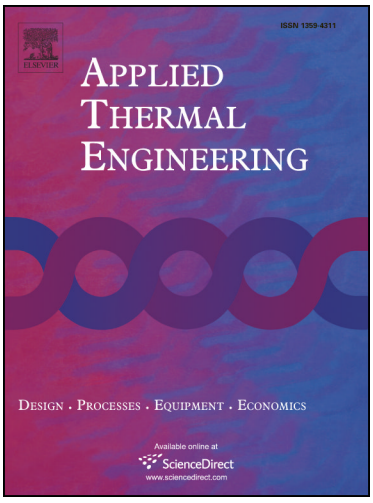

Research Paper

Impact of solar energy on the energy balance of attic rooms in high latitude countries

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Impact of solar energy on the energy balance of attic rooms in high latitude countries

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Abstract
Knowledge of the impact of solar energy on the energy balance of a building is necessary for the energy efficient design of a building regardless of the geographical location of the country. The aim of this paper is to show how important it is to evaluate the energy balance of a building through the whole year to know the real annual energy intensity of its energy consumption. Large windows in attics rooms can cause high cooling demands even in high latitude countries. This is because of the solar energy transmitted through them into the interior of the building. Nowadays, thanks to good thermal insulation and the high thermal capacity of buildings, the heat – also resulting from solar energy conversion within the building - is trapped within it and cannot "get out" naturally. Cooling demand becomes the dominant part of the energy balance not only in low latitude countries but also in high latitudes for some room locations. Numerical simulations of the dynamics of a building and its surroundings have been used to create a number of patterns of the heating/cooling demand and other components of the energy balance of the building. Calculations have been performed for different room locations and construction of envelope elements. Some results of the study for the attic rooms are presented. The results show that cooling demand which was previously very small and neglected in higher latitude countries, now becomes of the highest importance in determining the total energy demand of attic apartments in new buildings. This high cooling demand emphasizes the great importance of windows in the design of energy-efficient buildings. It turns out that attic apartments facing the four principle directions can need nearly two times more cooling energy than heating energy in a high latitude country. The results of simulation studies presented in the paper can be applied to create new regulations on thermal energy use in buildings, especially for the certification of the energy performance of residential buildings. These considerations prove that primary and final energy indices should be based on the annual energy consumption through the whole year (rather than just the heating season).

Highlights:

- The impact of solar radiation on thermal energy balance of a new building in high latitude countries can be high for attic rooms
- Attic apartments facing the four principle directions can need nearly two times more cooling energy than heating energy in a high latitude country
- Results of simulation studies of the dynamics of a building throughout the whole year (rather than just the heating season) should be the basis for the creation of energy efficient designs for modern buildings and building energy efficiency regulations
- Certificates on energy performance of residential buildings should include primary and final energy indices for cooling

Keywords:
Solar energy; energy balance; building energy demand; space heating/cooling; overheating of buildings

Nomenclature

a	thermal difussivity, m^2s^{-1}
A	surface area, m^2
A_i	anisotropy index A_i
c	specific heat, J kg^{-1} K^{-1}
C	thermal capacity, JK^{-1}
f	modulating correction factor for cloudiness
g	gravity constant, $9.81m^2s^{-1}$
G	irradiance, W m^{-2}
h	convection/radiation heat transfer coefficient, W $m^{-2}K^{-1}$
I	irradiation, Jm^{-2}
L	characteristic dimension, m
n	number of a day
Nu	Nusselt number
R	correction, geometric (view) factor to given radiation
Ra	Rayleigh number
T	temperature, K
t	time, s
$\dot{Q}$	energy flux, W
$\dot{q}$	density of energy flux, Wm^{-2}
V	volume, m^3