Energy Efficiency Recommendations for Palm Hills Alexandria, Egypt

IKI Project: Accelerating 0-emission building sector ambitions in the MENA region (BUILD_ME)

February 2021

Introduction to the BUILD_ME project

BUILD_ME

Fund

IKI International Climate Initiative, German Federal Ministry of Environment

Supported by:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

based on a decision of the German Bundestag

MENA Region

EGY | JOR | LEB | ALG | MOR | TUN

Team

IDG MATRIX Integrated Development Group

الجمعية العلمية الملكية
Royal Scientific Society

LCEC
LEBANESE CENTER FOR ENERGY CONSERVATION

European Bank
for Reconstruction and Development

Guidehouse

TRACK

EGYPT GBC
EGYPT GREEN BUILDING COUNCIL

LGBC
lebanon green building council

ALCOR
Développeur d'avenir durable

RCREEE

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Photo by Scott Graham on Unsplash

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BUILD_ME

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BUILD_ME

WP2
Support the Implementation of Pilot Projects

Objectives

Demonstrate technical and financial feasibility of EE buildings

Benefits for PP

Potential financial support

WP4
Capacity Building and Dissemination

Project website
National Workshops
Regional Workshop
Training and webinars

Provide training(s) for the staff implementing EE/RE measures

Green Marketing
Dissemination via Web.
Share experiences in WS

Enhance your projects visibility

Calculation of economic performance
Support with application to funds

Methodology

Cost Benefit Analysis

HIGLIGHTS

- Besides classic CAPEX/ OPEX cost, it considers residual values
- Hourly based energy calculation
- Detailed local weather data is considered
- Energy price systematic and PV clearing adapted to local situation (Egypt)

ENERGY CALCULATION

- individual building geometries and windows (incl. orientation)
- Hourly based energy calculation using the international ISO 52016 norm
- Based on the energy demand calculation (useful demand) the HVAC systems are sized
- Five efficiency levels for each HVAC system can be selected individually
- Meteonorm data base delivers detailed local weather input (hourly)

GLOBAL COST

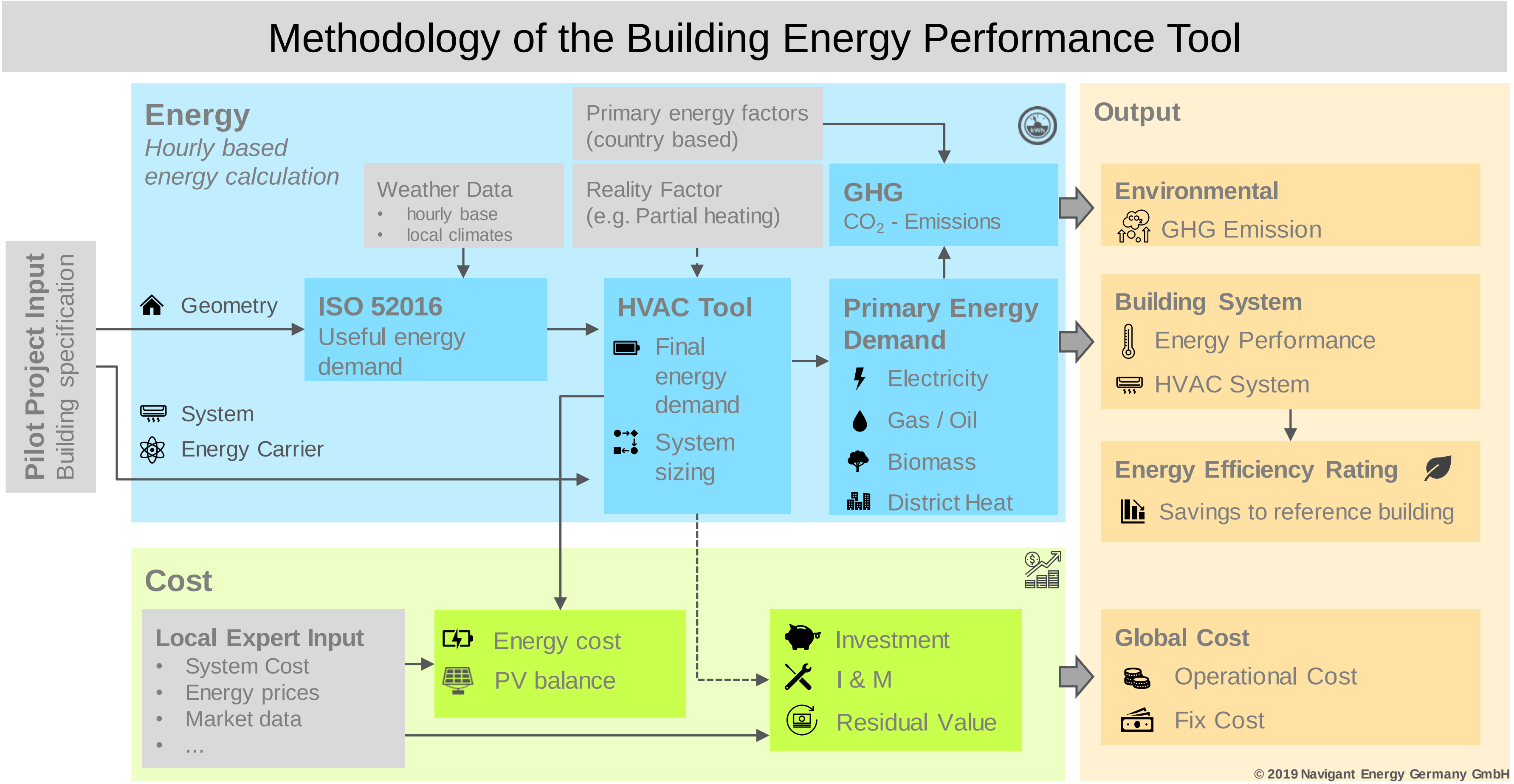
- Calculation of energy cost and investment cost of the systems, based on the HVAC system sized in the energy calculation
- Energy price systematic and PV clearing can be adapted to local situation (here: Jordan)
- Residual values at the end of the calculation period for the systems are considered

Methodology

Cost Benefit Analysis

HIGLIGHTS

- Besides classic CAPEX/ OPEX cost, it considers residual values
- Hourly based energy calculation
- Detailed local weather data is considered
- Energy price systematic and PV clearing adapted to local situation (Egypt)



Introduction
Boundary conditions

Photo by Matt Duncan on Unsplashed

Palm Hills, Alexandria

Aims

Creating a multifamily house that provides residents with the high levels of thermal comfort and provide an example of the energy efficient buildings in Egypt.

Target Groups

Upper middle class housing for families in Greater Cairo.

Function

A diverse range of residential units that will be offered for both sale and rental.

Size

Total area of around 1200 m2 on 6 floors. The building has 15 housing units with total number of around 60 occupants/users.

