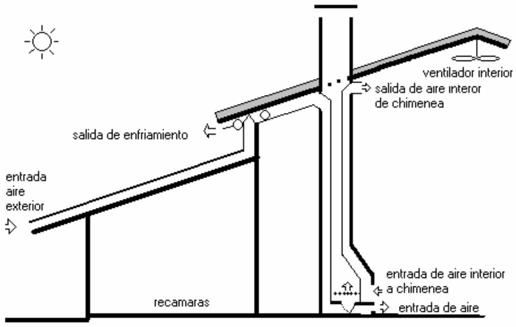


Fig 2. Scheme for the Air Heat Roof Collector and distribution system

3. General Design Strategies

3.1 Existing Building

The existing building will undergo a major renovation. It is a single non-insinuated brick wall construction with a non-insinuated wooden roof. General condition is poor due to lack of use and maintenance. All water installations have failed because pipes and systems have been exposed to freezing temperatures for long periods of time. There is no electricity on the premises. Water is supplied with a truck that makes a 10 km trip from the nearest well.

Fig 1. Southern view of the site
(under construction in February 2008)

We will build a 80 m2 of south facing green house. The south windows are 120 m2 plus 20 m2 facing southeast and 20 m2 facing southwest. Southern greenhouse will contain water tanks for thermal mass and work as a wind barrier between indoors and outdoors year around. All greenhouse construction will be made of double pane Low E glass panes. A stainless steel structure will be prefabricated and ensemble on site.

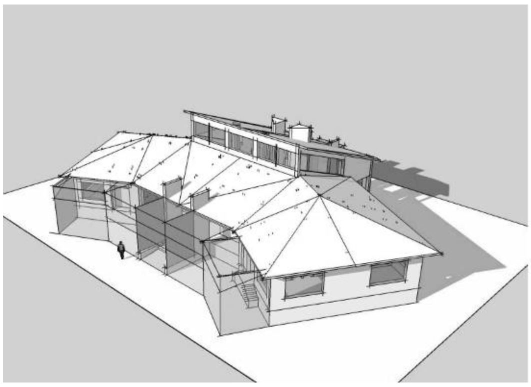


Fig 3. View of the project from the south east with added south green house

3.2 Passive Solar Heating

Due to the site conditions passive and active solar heating is the main strategy. Estimated winter average heating requirements are 600W/hm2, therefore the average winter hourly heating load is 420 KWh. Total solar radiation in most winter months is above 700W/m2, thus we have decided to use all southern roofing (300 m2)

Finally a radiant floor system will be installed. Taking advantage of a large basement, this space will be insulated with polyurethane panels and a combined water and air heating system will warm the indoor space. In the daytime, indoor air will be directly re-circulated within the roof heat collector and the basement radiant floor with a low speed fan system. At night, heat will be radiated from thermal mass located on the basement in large warm water tanks.

3.3 Insulation and thermal mass

14 cm fired brick walls require extra insulation. An insulated space will be added in the inside face of all walls. An natural fiber panel will be installed to provide a new finishing surface in all walls. This construction system will allow us to house all electric and water piping in a well insulated indoor environment to control freezing problems.

Due to the large daily temperature swings (18°C average), we need to add thermal mass the building. Most of it will be located on the basement on twenty large 2500 l. water containers. We have decided on this solution because it does not impact the existing structure neither in weight or in cost, and the large thermal capacitance of water will be combined with the low speed air circulation system to stabilize the indoor temperature.

As a necessary complement to direct heat gain and mass measures, an R15 ceiling, walls and basement insulation will be installed. In order to achieve it, a 15 cm high density polyurethane will be applied in all indoor surfaces. It will be covered by a standard board to protect it and provide a finishing surface.

All windows will be substituted by Low E double pane glassing. Special attention will be placed on the sealing of window frames and walls as well as glassing.

