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Technical and economic efficiency of passive cooling systems.

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Passive cooling is a set of natural processes and techniques to reduce indoor temperatures, through exploitation of all elements of building materials. Passive cooling techniques are aimed to achieve the thermal comfort conditions in the building.

Introduction

About 40% of the entire world's annual energy consumption is expend on cooling industrial and residential buildings. Recently, alternative energy sources, especially passive cooling, have been increasingly used for these purposes.

The passive cooling of buildings is categorized as follows:

Reducing radiative heat load on the building

Solar radiative heat load contributes most to the overall heat load of a building. The complete or partial, permanent or temporary exclusion of solar radiation from surfaces of the buildings will significantly reduce the heat load on the building. A reduction in radiation load can be achieved through the following techniques:

- Shading systems.
- Glazing.
- Radiant heat barriers.

Stabilization of the heat load in the building

The thermal load control of a building could be achieved by two methods.

In the first method the thermal mass of a building absorbs heat during the day and regulates the magnitude of indoor temperature swings, reduces peak cooling load and transfers a part of the absorbed heat to the ambient in the night hours. For these purposes, use the following methods and systems:

1- Thermal mass in the construction material (Without thermal energy storage).

2- Thermal mass using Phase change materials based systems (With thermal energy storage).

3- Heat sinks.

4- Passive cooling shelter.

In the second method the building is pre-cooled during the night by night ventilation. This is enough to create comfortable conditions in the morning, thus reducing energy consumption for cooling by close to 20%.

Night ventilation techniques are based on the use of the cool ambient air to decrease the indoor air temperature as well as the temperature of the building's structure. The cooling efficiency of night ventilation is based mainly on the relative difference between indoor and outdoor temperatures during the night, the air flow rate, and the thermal capacity of the building.

Heat dissipation from a building

Heat dissipation from the building is achieved:

- Natural ventilation.
- Eco-evaporation cooling.
- Ground cooling.

- Radiative cooling.
- Solar-assisted air conditioning system.

Economic and technical feasibility of use some passive cooling systems in a dwelling.

As an example, the economic and technical indicators of some of the presented methods of passive cooling of buildings are estimated

The feasibility of shading systems the residential sector is high approximately up to 500 € for a 120 m^2 building at the stage of implementation, low maintenance need) but characterized by the relative easiness of application. Radiant heat barriers currently do not have a high cost benefit (a balance between the benefits and the cost). This is based on terms of implementation and maintenance. For instance, green roof prices are ranged in 30–60 €/m^2, coating roofs in 20–30 €/m^2 and inherently cool roofs up to 80 €/m^2, without counting maintenance.

The cost of the shelters, which range from 500 to 20000 € depending on factors various. Regarding Heat sinks costs, in general, ground and bodies of water have the advantage of being relatively affordable to implement, while a masonry or a Phase change materials massive body for cooling a 140 m^2 building can cost up to 3000 €. Building thermal capacity, as high heat capacity materials have a wide costs range at the stage of purchase and implementation (an additional cost for a regular building is ranging from 500 to 3000€ for a 120 m^2 building) the economic feasibility depends on the necessities and purchasing power of each particular, taking into account that the implementation occurs only once (construction stage) with very low maintenance and operating costs at the stage of operation.

Wind catchers and solar chimneys can have a cost up to approximately 1000 € each, while night and controlled ventilation have no extra cost at the stage of implementation. Also, there is a high cost-benefit at the stage of design, function and maintenance. Eco-evaporative cooling is a “low cost” technology compared with active evaporation cooling (one ceramic porous wall to cool 120 m^2 can cost approximately 1800 € at the stage of implementation, with the advantage of having practically no maintenance). Regarding the cost and feasibility of implementation solar-assisted AC, a system suitable for a dwelling of 4–5 occupants has a benchmark price of 6800 €, being approximately 3 times more expensive than a traditional air conditioning system.

The recent concept of energy efficient Green buildings attracted all the researchers to switch over from the present practice of mechanical cooling to passive cooling methods in an efficient modern way. It is found that, for some outdoor conditions, passive methods such as passive cooling shelters, wind towers and solar-assisted air conditioning can decrease the indoor temperature as much as active cooling methods do.

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