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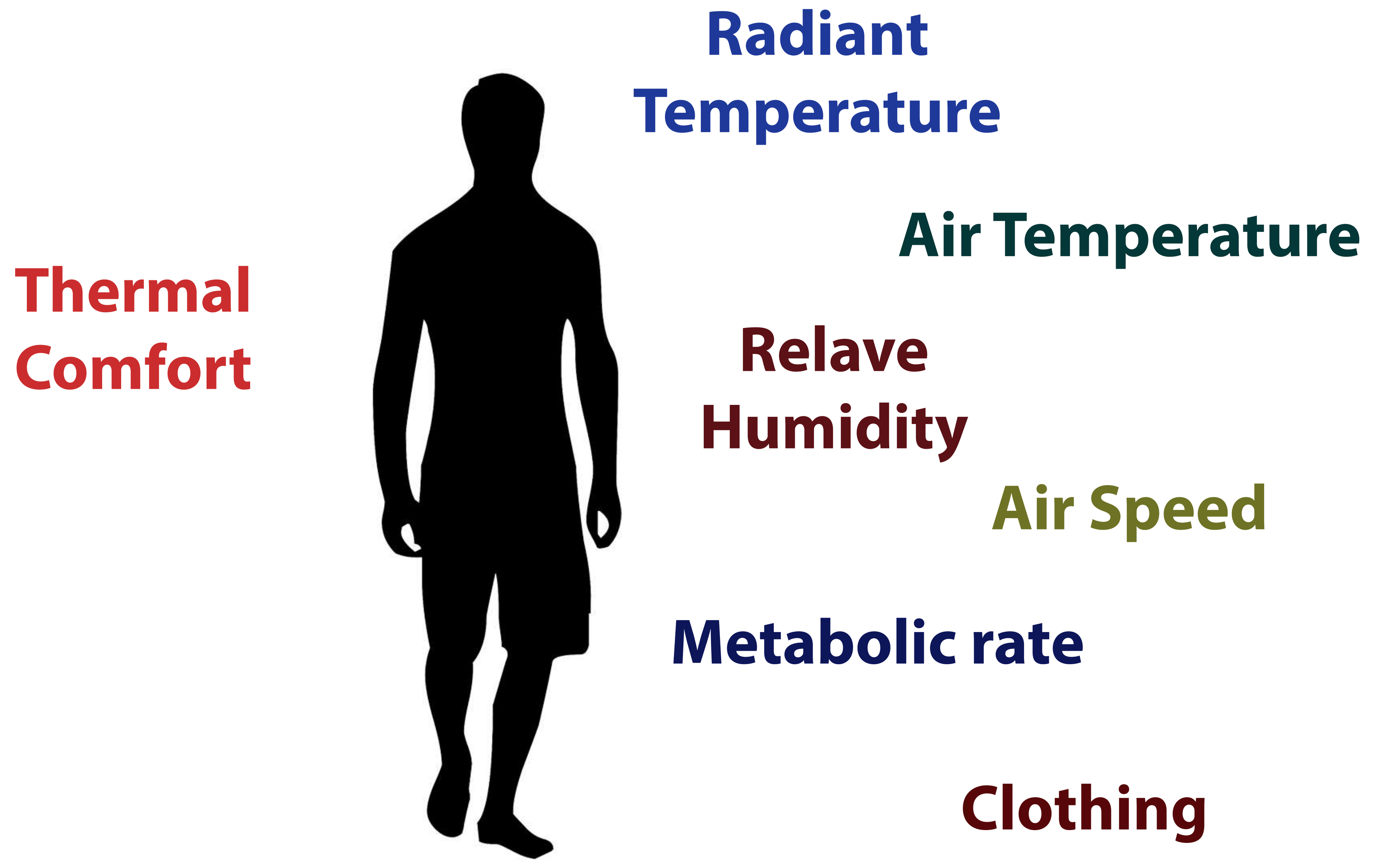
Energy Retrofitting of Existing Buildings to Enhance Thermal Comfort of the Users During Winter- The Case of Palestine

Introduction

Developing countries face several challenges concerning energy provision. This is more perilous in conflict zones like Palestine due to political instability. A tremendous energy demand in the Palestinian Territories in recent years was created by population growth, increasing living standards and rapid industrial growth [1]. The energy shortage is coupled with the unsustainable consumption of energy attributable to the poor quality of housing in terms of thermal performance [2]. In many cases, users cannot reach thermal comfort level in winter which affects their health and well-being [3, 4]. Therefore, there is a crucial requirement to enhance the thermal performance and optimize the energy consumption considering the occupants behaviour [5, 6]. This paper investigates the energy savings for heating and cooling of residential buildings with specific reference to Palestine. A case study apartment in a residential building in Hebron is used to verify the developed approach of energy optimization.

