Measures to Reduce Cooling Load of Residential Buildings in Qatar

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Doha 2013 12 22

Presentation structure

1. Energy Survey

2. Literature review

3. Aims

4. Results

Energy Survey

- ✓ Qatar consumes $44 \cdot 10^{10}$ kWh/year, all of which comes from fossil fuel
- ✓ Air conditioning systems account for 65 % of total energy consumption
  - **A/C systems accounts for $29 \cdot 10^{10}$ kWh/y.**

Climate Consequences

Qatar annual emission of CO_2 >65 Mtons/y

- **A/C systems account for 42 Mtons/y**

No Climate justice

Thus

Reducing fossil-fuel energy consumption in building sector is it an urgent issue.

1. improving the performance of A/C systems
2. improving the thermal quality of the buildings

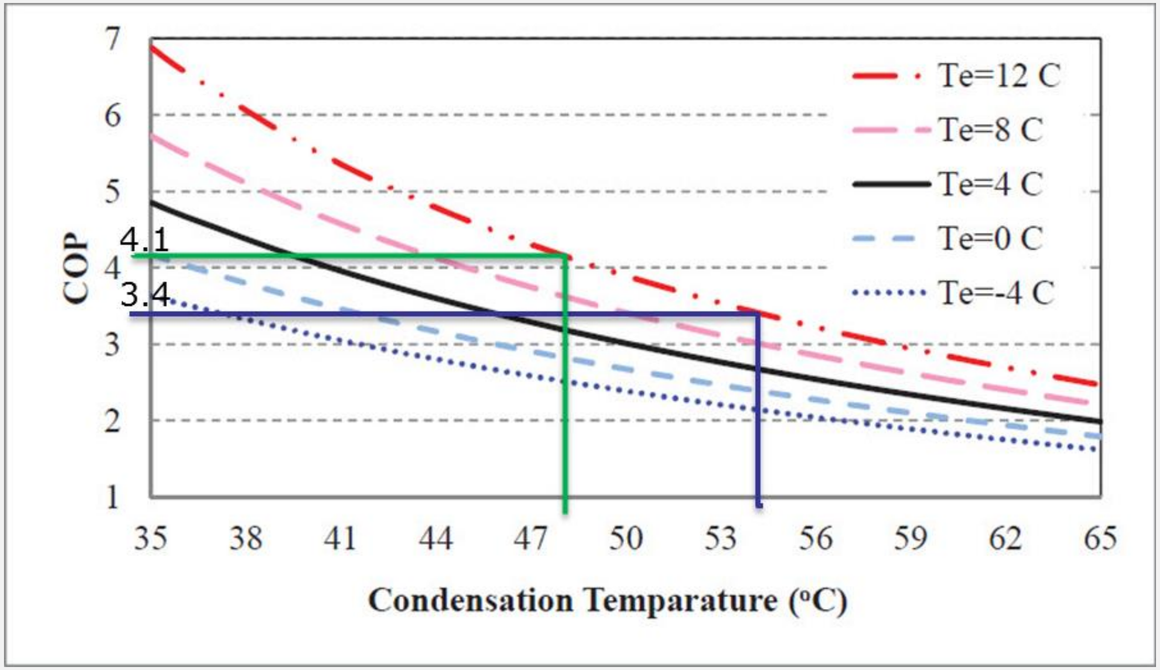
Have a clear potential for saving energy and the environment in Qatar.