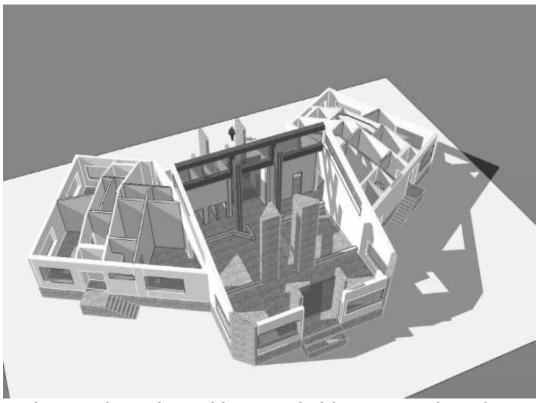


Fig 4. Indoor view with central chimneys and outdoor insulated walls

3.4 Controlled air infiltration

Air tightness is a major concern, to keep the heat gained inside. This is particularly critical on cold winter nights when the outdoor temperature drops every night to -8°C and can reach extremes of -22°C. Window frame and glassing sealing need to be installed with freezing resistant silicon. A multilayer roofing system will warranty air tightness. In all cases, access areas will be provided with double doors. There are two public access doors, the main one faces south to reduce wind impact and will open to the new south facing greenhouse. On the other two service areas, a tight closing glassing system will be installed.

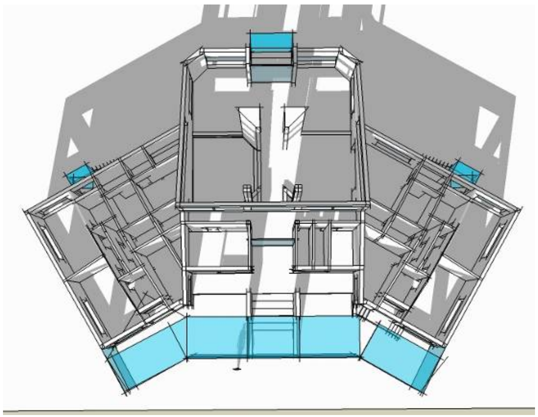


Fig 5. Project´s Plan. Notice the added double entrances to the south green house and northwest, north and northeast entrances.

3.5 Water recovery, treatment and storage

Water is limited on this site. A new well will be perforated to warranty fresh water supply year around. Pumping electricity will be supplied by a photovoltaic array.

A new piping system is under development, it will include 4" polyurethane insulated pipes and a water treatment plant. An insulated construction will protect the treatment system from freezing and will be provided with a passive heating system to maintain a 20°C minimum working temperature.

Water Storage will be located on the same separated building. Additional water storage (50,000 l) will be located at the basement. However this will not be usable water, but a fire and emergency reserve, that will work also as thermal mass for the indoor air heating system. The efficient use of water will be provided with dry sanitary services and water saving devises in all bathrooms, sanitary spaces and kitchen.

Fig 6. 800 Watt photovoltaic test system with battery and control building (February 2008)

3.5. Photovoltaics.

A 6 MW photovoltaic system will be installed to provide enough electricity to the center. Battery systems will storage the energy. The photovoltaic panels, storage and control systems will be located on a separate building to improve sun exposure and reduce risk. In a first stage, an 800 watt photovoltaic system has been installed on top of a prefabricated structure that houses the control devises and battery system. This small installation has a programmable electronic timing control for all lights and energy outlets. It let the user choose a 3 minute use or a 15 minute use cycle. It also feeds emergency and security led and compact fluorescent lights activated by motion sensors. So far it has proven that even a very small system is effective if it has a tight consumption control. Therefore the center will have a similar electric demand and load management system

4. Conclusion

San Pedro National Park Visitor's Center Zero Energy Plan is now under development and construction. It has given the design group a unique opportunity to work with extremely cold conditions in a country that is dominantly warm. At the same time, its emplacement combines many desired conditions for zero energy buildings such as large solar radiation with distant (and therefore expensive) services and infrastructure.
Upon its completion, it will be one of the first truly autonomous buildings in this country and will provide a close example and testing ground for other zero energy buildings in Mexico.

5. Acknowledgements

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