Boundary conditions

Site : Context matters

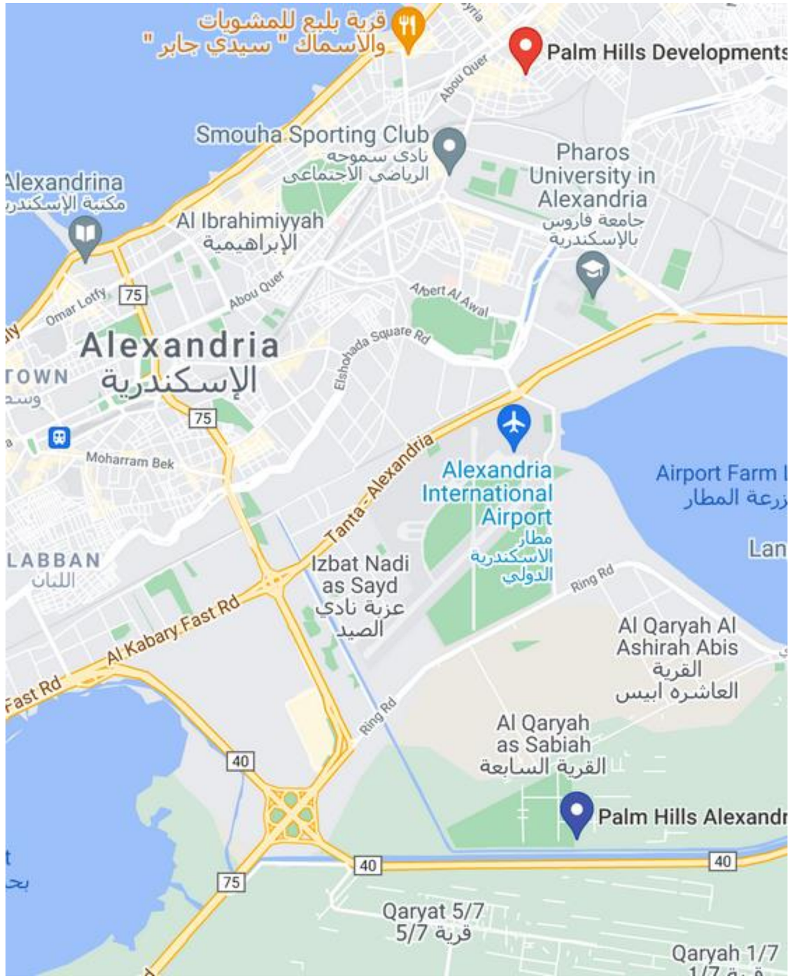
City : Alexandria

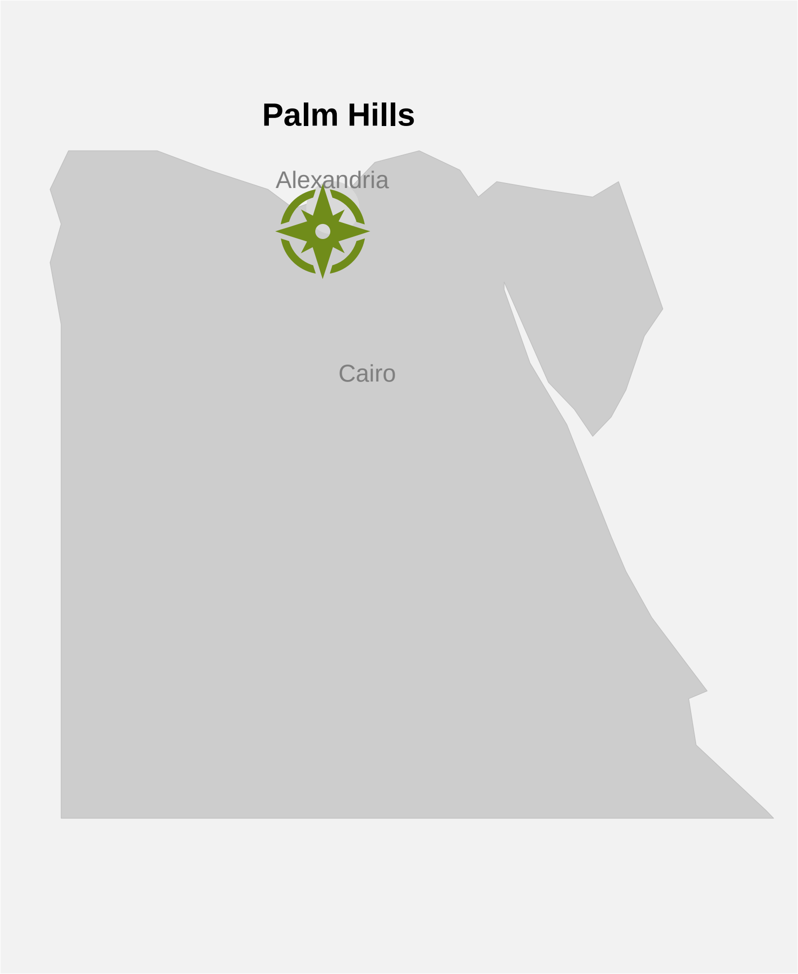
Location : Southern to the airport

Context

The building located is located in a gated community

Source: Google Maps



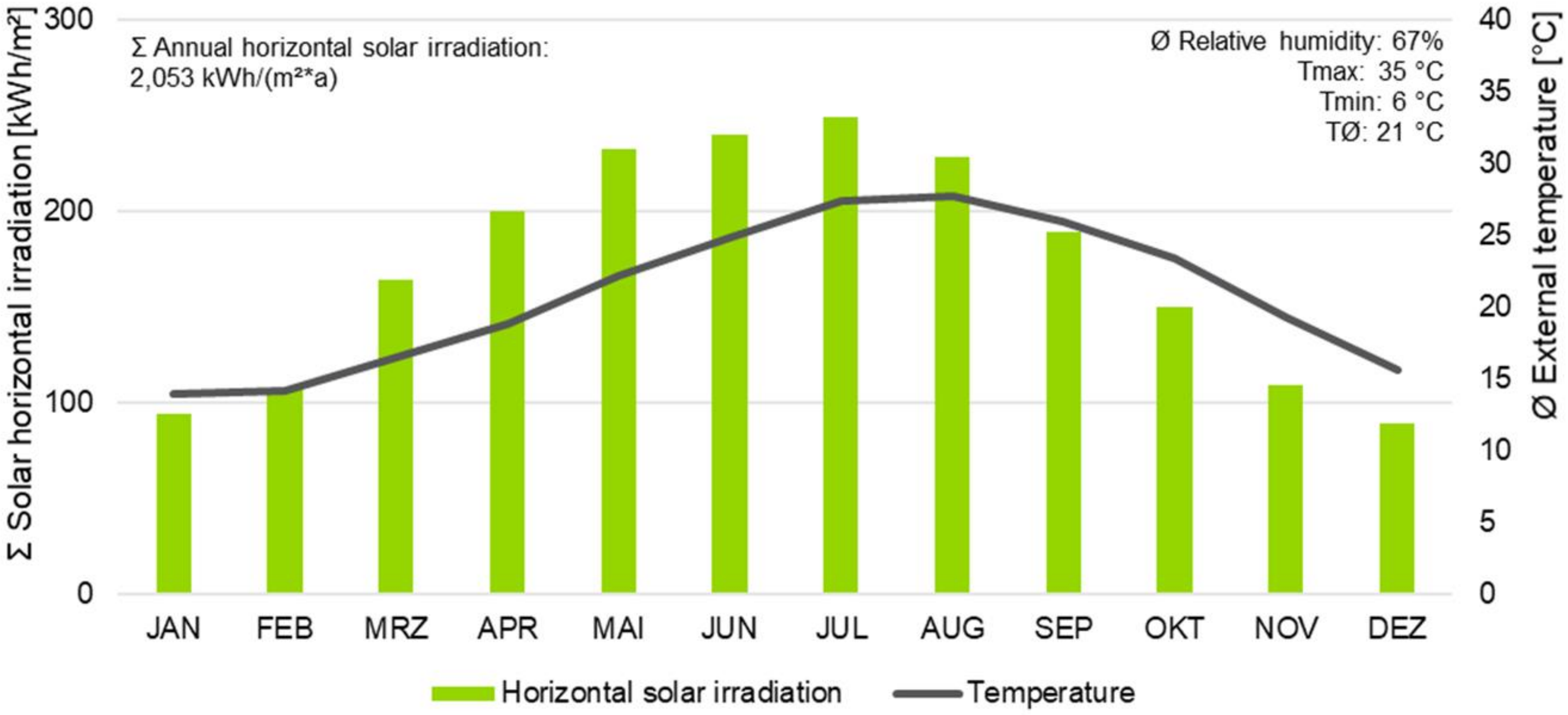


Boundary conditions I Climate Analysis

Alexandria

Description

External temperatures in Alexandria range from above zero to 35°C with yearly average temperatures around 21°C. January is the coldest month, August is the hottest one. The minimum temperature level