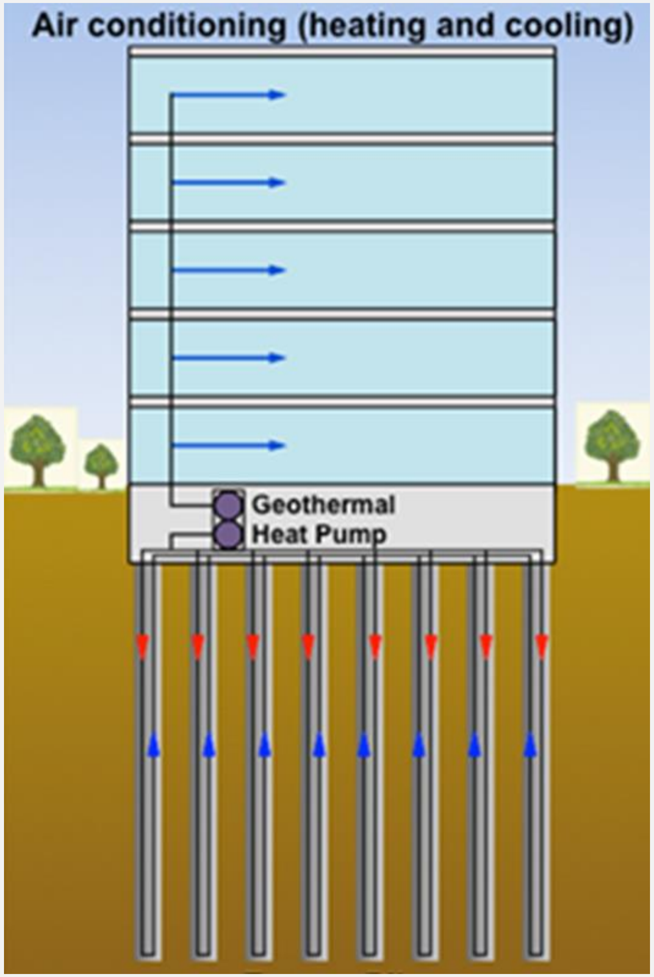
1. improving the performance of A/C

Shallow geothermal

Lower condensing temperature => better COP

COP = cooling load/driving energy





2. Improving thermal quality of building envelope (TQBE)

TQBE refers to the performance of the building shell as a barrier to unwanted heat transfer between the interior of the building and the outside environment.

The TQBE depends on following factors:

(1) insulation level of the exterior wall, ceiling, and floor;

(2) thermal properties of windows;

(3) air tightness of the envelope;

(4) the cooler of external shell; and

(5) thermal mass of the external shell.

2. Improving TQBE

The TQBE plays the fundamental role in determining the thermal load of building. For instance, high TQBE can reduce heat losses from building to the point where internal heat gain and passive solar heat gain can offset a large fraction of the remaining heat loss. On the other hand, improving the TQBE in hot climate certainly results in reduce the cooling load of the buildings.

2. Improving TQBE

Although building regulations are changing toward reduce the thermal loads of buildings, the energy demand for heating and air conditioning systems is increasing worldwide.

This increase in the energy consumption in building sector is attributed to

- the increase standards of living and comfortable requirements
- in modern designs, many elements that help in reducing the thermal load of the buildings have been discarded.

Measures to Reduce Thermal Load

In Ankara, it has been shown that a reduction in **heating** load of **45%** can be achieved by:

- reorienting the buildings
- increasing the insulation level of external shell of buildings

Low-emissivity double glazing windows alone could reduce the **cooling** load by 24%.

Measures to Reduce Thermal Load

In as US, Japan, Finland, Germany, and Canada the simulations showed that improving the TQBE can lead to **10-75%** reduction in heating and cooling energy requirements compared to the buildings built according to the conventional standards.

Theses uncertainty in saving rate is a result of <u>different climate</u> and <u>different use</u> of the considered building.

The Impact of Different Measures

Certainly, the impact of applied measure strongly depends on the climate conditions and the use of the building.

It has been shown that a specific measure leads to different energy saving rates if it was applied in different climate conditions or in different building use.

In Turkey, as an example, it was shown that introducing insulation on the external wall can result in yearly saving of **30%** in cold climate and **23%** in hot and humid climate.

The Impact of Different Measures

in South of Iran the following measure were investigated

- ✓ adding insulation to the wall,
- ✓ changing the color of external shell from mild to light color,
- ✓ doubling air circulation rate, and
- ✓ shading screen was investigated.