Goal and scope

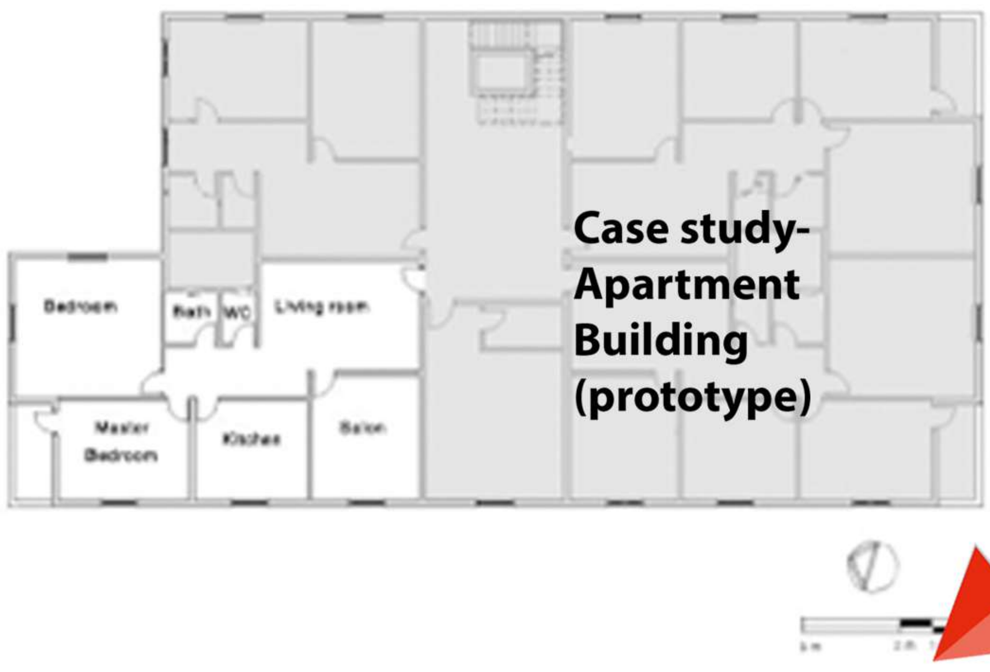
The main goal of this paper is to estimate the energy savings through retrofitting of the building envelop using a calibrated model of an apartment in the city of Hebron, West Bank, Palestine during the heating season.



Research Method

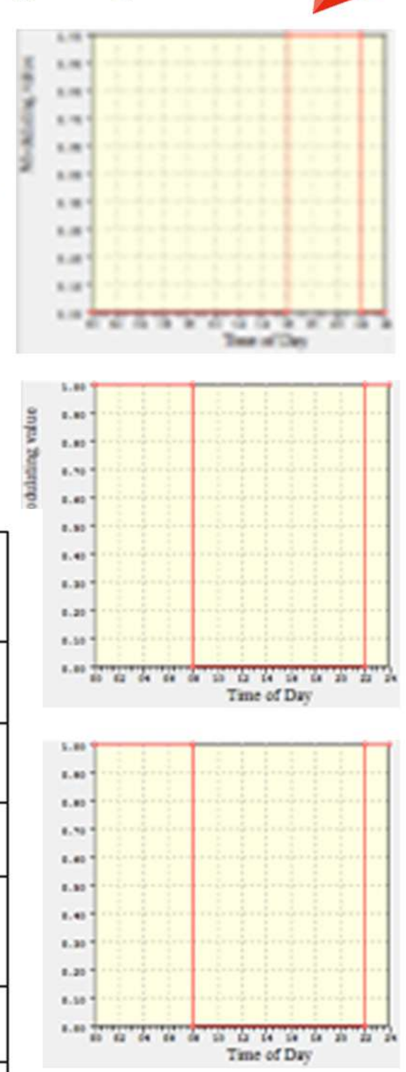
A case study apartment in a residential building was selected as a prototype model for the residential apartment in Hebron. The building is located to the north of Hebron. It is consisted of six floors with three apartments in each. The case study apartment is in the fourth floor and is open from three facades to the north, east and west. The apartment was occupied by early thirties working married couple.