does not fall below 0°C, which means that frost issues do not play a role in terms of construction projects.



Boundary conditions I Climate Analysis

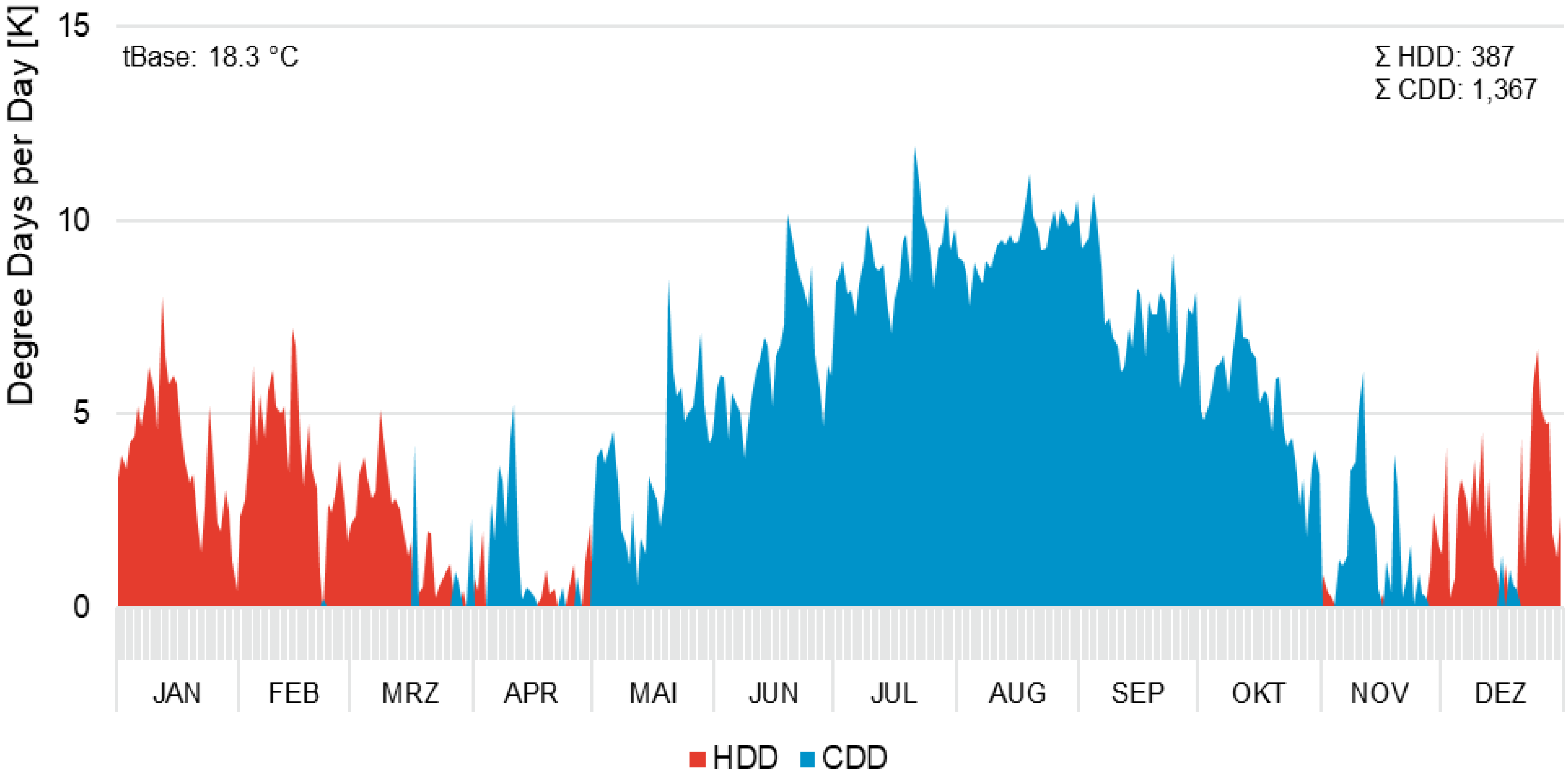
Heating and cooling degree days in Alexandria

Description

High number of >1,300 of CDD cooling degree days and a limited number of 291 of HDD heating degree days.

Challenges and Potentials

The amount of cooling degree days are roughly three times higher compared with the heating degree days. Therefore, a significantly larger amount of the energy demand accumulates for cooling.

