Air Infiltration Testing in Social Housing

In situ testing of envelope air leakage to estimate improvements between the current and green models

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The American University in Cairo

CONTENT

1) INTRODUCTION
   I. *Objective of the study*
   II. *Testing and reporting methods for air infiltration in buildings*

2) METHODOLOGY
   I. *Description of tested dwellings*
   II. *Air infiltration measurements*

3) RESULTS
   I. *Airtightness results using the fan pressurization method*
   II. *Airtightness impact on energy consumption*

4) CONCLUSION

Hadayek El-Asema Social Housing Complex

1- Introduction

1.1 Objective of the study

- Understand the air infiltration rate in social housing buildings in Egypt and its impact on energy consumption and indoor thermal comfort.
- To measure and quantify air infiltration rates in different types of social housing buildings in Egypt using blower-door testing.
- To provide evidence-based recommendations for improving building envelope performance and reducing energy consumption
- To contribute to the existing knowledge on building performance in the context of Egypt's unique climate and building practices, and to provide valuable insights for policymakers, building practitioners, and researchers to develop effective strategies for enhancing energy efficiency and sustainability in residential buildings in Egypt.

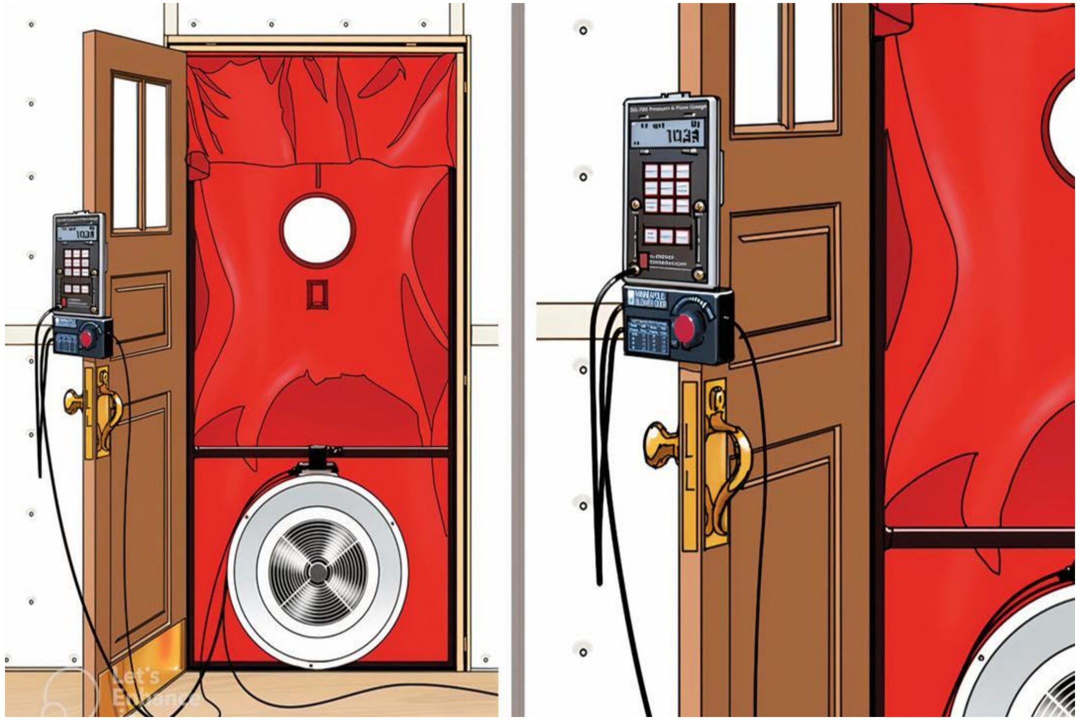
1- Introduction

1.3 Testing and reporting methods for air infiltration in buildings

A- Blower Door Test:

It is based on numerous pressure/air flow rate measurements obtained over a differential pressure range of 0 to 10 pa. 25 to 75 Pa above and below ambient conditions.

- Blower door tests were conducted on a total of 23 dwellings located in Hadayek El Asema Project.
- The 23 dwellings were categorized into two groups: green and traditional.