A model was developed using Revit, the building mterials and the occupancy profiles were assigned depending on interviews and site visits. The model was first calibrated based on ASHRAE standards using internal environment measurements that were recorded over two monitoring phases the first was between 12th Oct -1st Nov 2017 and the second was between 28th Jan -10th Feb 2018. Data loggers was used collect the environmental parameters. Optimisation was performed using IESVE software.



Case study- Apartment Building (prototype)

Interviews with the household



Occupancy profiles of the different rooms

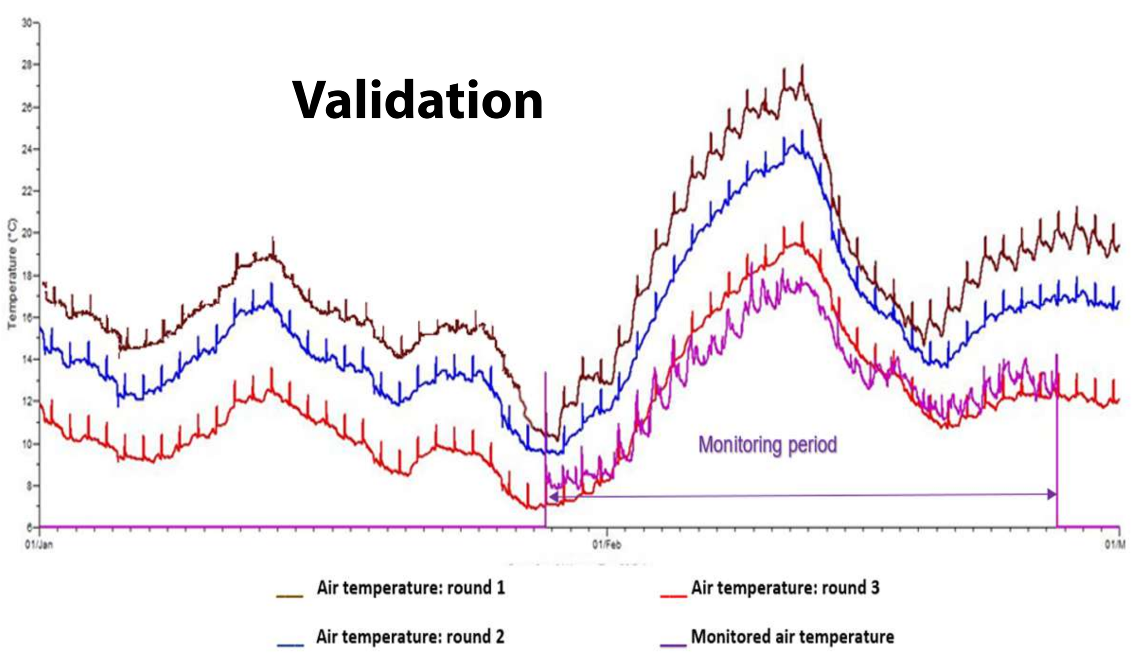
Building's Materials and Components and building the model

Building component	Materials used	U value (W/m^2k)	Thermal mass ($kg/(m^2.K)$)
External walls	Stone 7, concrete 15, concrete hollow blocks 7, plaster 1.5	2	143.8
Ground	Reinforced concrete20, concrete baking8, sand 5, mortar 2, concrete tile 2	1.5	175.7
Roof	Waterproof membrane 0.3, concrete baking 8, bricks and ribs 17, plaster 1.5	1.7	108.4
Ceiling	Concrete tiles 2.5, mortar2.0, sand 2.0, concrete baking 8, bricks and ribs 12, cement plaster 1.5	2.4	146.7
Internal walls	Plaster1.5, concrete hollow blocks 7, plaster1.5	2.7	74.6
External doors	Iron 0.5, cavity 1.5 , iron 0.5	5.7	---
Glazing (g) value 0.5, transmittance (T) 0.7	Single glazing	5.7	---

Monitoring

T in, T ex, RH in (2 periods)