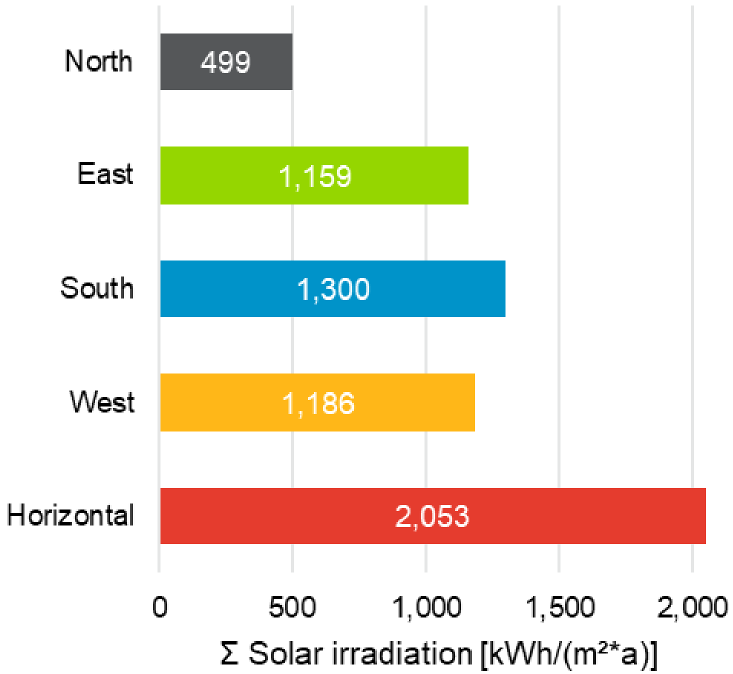


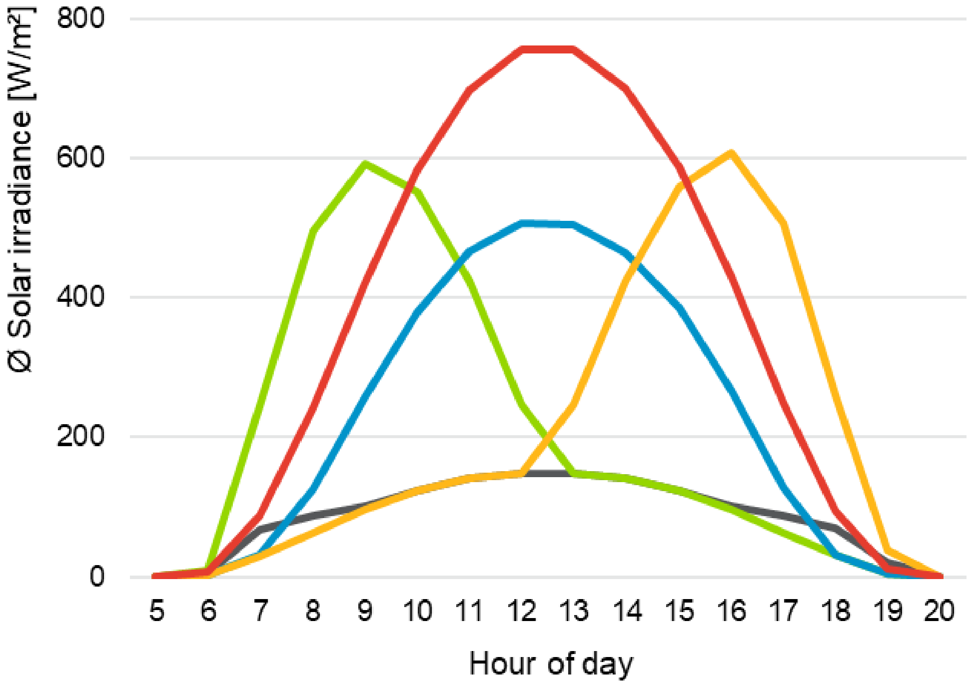
* Calculated according to ASHRAE 2001 methodology

Boundary conditions I Climate

Solar Irradiation in Alexandria (Egypt)

A big potential for renewable energy lies within the solar irradiation in Alexandria. Horizontal irradiation of > 2,000 kWh/(m²*a) and >1000 kWh/(m²*a) for East, South and West orientation bring opportunities for energy generation through solar radiation. Especially the solar energy for cooling purposes appears to be interesting for the area. Meeting the need of the population with a source that is already and infinitely in place.





Boundary conditions I Economic and Emissions Inputs

Cost of Energy and Environmental impact

Status

In Egypt, electricity is main source of power in household consumption. Natural gas is also used for cooking purposes.
Energy subsidies will be totally cut in 2023.

Objectives

Energy price increases are assumed in the future and will be calculated in.

Energy prices and CO2 emissions			
Parameter	Unit	Electricity	Natural Gas
Energy price	EG Pound/kWh	Mean 1.0 - 1.45	3.10 per m3
Energy price	EUR/kWh	0.056 – 0.082	0.18 per m3
Price development in the last 5 years	%/year	25%	6%
CO2 emission factor	gCO2/kWh	444	220
Economic parameters			
Interest rate (real)	%/year	9.25	
Calculation period	years	20	

- **Exchange rate: 1 EUR = 17.61 EGP as of 29.05.2020**

Boundary Conditions I Building

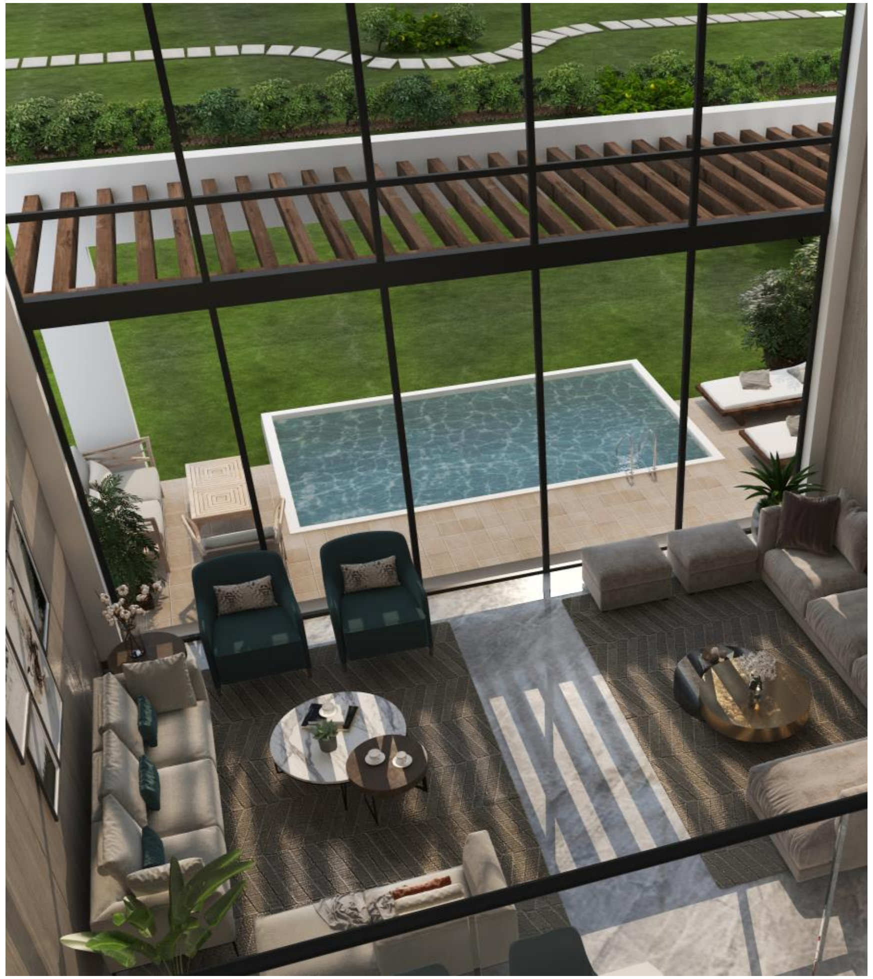
Building Data

Status

The multi-family house is under construction and planned to be delivered in 2022.

Specific Challenge

The high level of outdoor humidity in the summer.