According to the simulation the cooling load can be reduced by

21% in the hospital

41% in the governmental building.

TQBE In Arab Gulf Countries

Unfortunately, most of the buildings in Arab gulf countries were built to standards that lower than those proposed by local authorities.

The lighting systems still use light bulb, which has the lowest lighting efficacy among the other lighting devices.

Finally, from my personal observation, it is very common to set the air conditioning systems on 18^{o}C.

Hence, there is a big potential for reducing energy use in buildings by improving the thermal characteristics of buildings and/or change our daily habit without changing the comfortable index of the building.

Investigated measures

The overall objective of current work is to show the contribution of different measures in saving energy and environment under designing conditions of Qatar.

The examined measures including:

(1) U-value of the external shell,

(2) indoor set-temperature,

(3) lighting efficacy,

(4) the cooler of external shell,

(5) windows quality.

Case study

In order to show the contribution of improving TQBE in saving energy and environment in Qatar, a common type of house located in Doha, was chosen as case study.

The model house consists of four identical external walls, 12 m in length and 3 m in height, with a total window opening of 20 m^2.

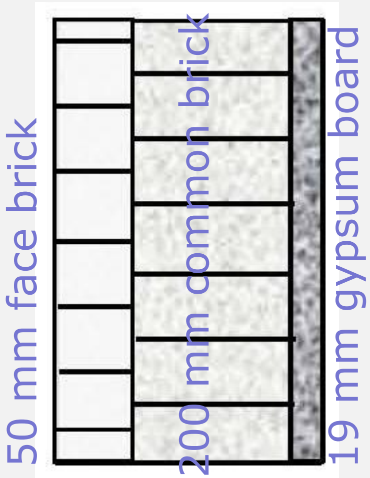
Specifications of studied building

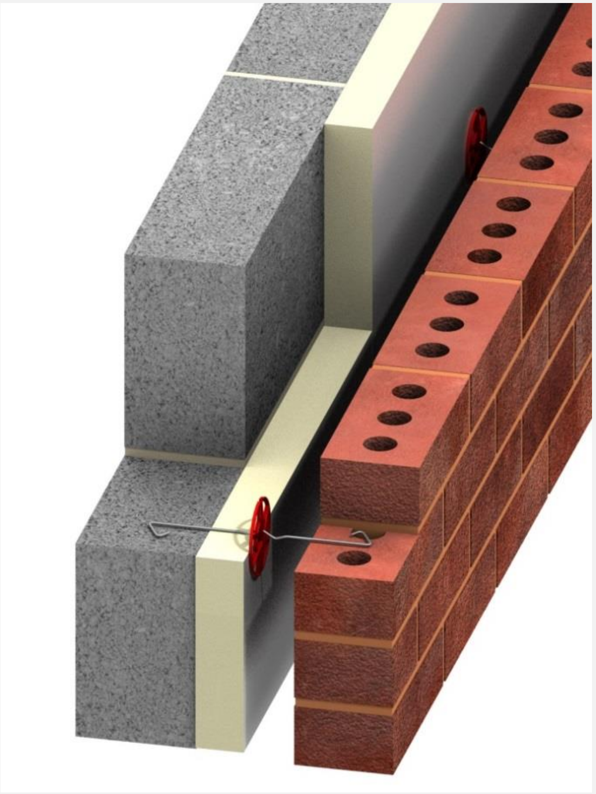
Throttling temp. range (^oC)	1	Designing outdoor temperature (^oC)	46
Building area (m^2)	144	Unoccupied indoor temperature (^oC)	27
Windows area (m^2)	20	Number of people	4
External walls area (m^2)	144	Outdoor ventilation air flow (l/s)	53
space volume (m^3)	389		