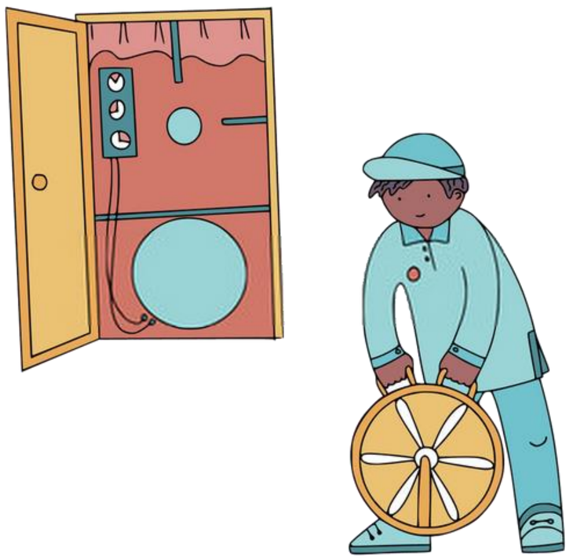


Blower Door Illustration

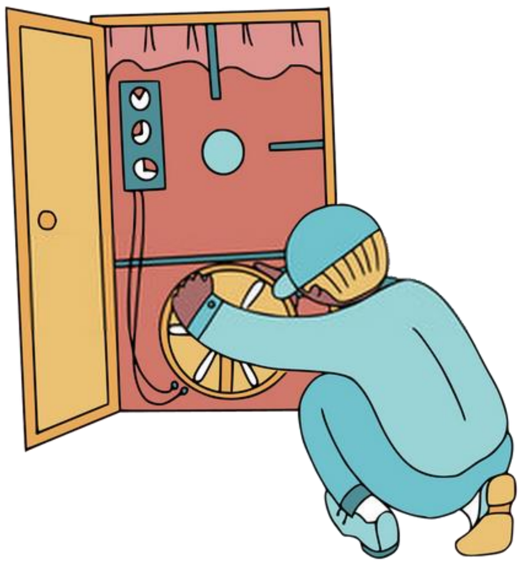
1- Introduction

1.3 Testing and reporting methods for air infiltration in buildings

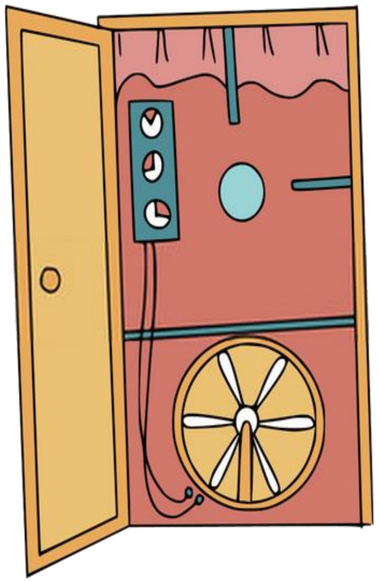
1. Set the frame and nylon door



2. Fix the fan and connect it to the gauge



3. Depressurize and pressurize the space



2- Methodology

2.1. Description of tested dwellings

Field measurements were conducted on 23 **social housing** units near **the new administrative Capital in Cairo, Egypt**, which is characterized as a hot arid region.

Dwelling Categories

- Conventional Apartments (15 Dwellings)
- Enhanced Apartments (8 Dwellings)

2- Methodology

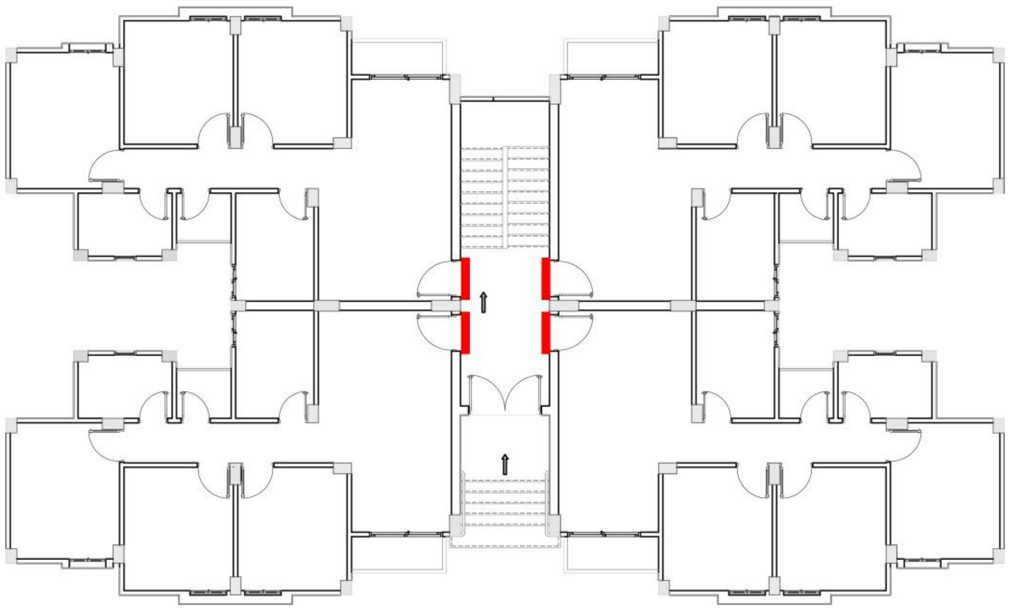
2.1. Description of tested dwellings

The critical difference between the units was the **quality of windows** and the **construction material**, with the conventional buildings constructed using mud bricks and wood-framed windows, and the Enhanced buildings utilizing cement bricks and aluminum-framed windows.