Building Key Information	
Data	Input
Adress	5X55+9Q9, Qetaa an Nahdah, Al Amaria First, Alexandria
Utilization	MFH
Number of floors	4
Number of apartment	4
Conditioned floor area [m²]	800
Clear room height [m]	3,2
Conditioned volume [m³]	2540
Number of inhabitants [#]	24
Year of construction	2020-2022

Analysis

Starting Situation - Baseline and Curren planning

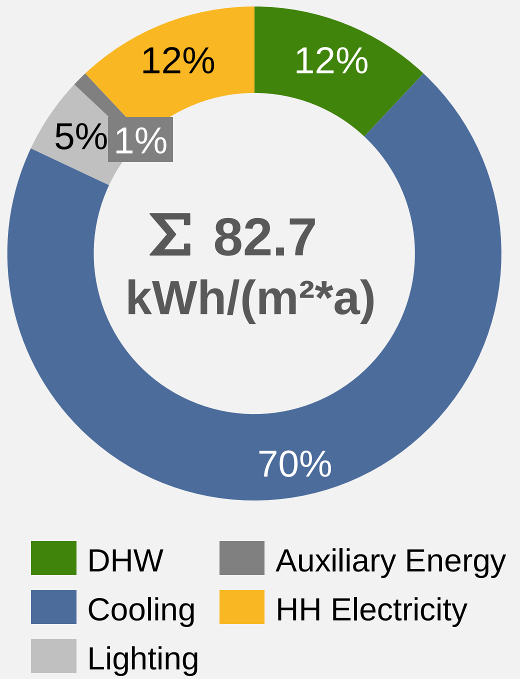
Photo by Jonathan Klok on Unsplashed

Business as Usual

Based on building typology analysis

The key components of the energy concept are illustrated in this table, it shows that the building envelope is in line with the thresholds of the baseline derived from the BUILD_ME building typology. A special attention needs to be put the inexistence of a heating supply.

Parameters	Baseline
Roof insulation (U-Value)	0.8 W/m²K
Wall insulation (U-Value)	2.4 W/m²K
Floor insulation (U-Value)	2.2 W/m²K
Windows (U-Value; G-Value)	5.7 W/m²K; 0.85
Window fraction	Ø 36%
Shading	Fixed shading
Air tightness	0.25 1/h
Heat supply	-
Cold supply	Single split - EER 3.4
Hot water	Direct electric
Ventilation systems	Free ventilation
Lighting systems	LED
Renewable energy	No
Set temperature cooling/heating	23°C (/ 20°C)



Energy Cost
5.8 EUR / (m²*a)

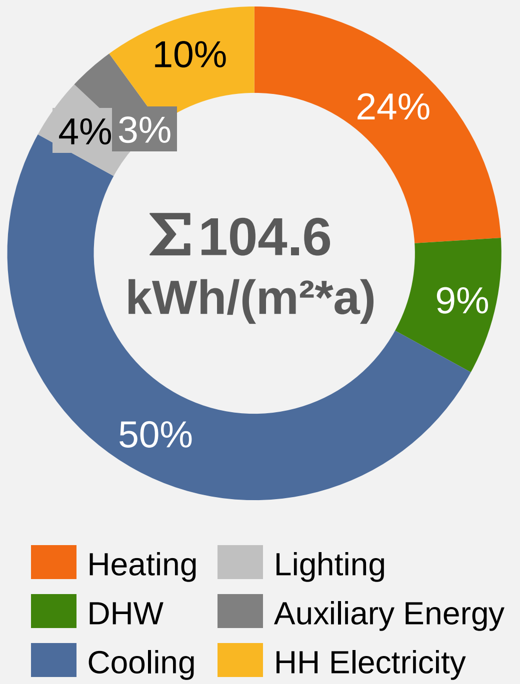
CO2 - Emission
3.0 kg / (m²*a)

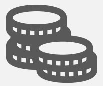
Current Situation

Building Characteristics as currently planned

The key components of the energy concept are illustrated in this table, it shows that the building envelope is in line with current planning of the project developer. The bold marked measures illustrate an improvement compared to the baseline (business as usual).

Parameters	Baseline
Roof insulation (U-Value)	**0.31 W/m²K**
Wall insulation (U-Value)	**3.0 W/m²K**
Floor insulation (U-Value)	**2.4 W/m²K**
Windows (U-Value; G-Value)	5.7 W/m²K; 0.85
Window fraction	Ø 36%
Shading	Fixed shading
Air tightness	0.25 1/h
Heat supply	**Reversible split – EER 4.4**
Cold supply	Single split - EER 3.4
Hot water	Direct electric
Ventilation systems	Free ventilation
Lighting systems	LED
Renewable energy	No
Set temperature cooling/heating	**24°C** / 20°C





Energy Cost
7.3 EUR / (m²*a)

CO2 - Emission
3.7 kg / (m²*a)