Investigated Measures: 1. Insulation

the impact of adding 3cm of insulation into the external walls

Indoor temperature (°C)	Wall U-value ($W/m^2.K$)
22	1.76
24	0.57

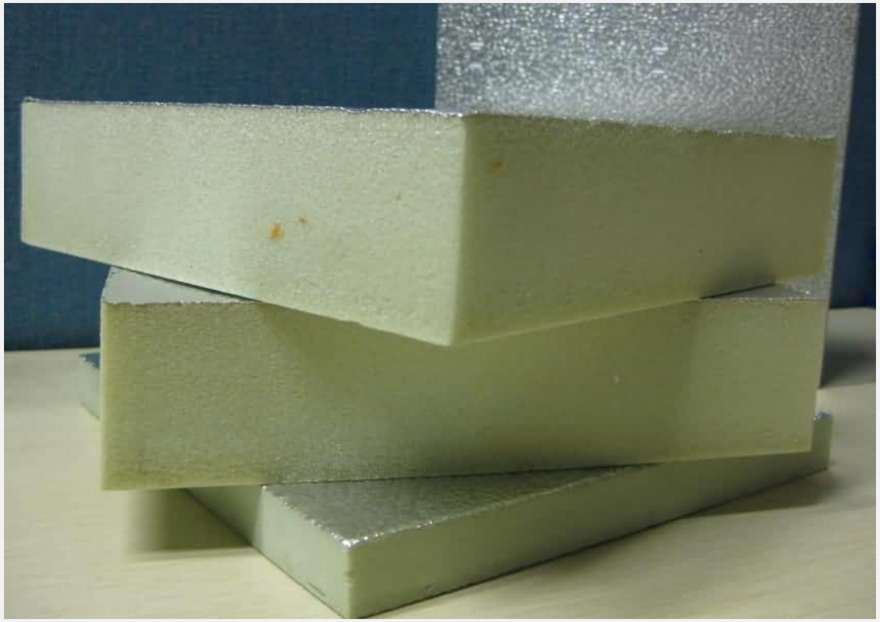




Investigated Measures: 1. Insulation

Polyurethane was chosen as insulation

Thermal conductivity	Density	Price
W/m.K	Kg/m^3	$/kg
0.03	30	4.25



Investigated Measures: 2. Indoor Temp.

