# Condition Assessment of Building Thermal Leakage Using Infrared Thermal Imaging: A Case Study of a University in the UAE

MAHMOUD ISSA, LEENA TATAN, SHAIKHA ALZAABI,

MD Maruf, TANIA JOSEPH

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# INTRODUCTION

Buildings consume ~30% of global energy, primarily for indoor heating and cooling, heat escapes through thermal bridges, air leaks, and poor insulation [1].

**Common issues include [2]:**

- Air leaks or unsealed windows (up to 1/3 of heat loss).
- Gaps around doors, windows and uninsulated roofs/walls.

**Consequences:**

- Increased energy demand and cost.
- Occupant discomfort (drafts, uneven temperatures).

**Problem** : Most insulation flaws are not visible using conventional inspection methods.
**Solution** : Use infrared thermography: a non-contact, non-destructive tool for visualizing surface temperature and detecting energy leaks [3].

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# Literature Review

IR thermography measures emitted thermal radiation to map surface temperatures [3].

Thermograms highlight heat loss zones through false-color imaging [4].

**Widely applied in [5]:**

- Retrofitting planning.
- Quality control during construction.
- Post-insulation performance checks.

**Commonly detects [6]:**

- Air infiltration.
- Thermal bridging.
- Missing/damaged insulation.


**Limitations:**

- Measures only surface temperatures.
- Requires consideration of emissivity, reflections [3].
- Mostly qualitative unless paired with additional analysis [5].

**Research Gap :**

- Lack of dual-assessment frameworks combining infrared imaging with occupant feedback [8].
- Over-reliance on design simulations vs real-world performance [9].

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# Research OBJECTIVES

To compare the heat loss characteristics of two buildings, an existing conventional building and a modern energy-efficient building, using infrared thermography and an occupant survey.

**1**

Use infrared thermal imaging to detect thermal leakage in building envelopes

**2**

Compare thermal performance between the Engineering Building (EB2) and the Engineering & Science Building (ESB)

**3**

Conduct occupant comfort surveys to evaluate observed thermal performance

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# METHODOLOGY

## Buildings selected

ESB (Engineering & Science Building): Newly constructed, high-performance envelope

EB2 (Engineering Building 2): Older construction, likely more leakage

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# METHODOLOGY

## Procedures & Data Collection

### A. Infrared Thermal Imaging

1. Pre-Inspection:
   - Carried out between 12:00–4:00 PM while HVAC systems are on.
2. Image Capture:
   - Taken on main entrances, side/emergency exits, and at least three window locations per building.
3. Visual Inspection:
   - Regular photos are taken of the same areas to document cracks/poor insulation.
4. Image Analysis:
   - Thermal irregularities (hot or cold spots) and compared between both buildings.

5. Occupant Thermal Comfort Survey
   - A Google Forms survey distributed to frequent users of ESB/EB2 buildings
   - Participants rating their thermal comfort on a 5-point Likert scale.
   - Respondents indicating which building entrances/exits they use most often.


Figure 1 : IR thermal camera used for the assessment (FLIR -T62101).


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# Analysis

## Infrared Thermographic Analysis of (ESB)

### Main Entrance Doors

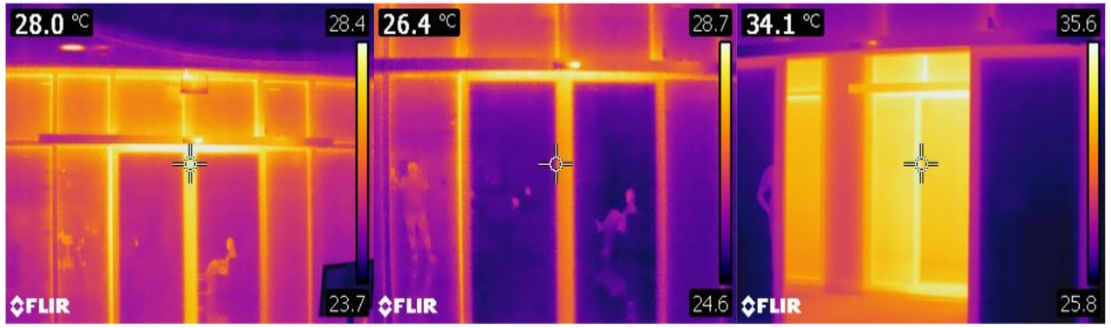


Figure 2 : IR images capturing the main entrance doors on the ESB building showing improved thermal leakage prevention by installing a two -door system.

### Emergency Exit Doors


Figure 3 : IR and normal images capturing the emergency exit doors of ESB building showing signs of thermal leakage and upon visual and physical inspection leakage detected.