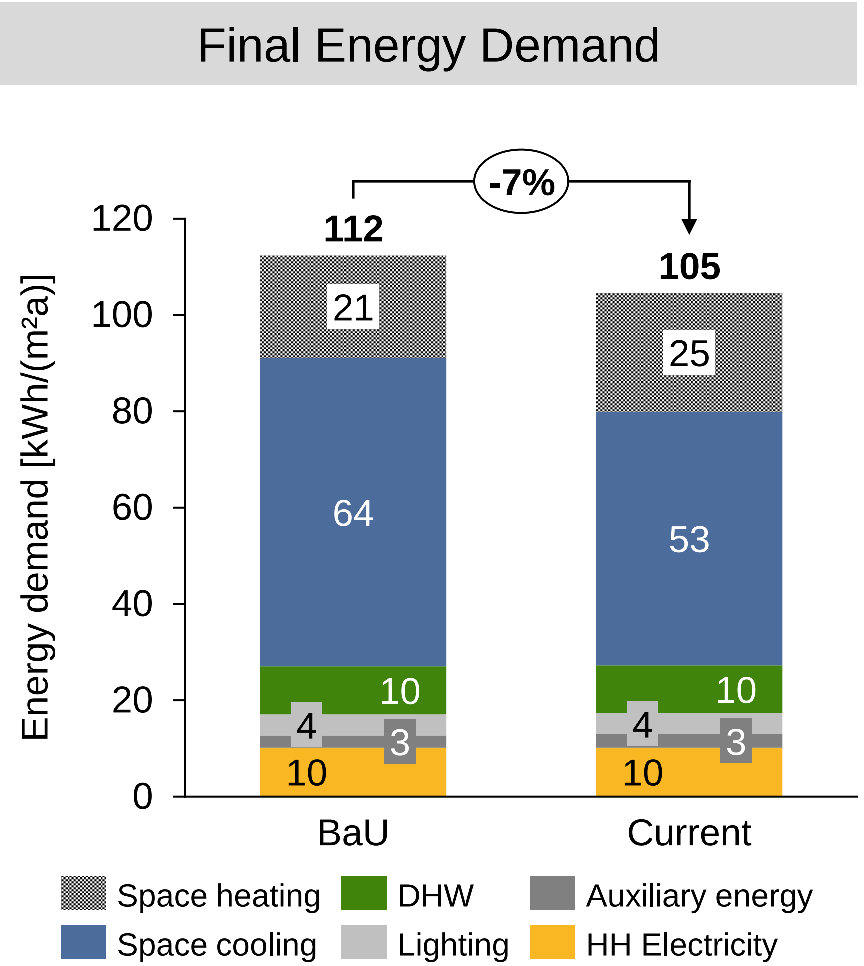
Comparison: BaU and Current Planning

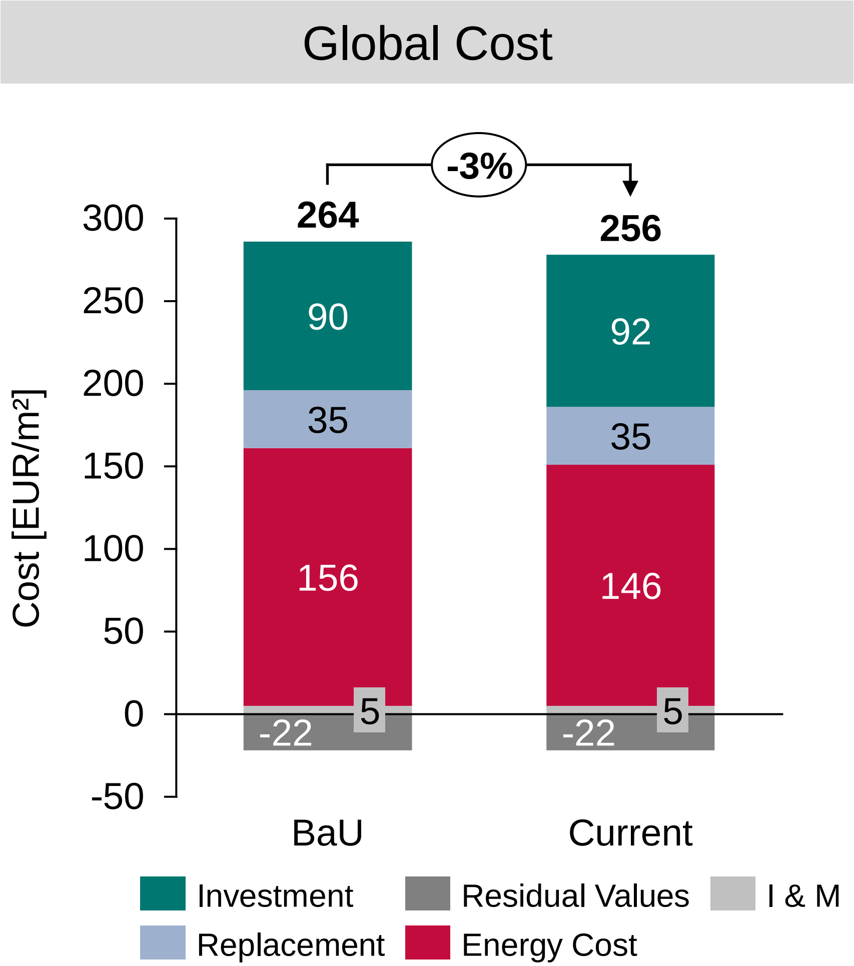
The current planning is already **more energy efficient** in comparison to the BAU cases.

The measures result in an overall **cost decrease** due to the slightly lower energy cost.

However, there is still a significant **optimization potential**.

Energy savings: 7%
Global cost savings: 3%





Analysis
Investigation of Possible Measures

Photo by Dan Dimmock on Unsplashed
Photo by Jonathan Klok on Unsplash

Building Envelope | External wall

Results

BaU: U-Value = 2.1 W/m²K
Single wall (25 cm bricks)

Var 1: U-Value = 1.11 W/m²K
Double wall with air gap 5 cm

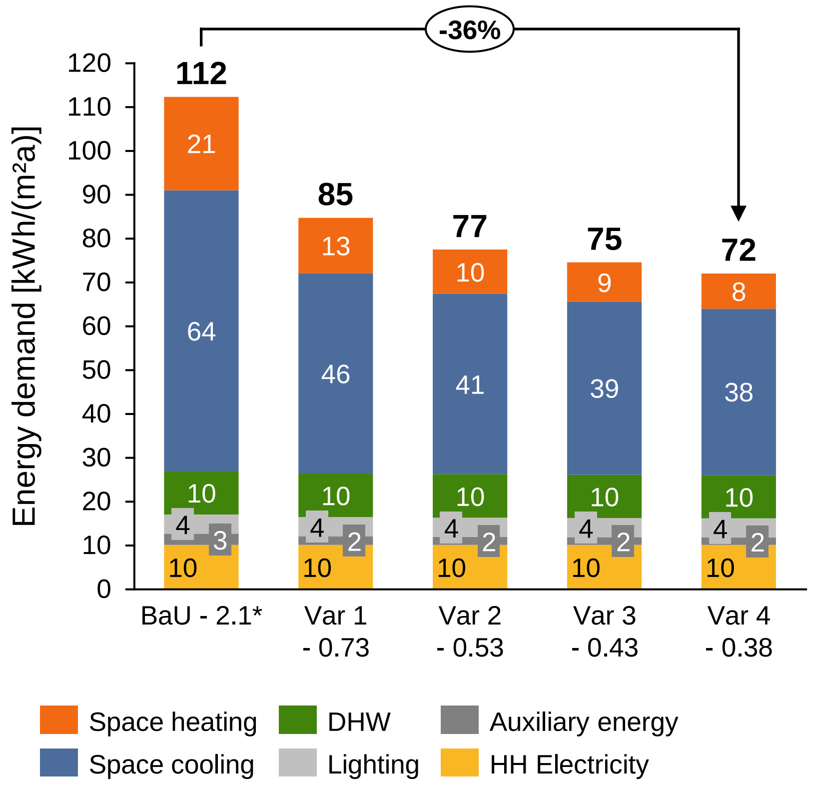
Var 2: U-Value = 0.73 W/m²K
Double wall 2cm air gap, 3cm insulation