the impact of increasing the indoor temperature from 22 to 24^{o}C

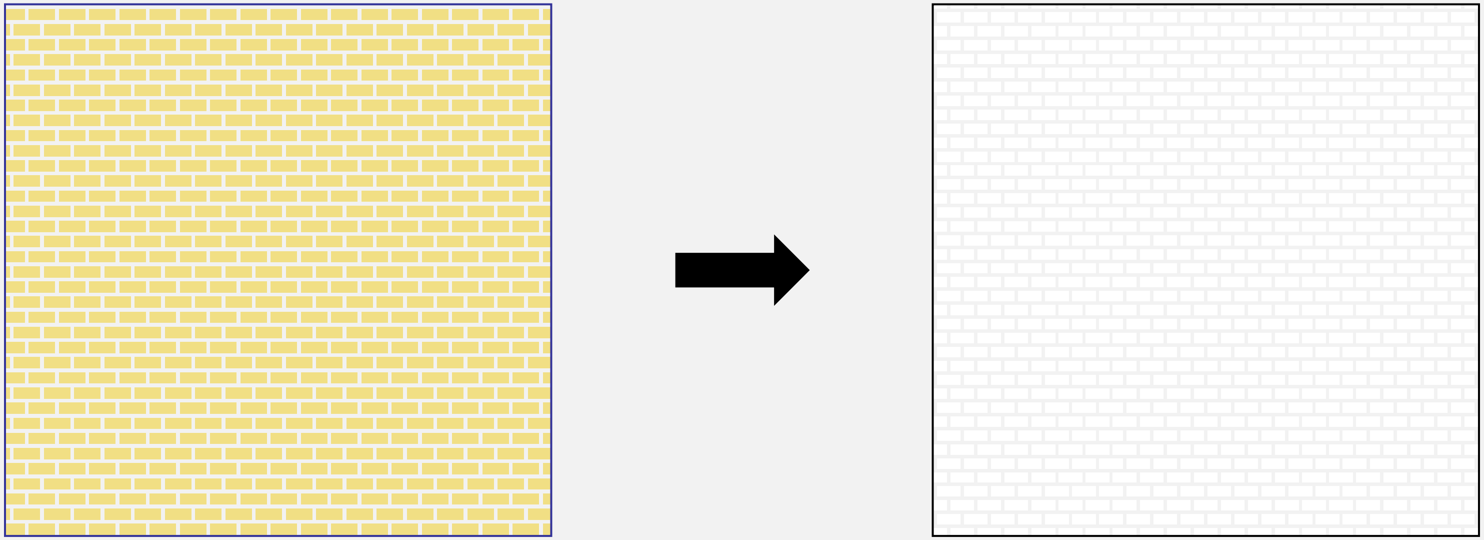
Investigated Measures: 3. Lighting

Indoor temperature (°C)	Shell U-value ($W/m^2.K$)	Lighting capacity (W/m2)
22	1.76	10
24	0.57	2.5

Type	Capacity	Price	luminous efficacy
	W	$	Lumens/W
light bulb	80	0.55	15
Fluorescent lamp	14	3.67	60