### Windows &Facades

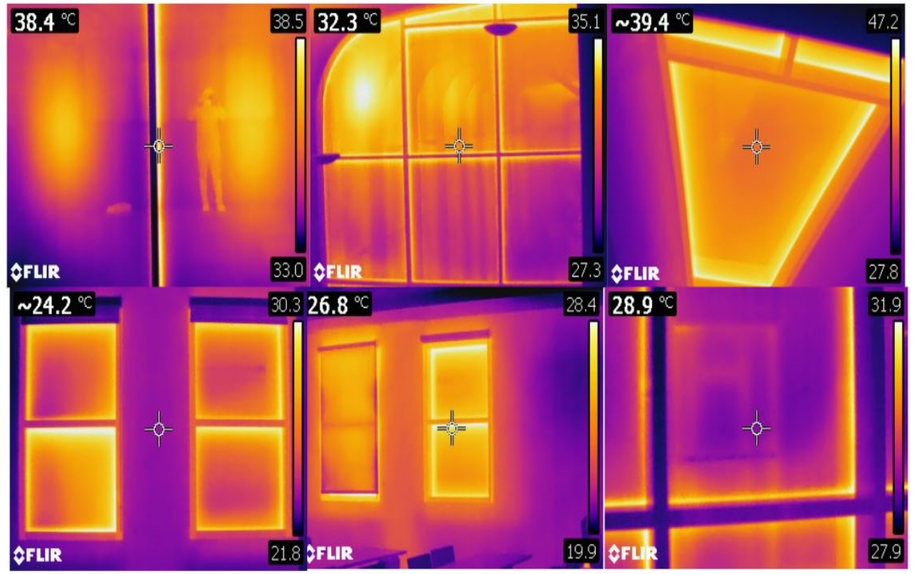


Figure 4 : IR Images capturing windows and facade of ESB building showing no sign of thermal leakage.

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# Analysis

## Infrared Thermographic Analysis of (EB2)

### Main Entrance Doors & Emergency Exit Doors

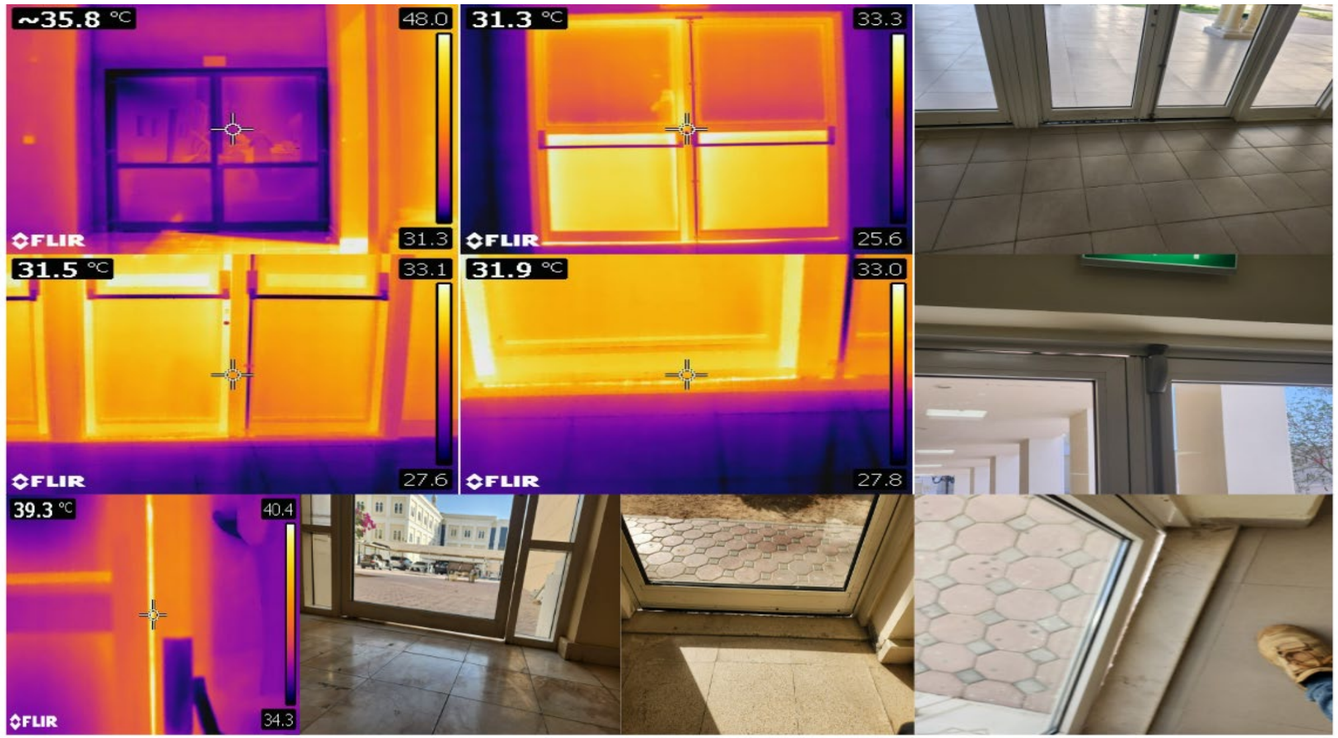


Figure 5 : IR images and normal images capturing the main entrance and emergency exit doors of EB2 building showing signs of thermal leakage and visual inspection confirmed leakage on several doors.

