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PROTOTYPE FOR THE HOUSE ENERGY TRANSITION

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Abstract

The term “ecological house” refers more to a concept than to a specific type of dwelling. The concept is to combine various modes of heating, ventilation, and power supplies to greatly reduce the consumption of energy, and therefore also exponentially reduce the CO_2 emissions, of a building. The aim of this paper is to optimize integrated solutions to the building energy system. Two methods are proposed to allow the heating and natural cooling for areas in moderate climate. A Ground Source Heat Pump system (GSHP), which draws heat from the ground via sensors which are buried (in the soil), and the **C**ontrolled Mechanical Ventilation system double flow **(**CMV**),** in which fresh air introduced into the house is heated by recovering heat from exhaust air. The economy of energy with CMV, compared to GSHP is 70%.

The results of the study will enable us to determine the most appropriate and feasible system for heating and cooling a passive house in Tlemcen (Algeria). A study of the energy and environmental balance , combined with a report concerning quality, price, and investment will validate the final choice.

Key words: Heat pump, temperature, mechanical, ventilation, energy

1. INTRODUCTION

Classical buildings and houses are the 3rd largest transmitter of GHG (Greenhouse Gasses) [1]. The energy requirements of these kinds of houses is very high s, using more than 46% of national energy consumption [1] (compared with other sectors). Other effects on the environment including the emission of waste, noise pollution, disturbance of microclimate, water consumption, and pollution of ground water are of importance. Our country faces a foreseeable shortage of fossil fuels and the consequences of their reckless use. Then it is time to modify building practices to embrace cleaner and more sustainable practices and to enter processes for energy transition.

We can look to the natural environment for taking models base to change and reach the ecological building practices. In this paper, we refer to the ecologically-friendly building as the "ecological habitat."

The ecological habitat has 4 objectives:
(i) ecological, including the utilisation of new energy resources such as solar energy, while respecting the ecosystem by monitoring greenhouse gas (GHG) emissions.
(ii) economic, including using flexible and adaptable materials, thus adding durability.
(iii) social, including consideration of the occupant's health and acoustic, thermal and visual comfort.
(iiii) cultural, which include maintaining the image of the site and preserving the history of the inheritance

2. CONCEPT PRESENTATION

Fig. 1: Ecological House

The ecological habitat (Fig. 1) enjoys an extremely pleasant interior climate in summer as in winter, has good thermal isolation as well as air tightness, consumes 90% or less of the average consumed energy in a similar house constructed using traditional methods, and makes an optimal use of all the available sources of heat.

3. OBJECTIVES OF THIS WORK

The objective of our work is to realize a prototype of an ecological house which uses renewable energies for heating and cooling and participates in the world energy transition in terms of energy type and use, and of energy quality.

We will start by explaining the architecture of the ecological house. Next we will describe materials used in the design and insulation, and in this context, the energy needs will be discussed. In the last section, we present two systems for heating/cooling, we study their advantages and disadvantages, and determine the most appropriate system for use in an ecological house