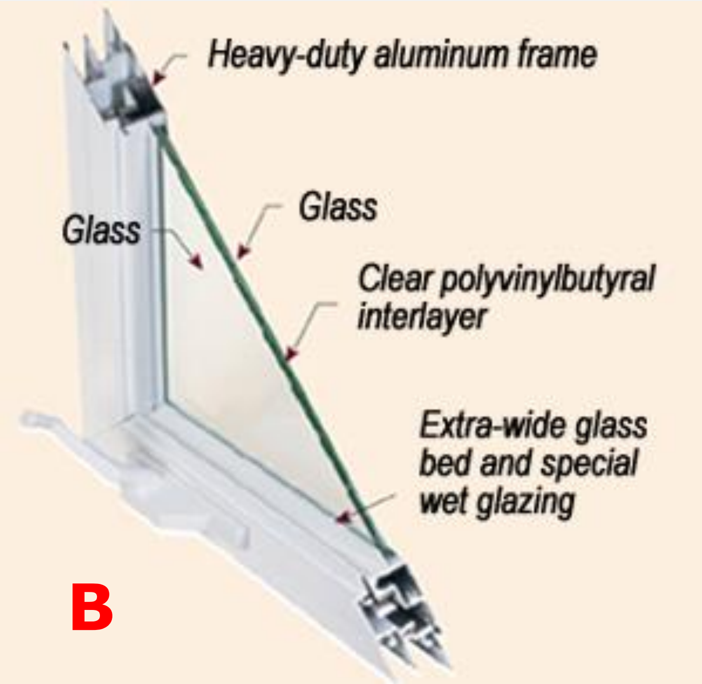
Investigated Measures: 4. Color

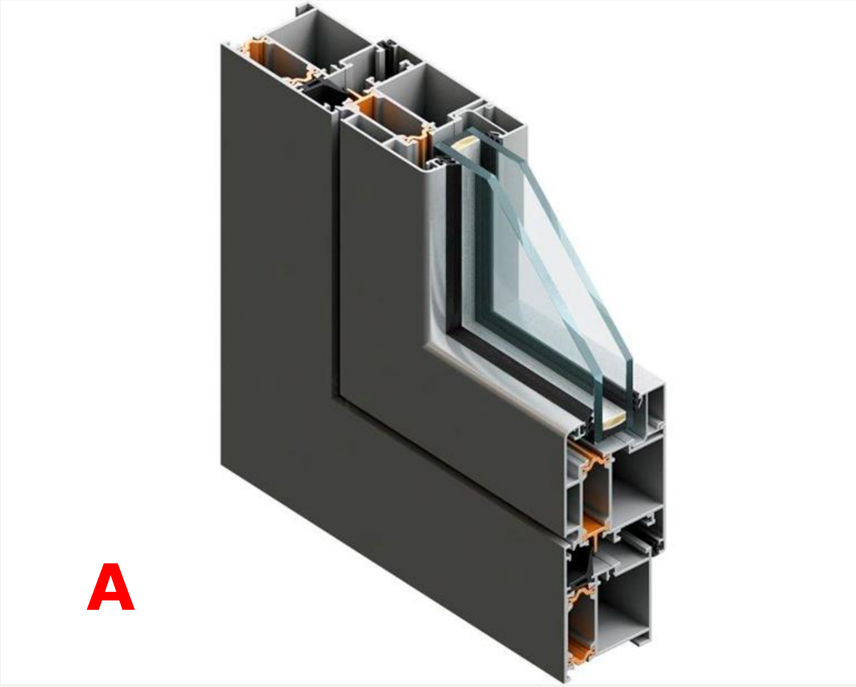
Indoor temperature (^{o}C)	Shell U-value ($W/m^2.K$)	Lighting capacity (W/m2)	windows quality	External color
22	1.76	10	A	Medium
24	0.57	2.5	B	Light



Investigated Measures: 5. Windows

Window quality	Frame type	Glass details	U-value (W/m^2.K)	Overall shade coefficient (%)
A	Aluminum with thermal breaks	5 mm gray Double glazing/6 mm air space	3.048	0.56
B	Aluminum without thermal breaks	5 mm clear single glazing	5.066	0.713