	Model	Construction Year	A_F (m^2)	V (m^3)	A_E (m^2)	FL (m)	FA (m^2)	No. of Exposed Facades	Position (Floor)
C1	Conventional	2022	73.00	199.29	94.14	34.6	11.50	2 (NW)	Ground
C2	Conventional	2022	73.00	199.29	94.14	34.6	11.50	2 (SE)	Ground
G3	Enhanced	2022	65.50	178.81	94.14	34.6	11.50	2 (NW)	Ground
G4	Enhanced	2022	65.50	176.85	94.14	34.6	11.50	2 (SE)	Ground

A_F = Floor Area; V = Volume; A_E = Envelope Area; FL = Frame/Fenestration length; FA = Frame/Fenestration area

Heading Example of Dwellings Characteristics



Blower Door Locations for Tested Dwellings

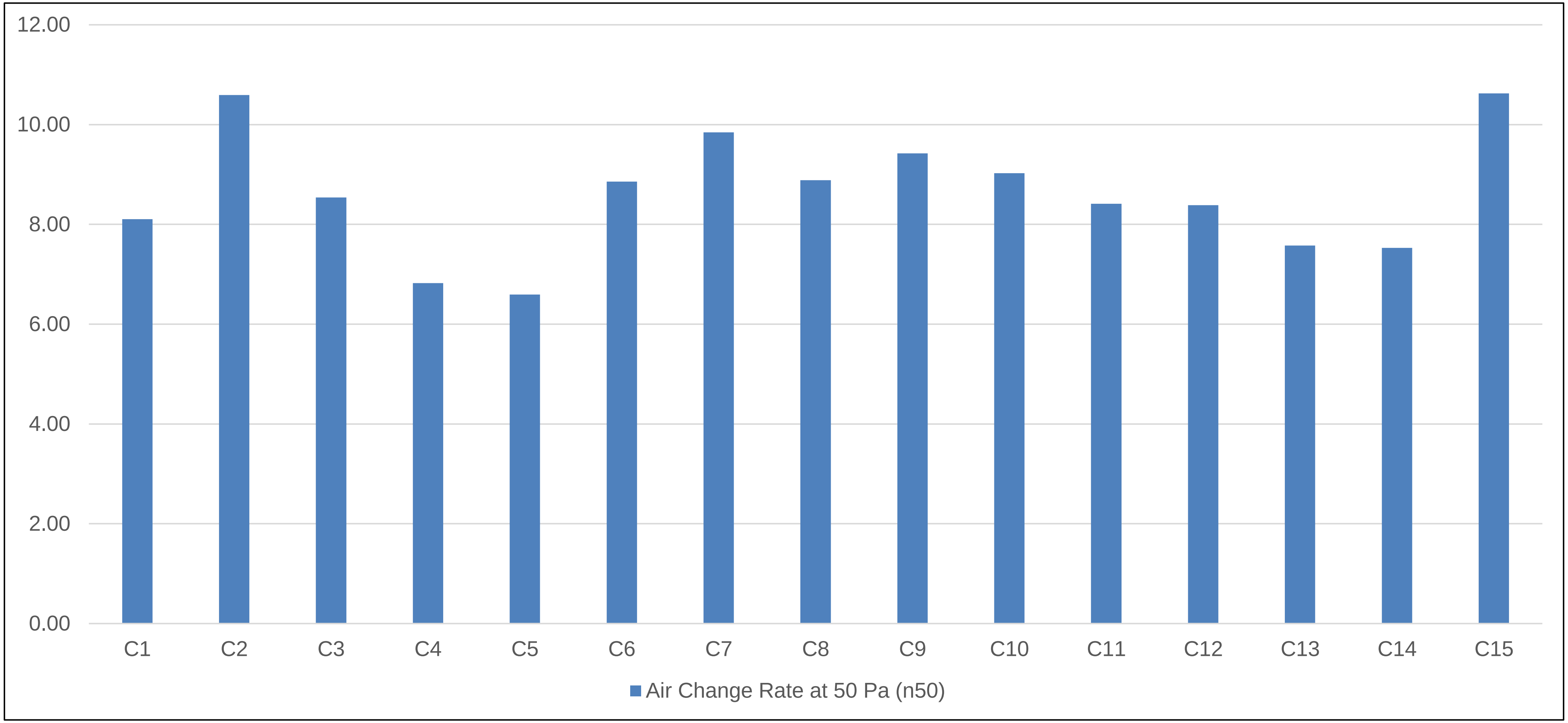
2- Methodology

2.2. Air infiltration measurements

Using Method B of ISO 9972, Minneapolis Door Setting

3- Results

3.1. Airtightness results using the fan pressurization method