Var 3: U-Value = 0.53 W/m²K
Double wall 2cm air gap, 5cm insulation

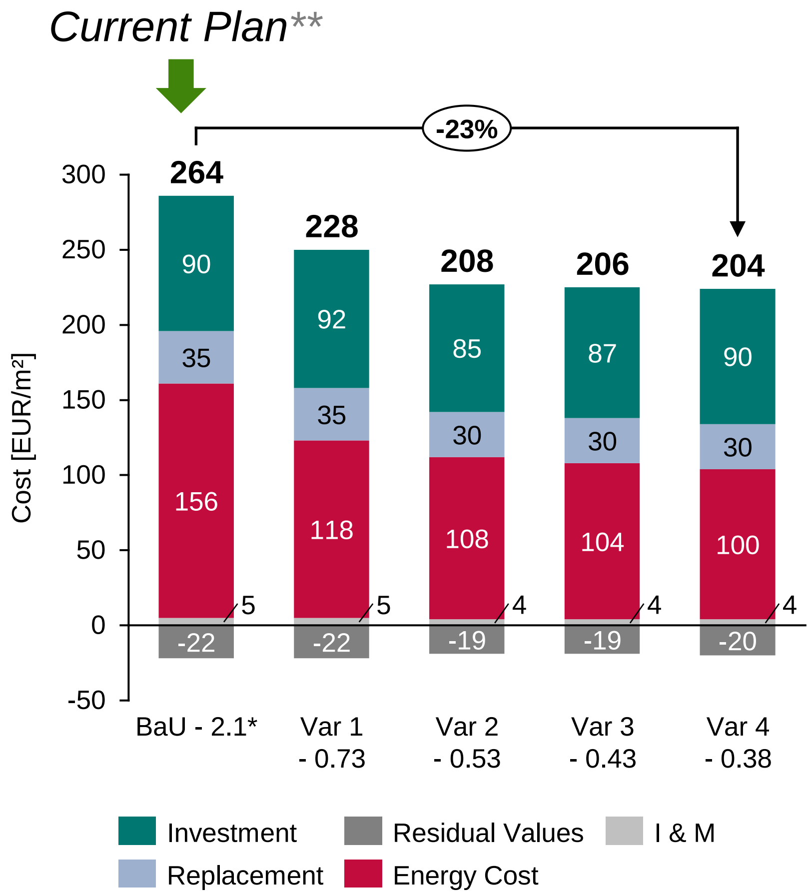
Var 4: U-Value = 0.38 W/m²K
Double wall 2cm air gap, 8cm insulation

Result: Var 4 with **8 cm insulation** is the most cost effective measure.

Final Energy Demand



Global Cost



*Baseline is 2.4, BaU as measure 2.1

**Current plan is actually even worse than BaU

Building Envelope | Roof

Results

BaU: U-Value = 3.2

2cm plaster, 20cm concrete slab,0.4cm waterproof membrane, 5cm slope concrete, 3 cm gravel

Current (Var 4): U-Value = 0.31 W/m²K

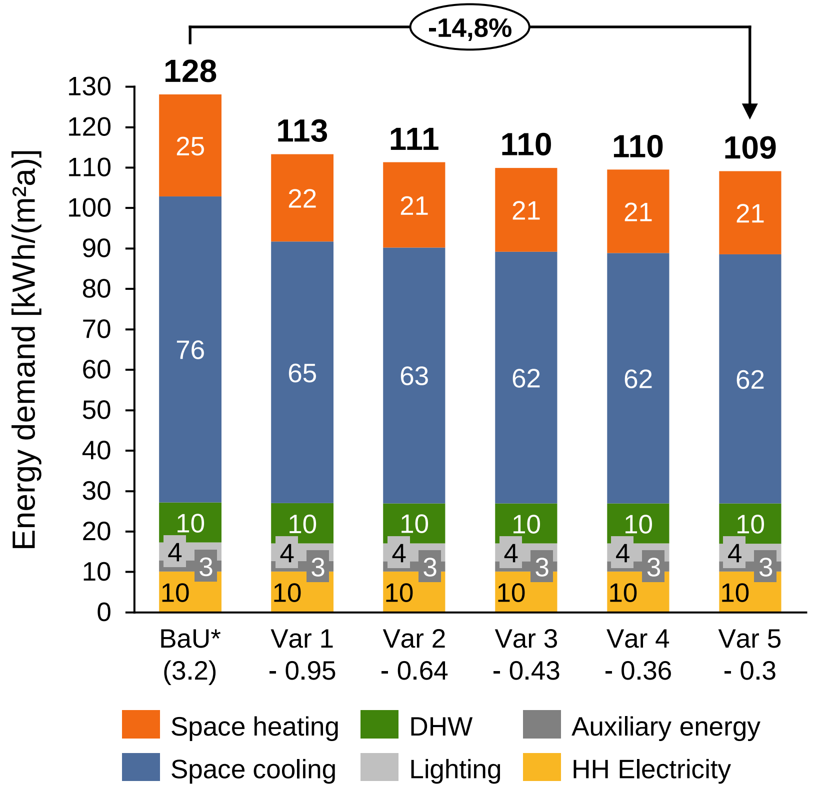
BaU + 12 cm insulation material

Var 1 – 4: U-Value = 0.95 – 0.3 W/m²K)

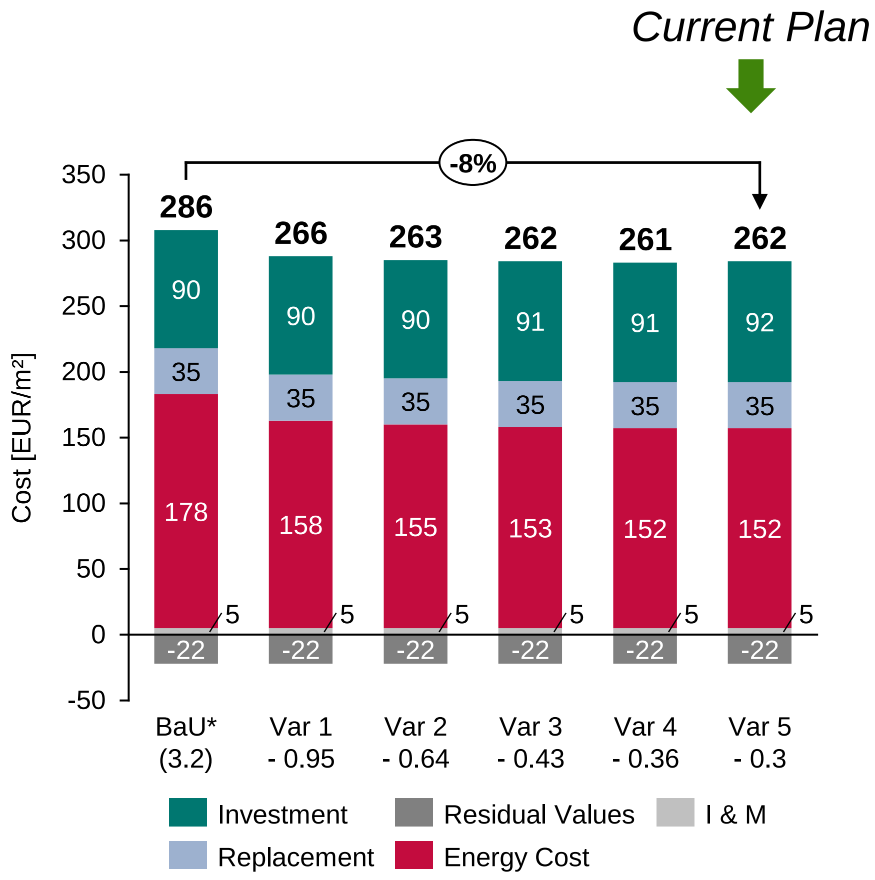
BaU + 3 | 5 | 8 | 10 | 12 cm insulation

Result: Current project plan is very cost effective, compared to the BaU.