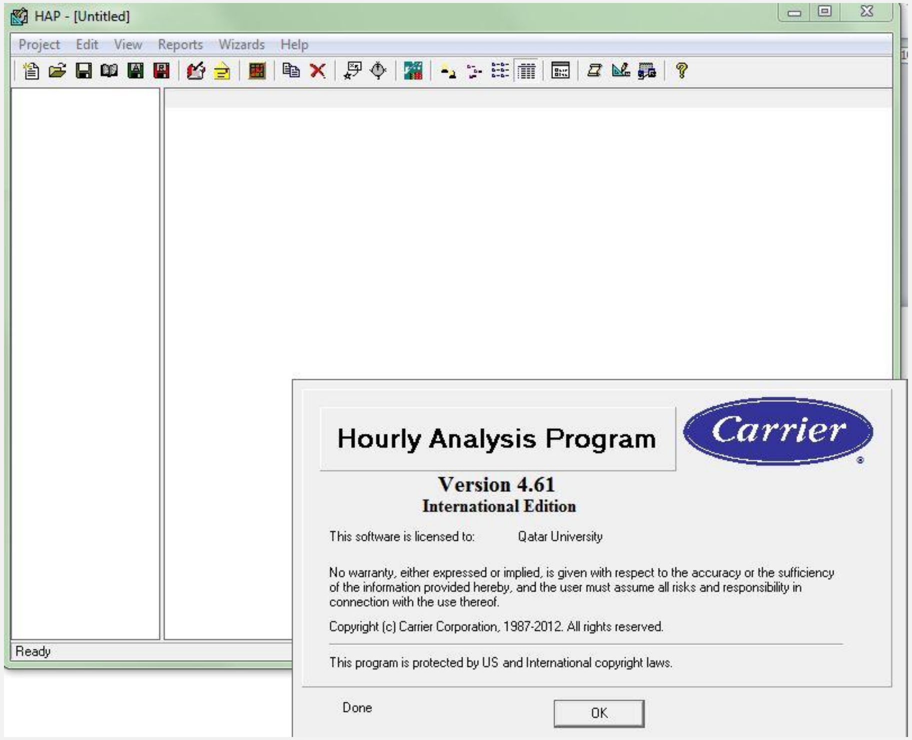




Cooling Load Calculation

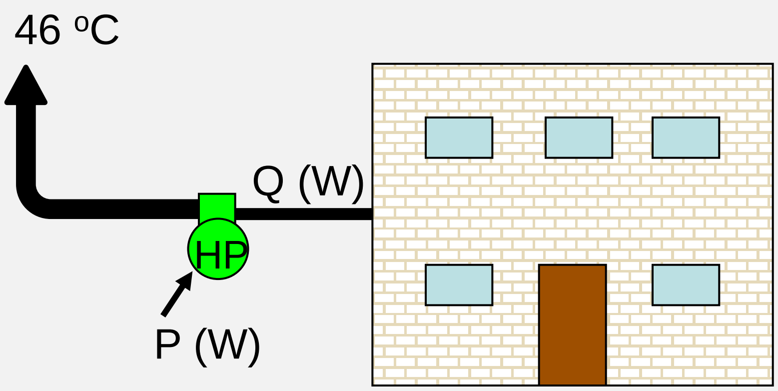
The commercial model hourly analysis program (HAP) was used for the estimation of cooling load:

- developed by Carrier Corporation
- using ASHRAE calculations method
- hour-by-hour energy simulation



Cooling Calculation Calculations

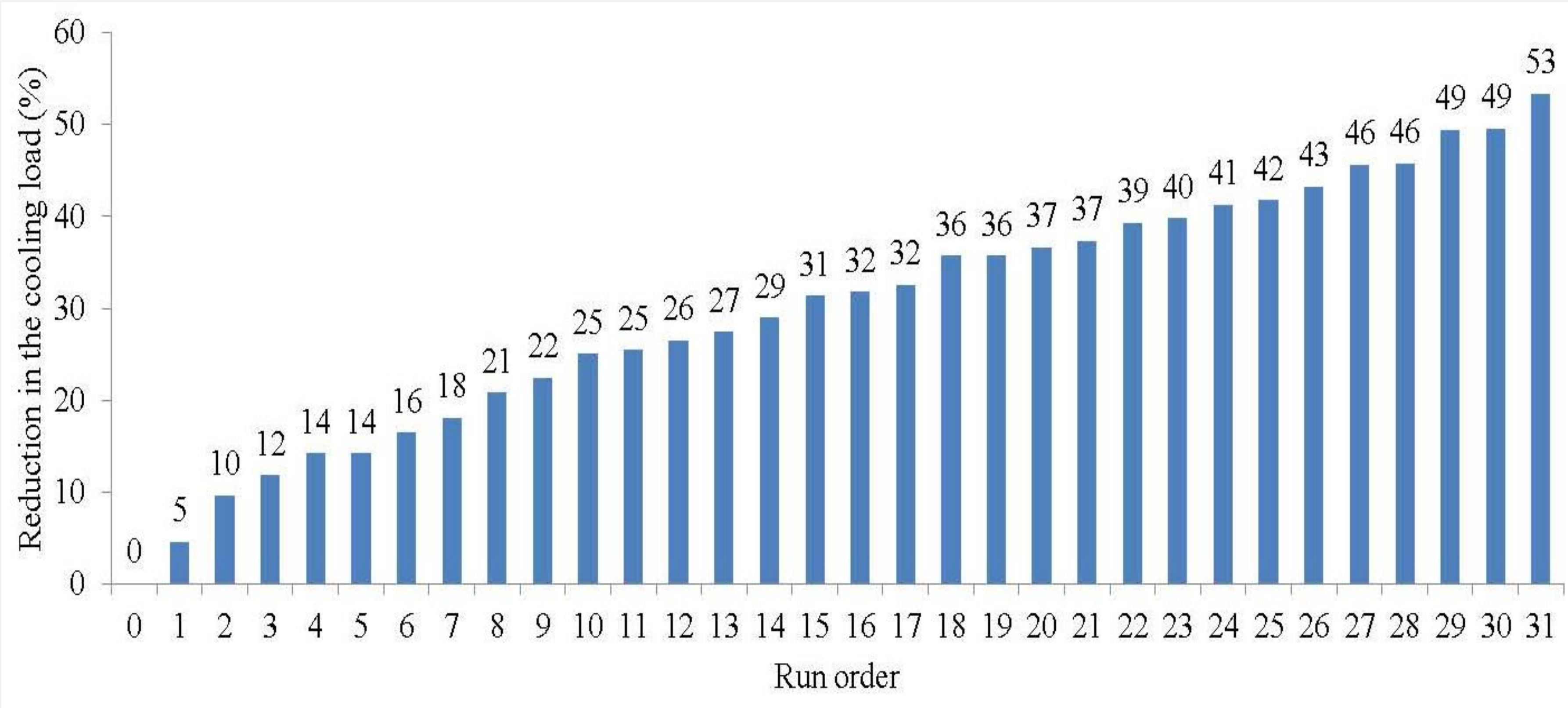
Indoor temperature (^oC)	Shell U-value ($W/m^2.K$)	Lighting capacity (W/m2)	windows quality	External cooler
22	1.76	10	A	Medium
24	0.57	2.5	B	Light