Conventional Model Airtightness Results

3- Results

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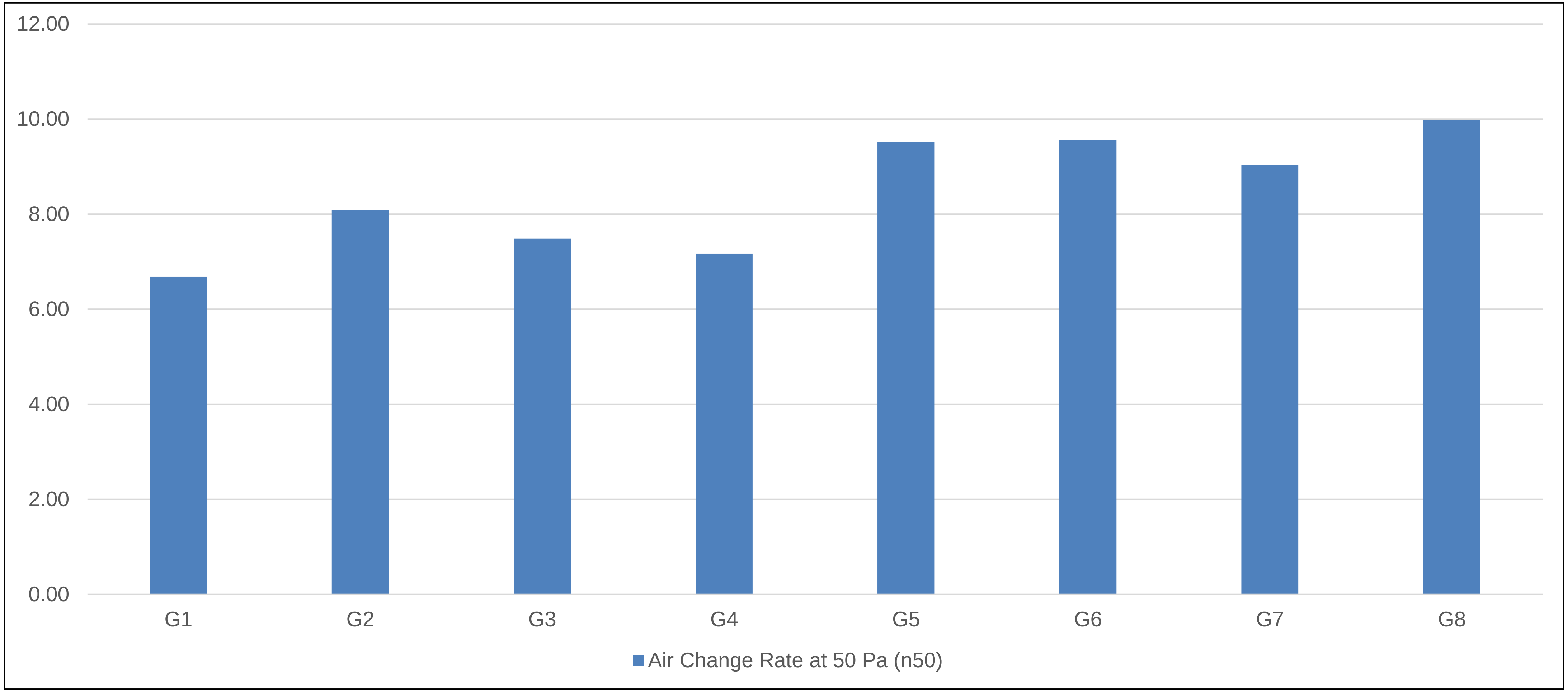

Green Model Airtightness Results

3- Results

3.1. Airtightness results using the fan pressurization method

Airtightness Parameters	Relation	Green Model	Conventional Model	Improvement Performance
Average (Q_{50})	Mean	1494.63	1716.80	12.9%
	STD	218.28	231.98	
	Min	1195.00	1314.00	
	Max	1765.00	2117.00	
Air change rate (n_{50})	Mean	8.44	8.61	2%
	STD	1.16	1.20	
	Min	6.68	6.59	
	Max	9.98	10.62	
Air Permeability Rate at 50 Pa (q_{50})	Mean	15.50	17.84	13%
	STD	2.16	2.59	
	Min	12.69	13.53	
	Max	18.18	22.42	
Specific Leakage Rate at 50 Pa (w_{50})	Mean	22.81	23.51	3%
	STD	3.33	3.28	
	Min	18.24	18.00	
	Max	26.94	29.00	