3.1 Architecture Of The House

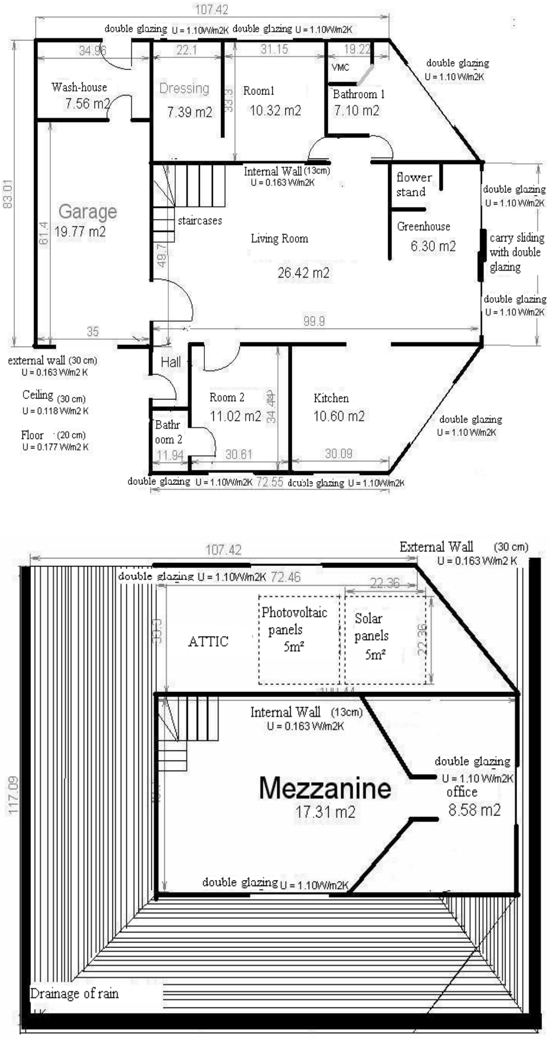

Fig 2 and 3: Architecture of the house

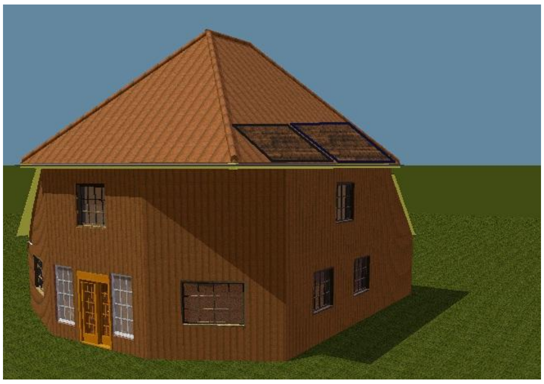

Fig. 4: Picture illustration of the ecological house (South South-East view of the house)

The house is located in Tlemcen (Western Algeria), on a surface of 150 m ² conceived in a ground floor and one stage. The ground floor comprises a hall, a garage, a stay, two bathrooms, two rooms, a kitchen, a wash-house and a dressing room. It has an office and attic as well as a mezzanine. The architecture and the provision of the house enable it better to collect solar radiation since the living areas face southeast and southwest; this principle of bioclimatic architecture is required for the ecological design. We chose wood for the primary building material , due to its many advantageous characteristics: since wood has a weak thermal inertia, its cost of construction is more economic; its only emissions come from atmospheric CO_2 [4]; and finally, its coefficient of thermal transmission is low compared to other ecologically-sound materials such as the brick monomur, so it is regarded as being a super insulator. Thus in our design, the external walls will be made of a wood framework 30 cm (thickness) and include a layer of 22 cm cellulose wadding (U = 0,163 W/m².K). The flagstone is isolated by 20 cm of cellulose wadding (Heat Transfer Coefficient "U" = 0,118 W/m².K). We will use also a very powerful double glazing (20 mm U = 1.1 W/m².K). The isolated external doors are installed to ensure a good air tightness (U = 0.94 W/m².K).

3.2 Energy needs of the house

For the heating and for the electricity of the ecological house, we use renewable energy sources:

(i) a solar-fired heater with fully southern-exposed sensors.

(ii) the production of electricity is ensured by photovoltaic cells inserted in the roof. (iii) for cooling/heating the house, we have the choice between the Ground Source Heat Pump system (GSHP), or the Controlled Mechanical Ventilation (CMV) double flow system.

The best choice of ventilation is one that is integrated into a general comfort and a reduced coast (of construction, installation and use, compared to a conventional system). Ventilating the home properly and economically requires a compromise between providing fresh air for the occupant's well-being and health, while evacuating excess steam.

The Ground Source Heat Pump (GSHP) system (Fig.5, 6) draws heat from the soil via sensors that are buried in the ground. A typical heat pump requires only 100kWh to 200kWh to transform, each year, environmental 300kWh heat freely available into useful heat. In all cases, this useful heat available will be greater than the electric energy used to operate the pump itself. Heat pumps also have a relatively low emission of CO_2 [5].

The three main elements of a GSHP include a ground loop, a heat pump and a system of heat distribution.

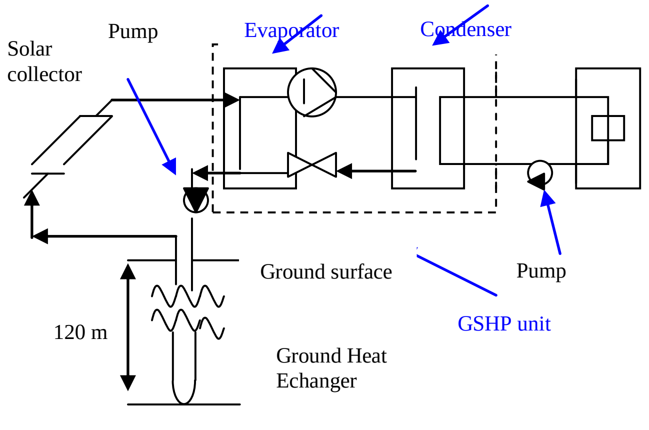

Fig. 5: Schematic of GSHP system coupled with solar collectors (winter cycle)