Cooling Calculation Results

Run order	Indoor temp. (ºC)	U-value (W/m².K)	lighting capacity (W/m2)	external Shell Cooler	Window quality
0	**22**	**1.78**	**10**	**medium**	**B**
1	22	1.78	10	medium	A
2	22	1.78	2.5	medium	B
3	22	1.78	10	light	B
4	22	1.78	2.5	medium	A
5	24	1.78	10	medium	B
6	22	1.78	10	light	A
7	24	1.78	10	medium	A
8	22	1.78	2.5	light	B
9	24	1.78	2.5	medium	B
10	24	1.78	10	light	B
11	22	1.78	2.5	light	A
12	24	1.78	2.5	medium	A
13	22	0.57	10	medium	B
14	24	1.78	10	light	A
15	22	0.57	10	light	B
16	22	0.57	10	medium	A
17	24	1.78	2.5	light	B
18	22	0.57	10	light	A
19	24	0.57	10	medium	B
20	24	1.78	2.5	light	A
21	22	0.57	2.5	medium	B
22	24	0.57	10	medium	A
23	24	0.57	10	light	B
24	22	0.57	2.5	light	B
25	22	0.57	2.5	medium	A
26	24	0.57	10	light	A
27	22	0.57	2.5	light	A
28	24	0.57	2.5	medium	B
29	24	0.57	2.5	medium	A
30	24	0.57	2.5	light	B
31	**24**	**0.57**	**2.5**	**light**	**A**

Reduction Rate of each Measures



0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Reference case	Window	Lighting	Cooler	lighting +Window	Temp.	cooler+ Window	Temp.+ Window	lighting+ cooler	Temp.+light	Temp.+cooler	Light+cooler+Window	Temp.+light+window	U	Temp+cooler+window	U+cooler
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
U+window	Temp+light+Cooler	U+cooler +window	Temp+U	Temp+light+cooler+window	U+light	Temp+U +Window	temp+U +cooler	U+light+ cooler	U+light+ window	Temp+U +cooler+ window	U+light+ cooler+window	Temp+U +light	Temp+U +light+window	Temp+U +light+cooler	Temp+U +light+cooler+window

Results

The simulation shows that different measure has different impact on the reduction of cooling load of the house.

As shown, the reduction in cooling load due to:

(1) improving the quality of the windows is **5%**

(2) improvement in lighting efficacy is **10%**;

(3) improving the cooler of the external wall from the medium to light cooler is **12%**;

(4) increasing indoor temperature two degrees is **14%**.;

(5) adding 3 cm on insulation to the external walls is **27 %**.

It is possible to reduce the cooling load of residential building in Qatar by **53%** if the all investigated measures were applied

Thank you for your attention