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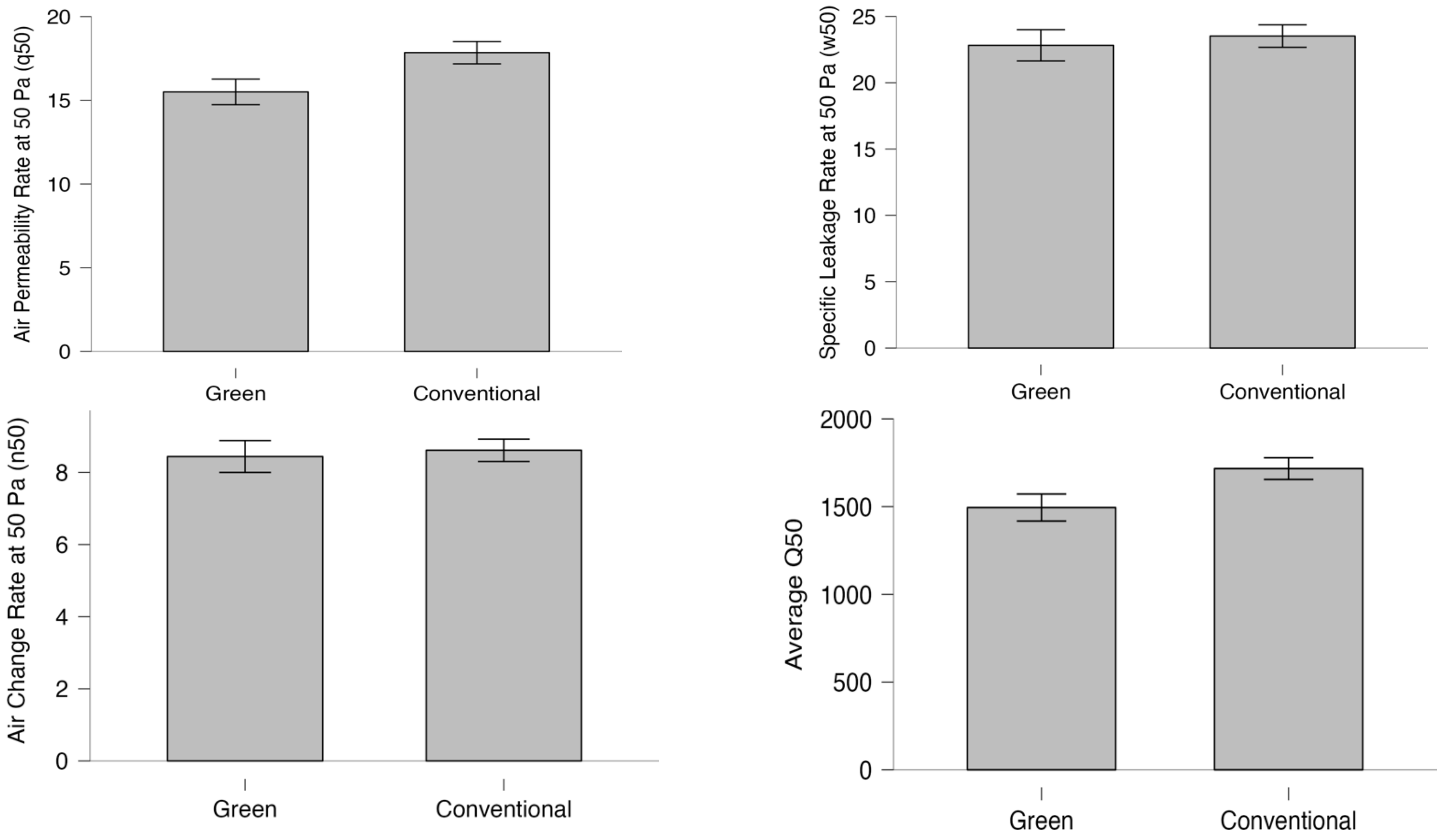