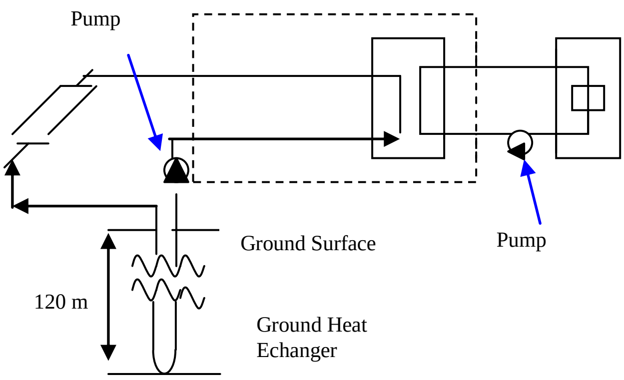

Fig. 6: Schematic of GSHP system coupled with solar collectors (summer cycle)

The Controlled Mechanical Ventilation (CMV) can be a simple or double flow system. It ensures optimal [6] air renewal and comfort in the home when combined with appropriate insulation.

The air renewal rate is controlled and the home is ventilated all year round in all the rooms. Furthermore, the operating cost of the Controlled Mechanical Ventilation is very low.

The presence of an exchanger recovers the heat from extracted air (air is extracted from wet rooms like the bathroom) to warm incoming outside air (incoming from outside the house). This technique helps to optimize air renewal and save energy [6]. With this configuration, combined with effective insulation and airtight walls, optimized ventilation produces comfort, energy savings, and reduced CO_2 emissions.

According to this study, the investment for an ecological house using the CMV system is higher than an ecological house using the GSHP system.

CMV is built into the house as a set of devices to ensure the renewal of air inside the rooms. CMV is a double-flow ventilation system to breathe fresh air into dry rooms (bathrooms) and extract it from wet rooms (kitchens) thus forming a circuit.

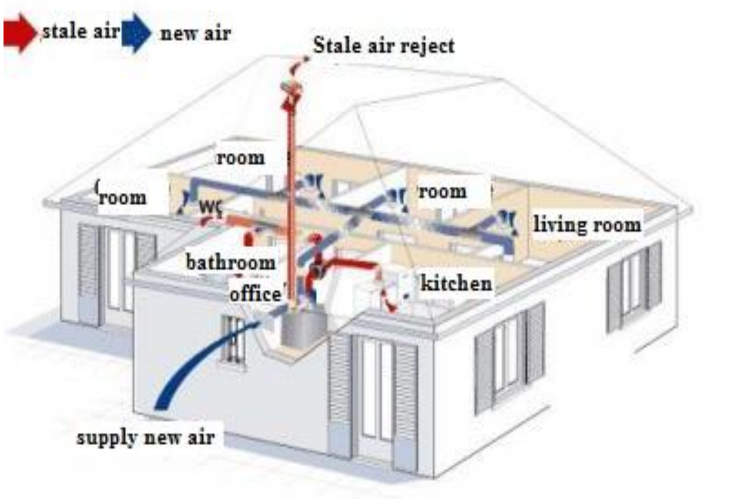

Fig. 7: VMC Double Flux Heat Recovery [7]

3.3 Economic balance sheet and system choice

The CMV method, (where fresh air introduced into the house by recovering heat from exhaust air), has a positive return. The energy savings will be around 70% for CMV compared to a classical ventilation / air conditioning. However, the cost of the system is € 6,000 for double flow CMV against € 600 for a single flow CMV, since the system requires the installation of duct insulation and of a condensor (the box connecting to the network of sewage) as well as ongoing maintenance.

Costs of GSHP system: 10.000 € to 18.000€. Running costs depend on a number of factors including the size of the hot/cold water loads being served, the size of the home and how well insulation of the house is [8].

Using average system efficiencies from the field trial, the above evaluations have been demonstrated when replacing conventional existing heating system in a 3 bed semi-detached home.

4. CONCLUSION

The feasibility study undertaken in this work showed that the best system for air-conditioning and heating, taking into account the quality/price time of return is the Controller Mechanical Ventilation system.

The higher investment in the building can be recovered within a few years (compensation investment through energy savings from reduced consumption) Nevertheless the paramount benefit lies in the exploitation of renewable energies, respect for the environment, and comfort while using exploitable materials, and following the example of other traditional products.

To build ecologically is thus a profitable operation which is more a question of choice than of means, and that returns within the framework of sustainable development

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