### Windows

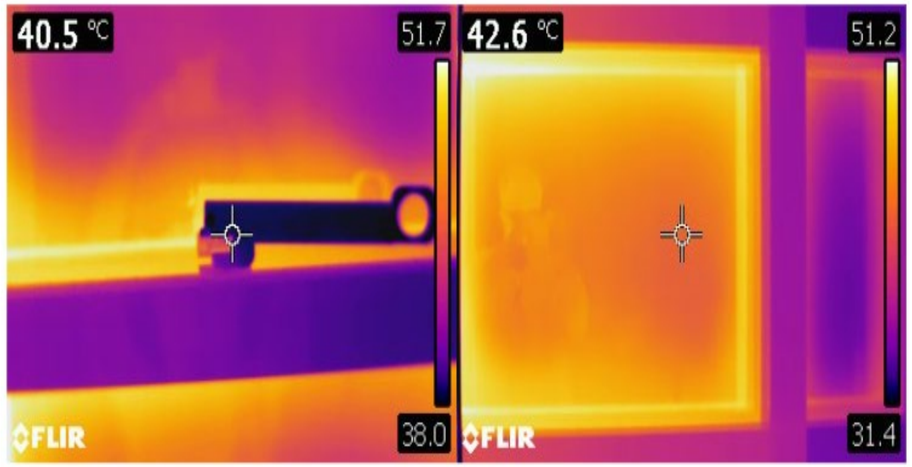


Figure 6 : IR Images capturing windows and facade of EB2 building showing no sign of thermal leakage.