3- Results

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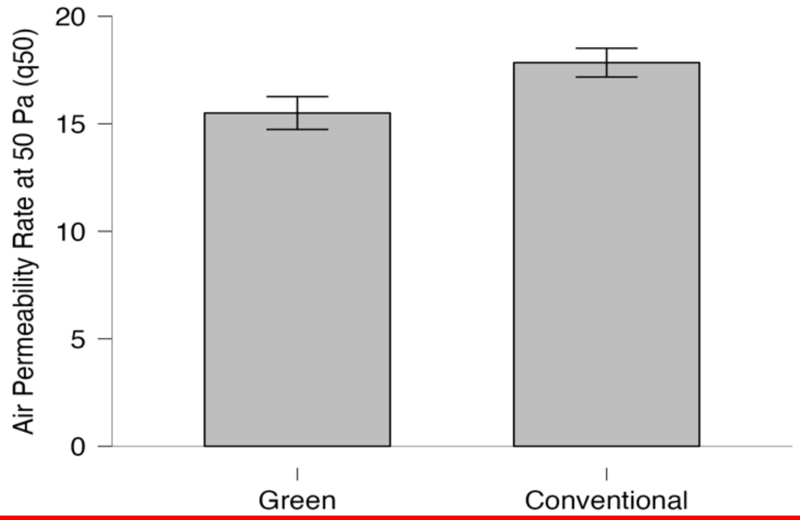
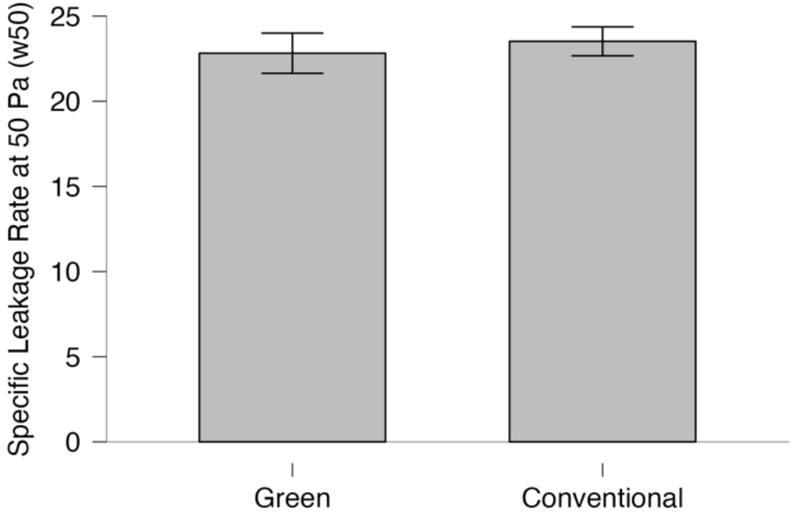
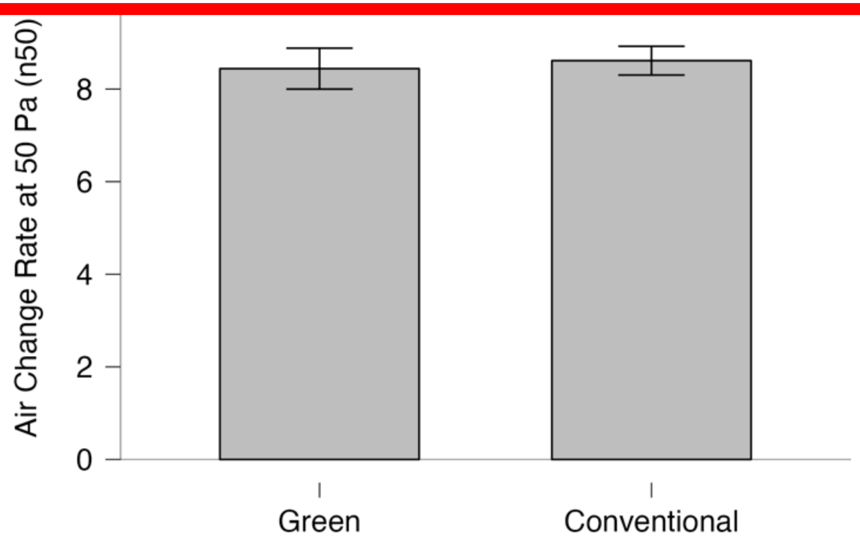
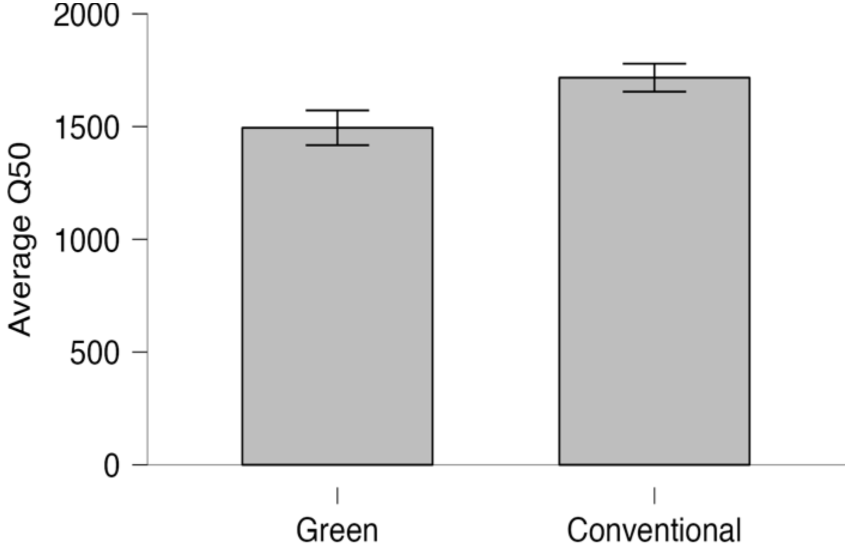