Validation



Optimisation and Results

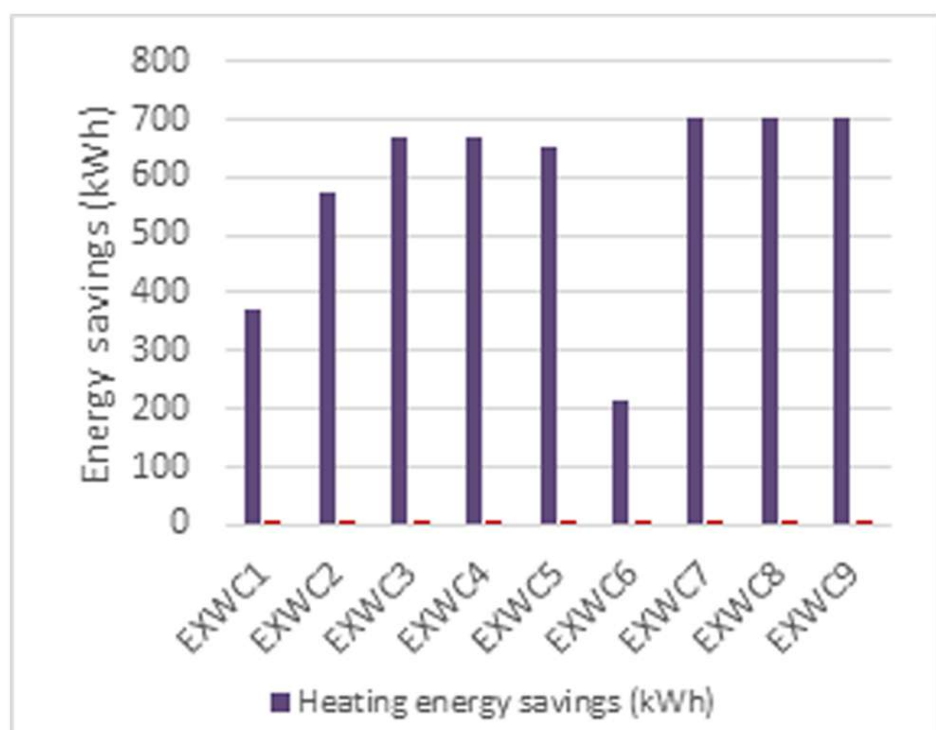
The optimization shows that using external insulation of 8 cm the extruded polystyrene covered with natural stone cladding can save up to 12.5% of the heating energy. Using extruded polystrnen that is covered by plaster in the ceiling can save up to 0.8% of the heating energy . When applying CC3, heating saving increased slightly to 0.8%. Insulating the internal walls can save up to can save 7.3% of heating energy while the total energy saved using insulated external doors was 2.2.%. Using tripple glazing can save 1.6% of the heating. Decreasing the infiltration rate was crucial in decresing the energy consumption. This shows that these measures can save a huge amount of energy if were applied on the existing stock (through retrofitting) and while constructing new buildings.

External walls configurations that were assessed

No.	Configuration (outside to inside) (cm)	U value (W/m^2K)	Thermal mass (kj/m2.k)
EXW C1	Stone (7), extruded polystyrene (1.4), concrete (15), concrete hollow blocks (7), plaster (1.5)	1.2, (Decreased by 50%)	149.0 (Medium weight)
EXW C2	Stone (7), extruded polystyrene (4), concrete (1.5), concrete hollow blocks (7), plaster (1.5)	0.61, (Decreases by 75%)	149.0 (Medium weight)
EXW C3	Stone (7), extruded polystyrene (8), concrete (1.5), concrete hollow blocks (7), plaster (1.5)	0.35	149.0 (Medium weight)
EXW C4	Stone (7), concrete (15), extruded polystyrene (8), concrete hollow blocks (7), plaster (1.5)	0.35	117.5 (light weight)
EXW C5	Stone (7), concrete (15), concrete hollow blocks (7), extruded polystyrene (), plaster (1.5)	0.35	19.5 (very light weight)
EXW C6	Stone (7), concrete (15), air gap (15), concrete hollow blocks (7), plaster (1.5)	1.6	117.5 (light weight)
EXW C7	Stone (7), extruded polystyrene (8), Aluminium foil 0.05 emissivity (0.2), concrete (15), concrete hollow blocks (7), plaster (1.5)	0.35	149.0 (Medium weight)
EXW C8	Stone (7), Aluminium foil 0.05 emissivity (0.2), extruded polystyrene (5.5), Aluminium foil 0.05 emissivity (0.2), concrete (15), concrete hollow blocks (8), plaster (1.5)	0.35	149.0 (Medium weight)
EXW C9	Stone (7), Aluminium foil 0.05 emissivity (0.2), extruded polystyrene (8 mm), concrete (15), concrete hollow blocks (7), plaster (1.5)	0.35	149.0 (Medium weight)

The results of external wall optimisation

The simulation results show that the impact on heating is substantial in all cases. The highest impact on heating loads was in EXWC7, EXWC8 and EXWC9 equally with a heating saving of 12.5%



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