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# Analysis

## Occupant Thermal Comfort Survey

- **In ESB, 52.4% felt comfortable, While EB2 42.9 % felt comfortable.**

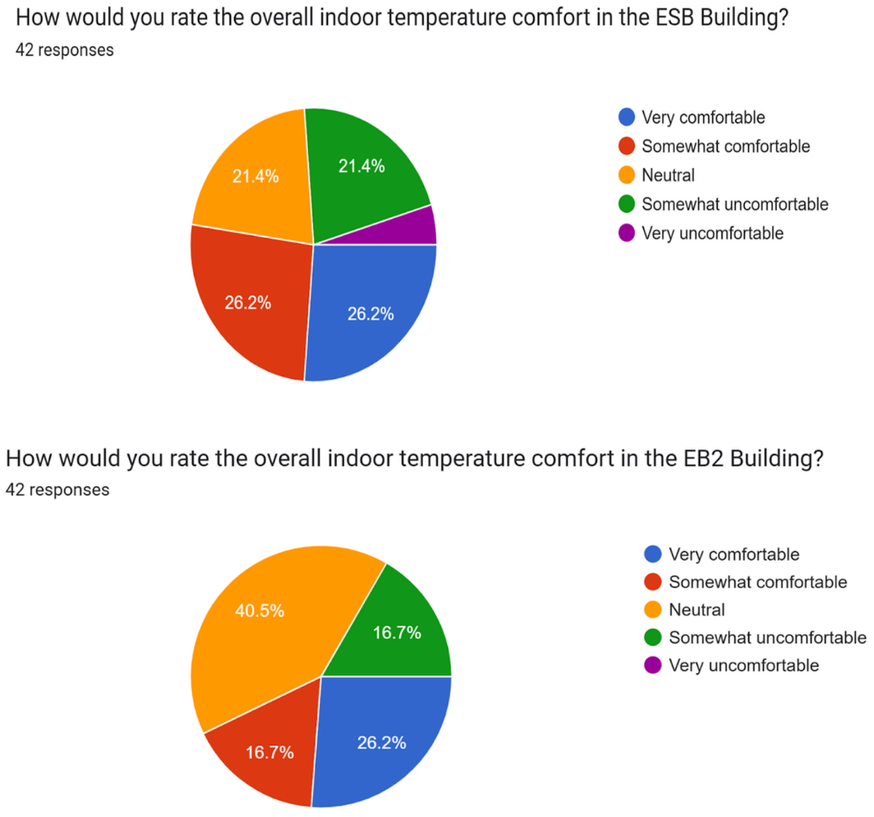


Figure 7: Questions 4&5 result summary

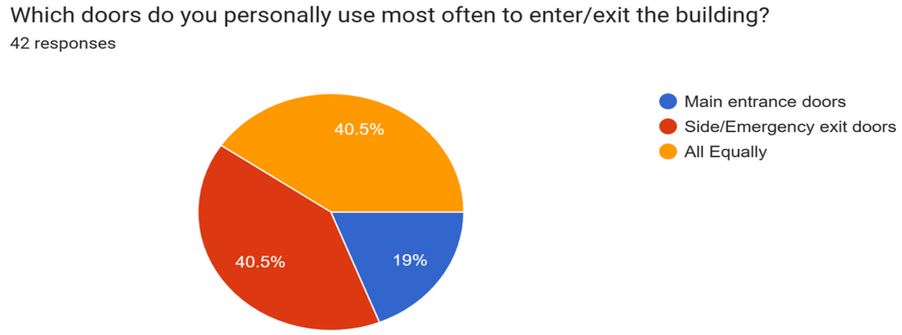


Figure 8: Question 7 result summary

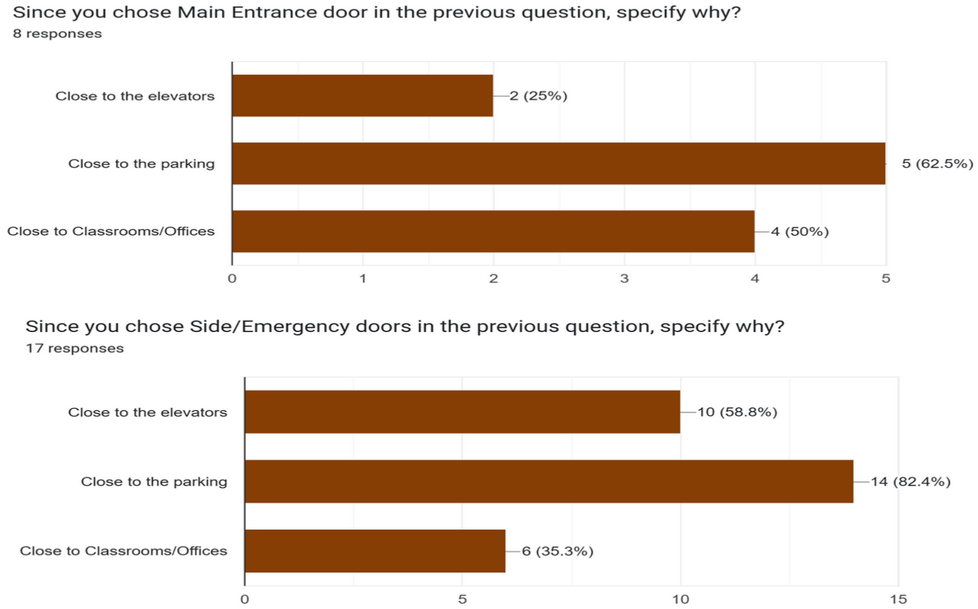


Figure 9: Question 8 -9 result summary

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# CONCLUSION

**Windows – Well Sealed**

- No major thermal leakage in ESB or EB2 windows
- Effective glazing and insulation confirmed

**Doors – Key Source of Leakage**

**ESB:**

- Emergency exits show minor leakage (frequent manual use)

**EB2:**

- Widespread leakage at all doors (Main & Emergency Exit doors)

*Overall Leakage occurred at manual doors and not automatic ones*

**Occupant Feedback Matches Findings**

- Discomfort higher especially near frequently used doors
- Comfort ratings: ESB 52.4% vs EB2 42.9%

Combining the infrared scan findings with the occupant survey reveals a strong correlation between user behavior and thermal performance.

## Thermography –Survey Correlation

**1**

In ESB, Thermal flaws appeared at the emergency exits, which 40.5% of respondents reported using it more frequently. These areas also matched locations where half of the participants reported discomfort.

**2**

In EB2, widespread leakage at main and exit doors, Survey results reflected this, with lower comfort rates only 42.9% of users feeling comfortable and a larger portion reporting neutral or uncomfortable conditions.

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# RECOMMENDATIONS

Implement IoT-enabled thermal sensors and drone-based infrared inspections, which will transmit real-time data onto a live dashboard for quick leak detection.

Create a digital twin of each building's envelope to enable virtual inspections using AR-guided seal checks and a scheduled retrofit timetable.


Integrate AI-driven control systems that regulate ventilation and temperature based on real-time occupancy data and thermal feedback.

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# Thank you

For any questions, please contact :

Mahmoud Issa

b00102199@aus.edu.....

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