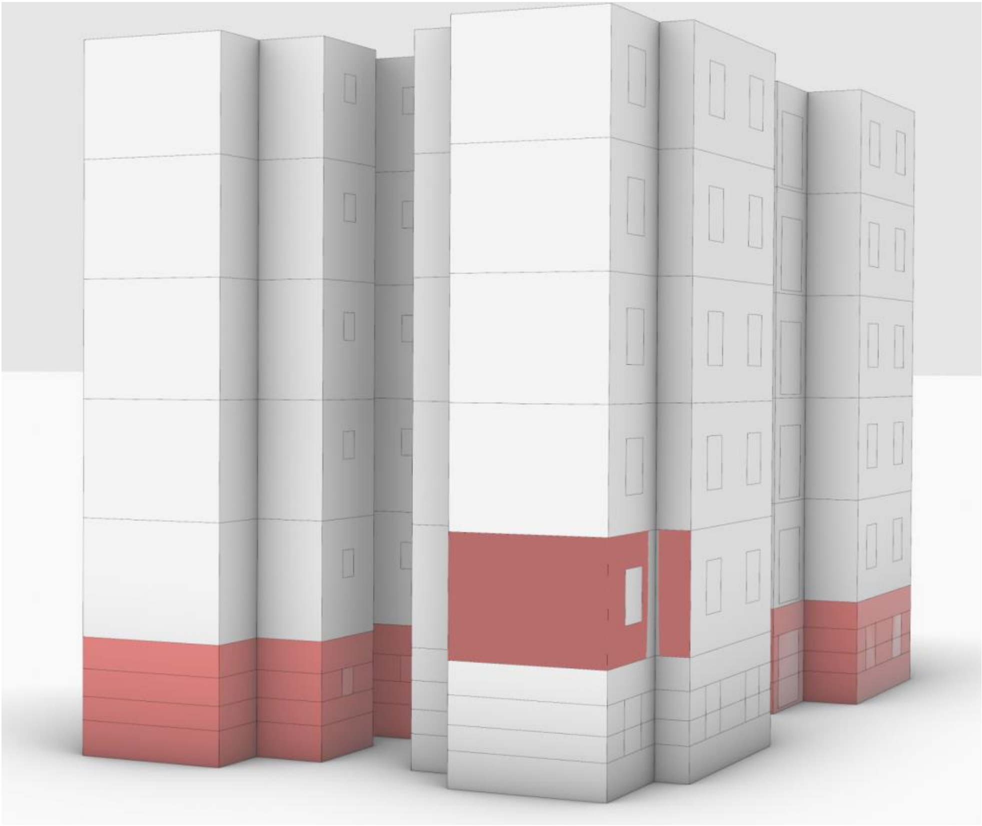


3- Results

3.2. Airtightness impact on energy consumption

Following the blower door tests, simulation modeling was conducted to examine the impact of air infiltration on energy consumption for 4 common units between conventional and green in position and floor level. Grasshopper is the simulation program used for the study.

Characteristics	**Specifications**
Building Model	Midrise Residential
Window	Conventional: Glazing: Single 3mm Clear Glass
	Green: Glazing: Single 3mm Clear Glass
Walls	Conventional: Outdoor layer: brickwork, indoor layer: brickwork
	Green: Outdoor layer: Cement Brick, indoor layer: Cement Brick
Floor	Concrete slab, tile flooring
Lighting Schedule	3 W/m^2
No. of People per Area	0.02 ppl/m^2
Load Schedule	6 W/m^2
HVAC	Split Units



Rhino Model showing the tested dwellings

3- Results

3.2. Airtightness impact on energy consumption

Parameter	Model	Mean	Std. Deviation	Minimum	Maximum
Cooling Load	Conventional	5279.30	2383.03	3060.39	7499.66
(kWh/yr)	Green	5165.24	2409.99	2930.48	7415.25
Heating Load	Conventional	4140.64	907.26	3197.33	5362.72
(kWh/yr)	Green	4020.62	945.19	3053.36	5285.82
Infiltration heat loss	Conventional	1214.00	28.52	269.30	332.00
(kWh/yr)	Green	960.30	41.89	188.30	290.50
EUI (Cooling)	Conventional	72.31	32.64	41.92	102.73
($kWh/m^2 \cdot yr$)	Green	70.75	33.01	40.14	101.57
EUI (Heating)	Conventional	56.72	12.42	43.79	73.46
($kWh/m^2 \cdot yr$)	Green	55.07	12.94	41.82	72.40

3- Results

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Cooling Load	Conventional	5279.30	2383.03	3060.39	7499.66
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($KWh/m^2 \cdot yr$)	Green	70.75	33.01	40.14	101.57
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3- Results

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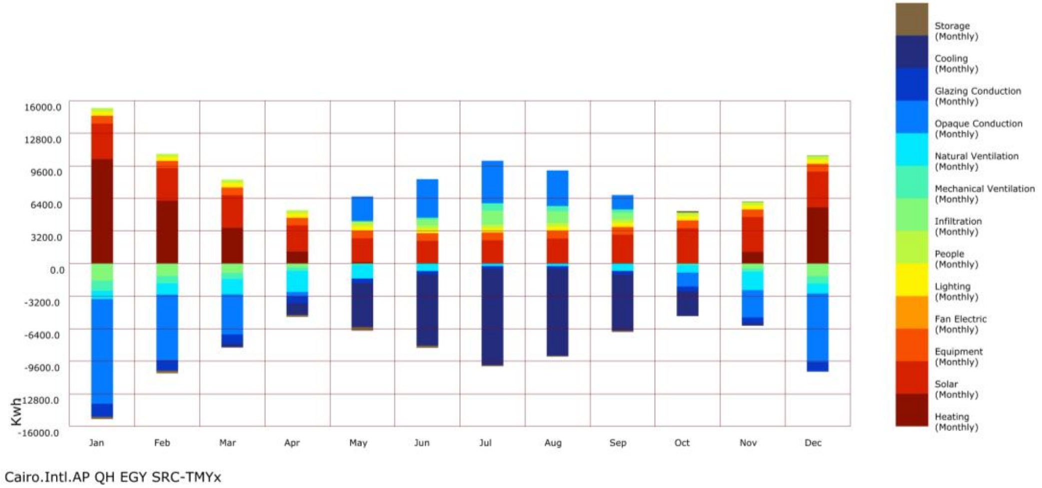
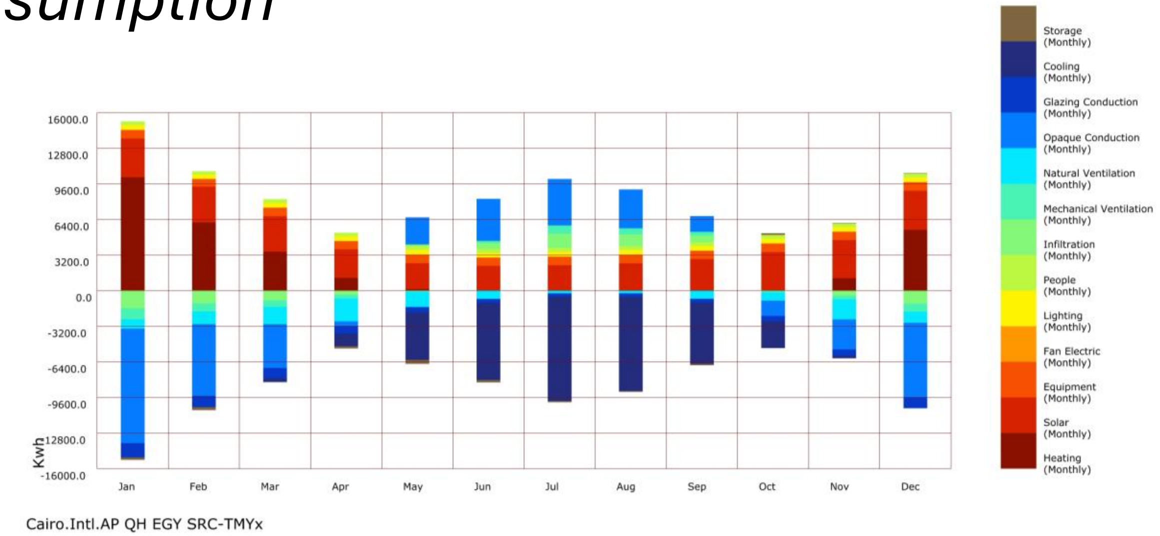


(A)



(B)

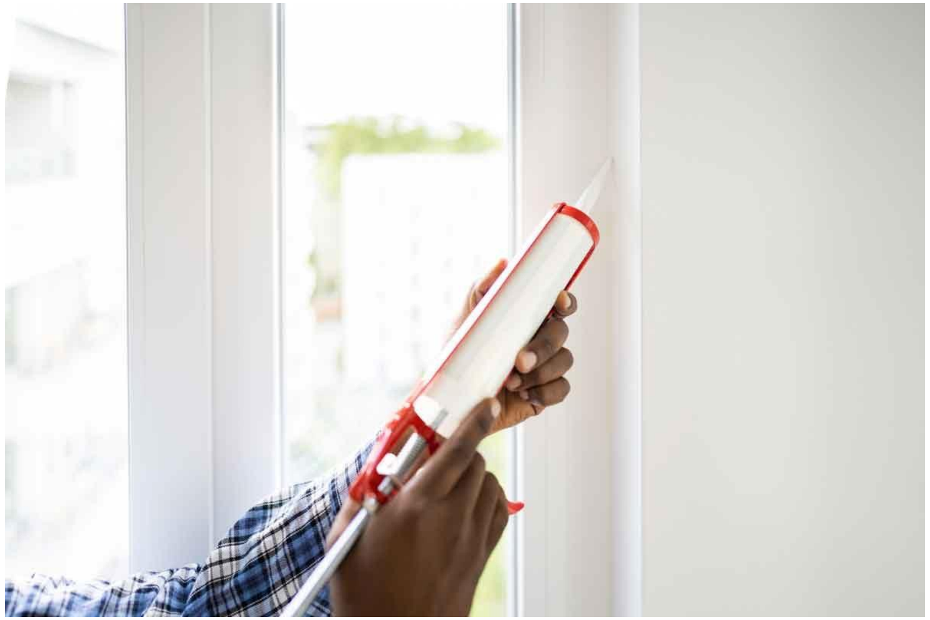
Energy Balance Chart (A)) Conventional and (B) Enhanced

Expected Energy Savings and EUI Reductions from Envelope Improvements

	Maximum	Average	Minimum
Cooling Load	4.24%	2.1%	1.1%
Heating Load	4.5%	2.8%	1.4%
Infiltration Load	30%	20%	12.4%

4- Recommendations

Use Weather Strips



Use window caulking

Use window shutters + drapes

5- CONCLUSION

This study's findings demonstrate how air infiltration affects energy consumption in new social housing units in Egypt.

- The assessments made in 23 residential dwellings show that conventional and green models perform very differently in terms of air infiltration.
- By improving the window frame's quality, green building models are 12.9% more airtight than conventional ones in terms of ACH and 13% less in air permeability.
- Using the Rhino and Grasshopper software, the energy performance analysis confirms the potential for energy savings linked to decreased air penetration. The simulations demonstrate potential reductions in cooling loads, heating loads, overall energy consumption, and overall improvements in Energy Use Intensity (EUI).
- Significant energy savings can be achieved by reducing air leakage through enhanced building envelope design. Further investigation is required to examine the location of dwelling variances and building-specific elements that affect air infiltration rates; it should be noted.