Final Energy Demand



Global Cost



*Baseline is 0.8, BaU as measure is 3.2

Building Envelope | Windows

Results

BaU – Single glazing

U value 5.7 W/m²K
G-Value 0.85

Double glazing (Var 1)

U value 2.9 W/m²K
G-Value 0.7

Double glazing low E

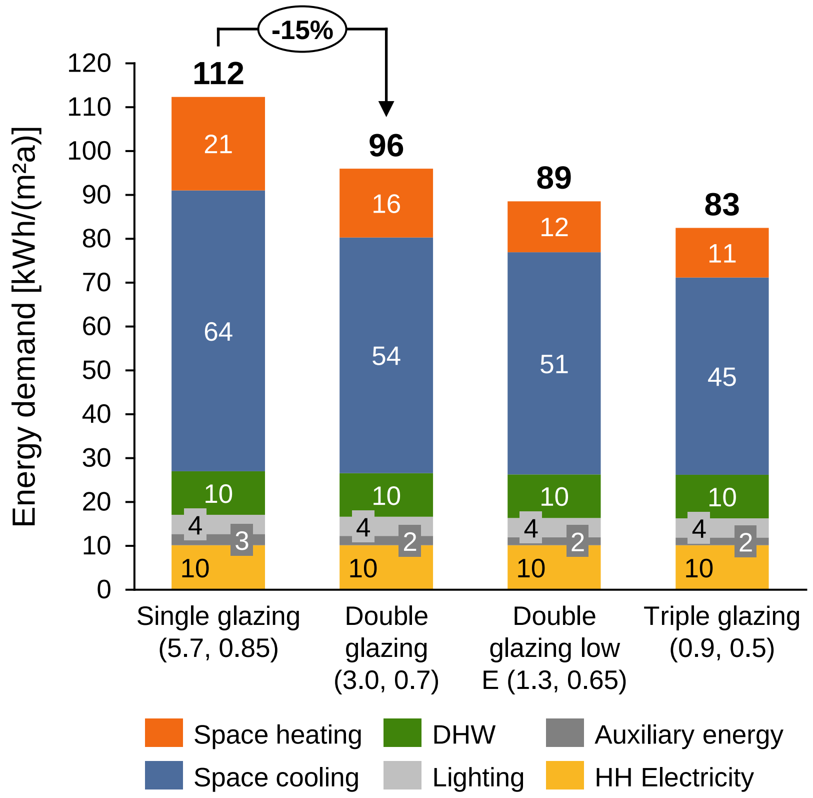
U value 1.3 W/m²K,
G-Value 0.7

Triple glazing

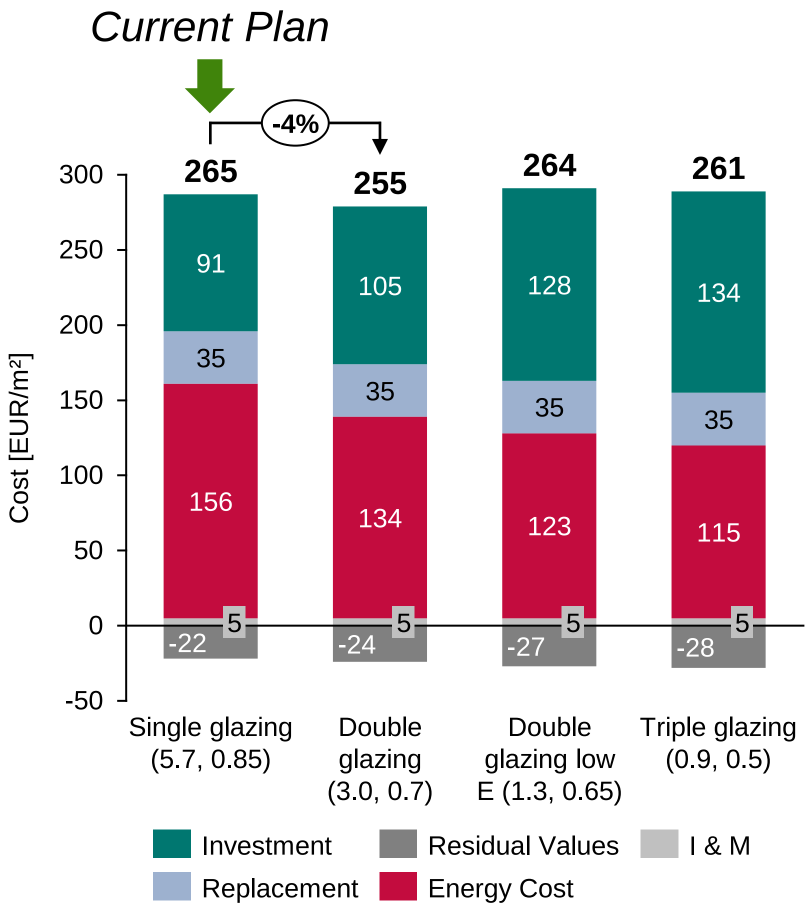
U value 1.3 W/m²K,
G-Value 0.7

Var 1 (double glazing) is the more cost-effective case, with improved but not best window.

Final Energy Demand



Global Cost



Window Fraction

Analysis

Var 1

Window fraction 40 %

Var 2

Window fraction 30 %

Var 3

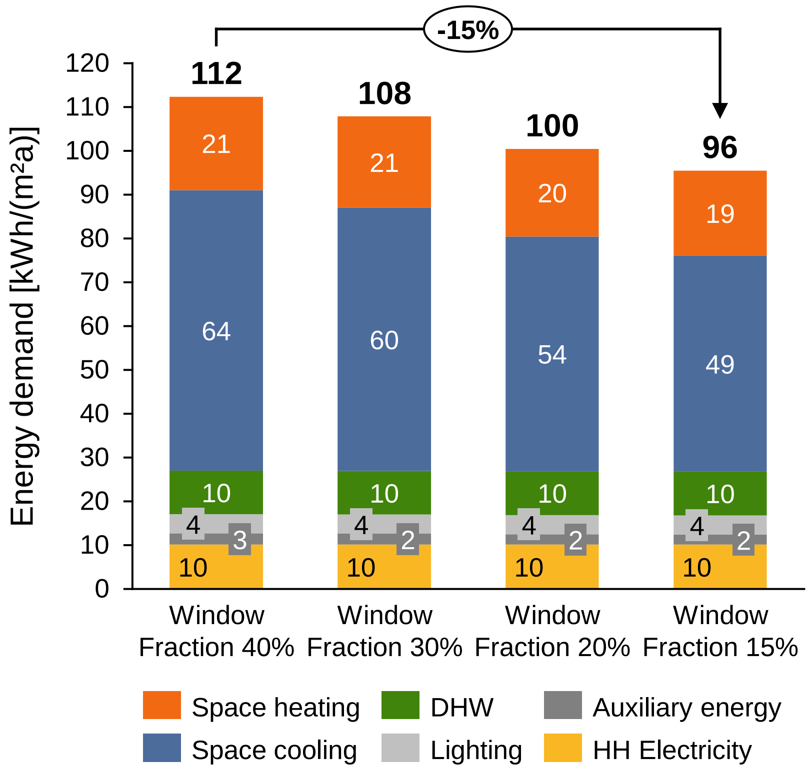
Window fraction 20 %

Var 4

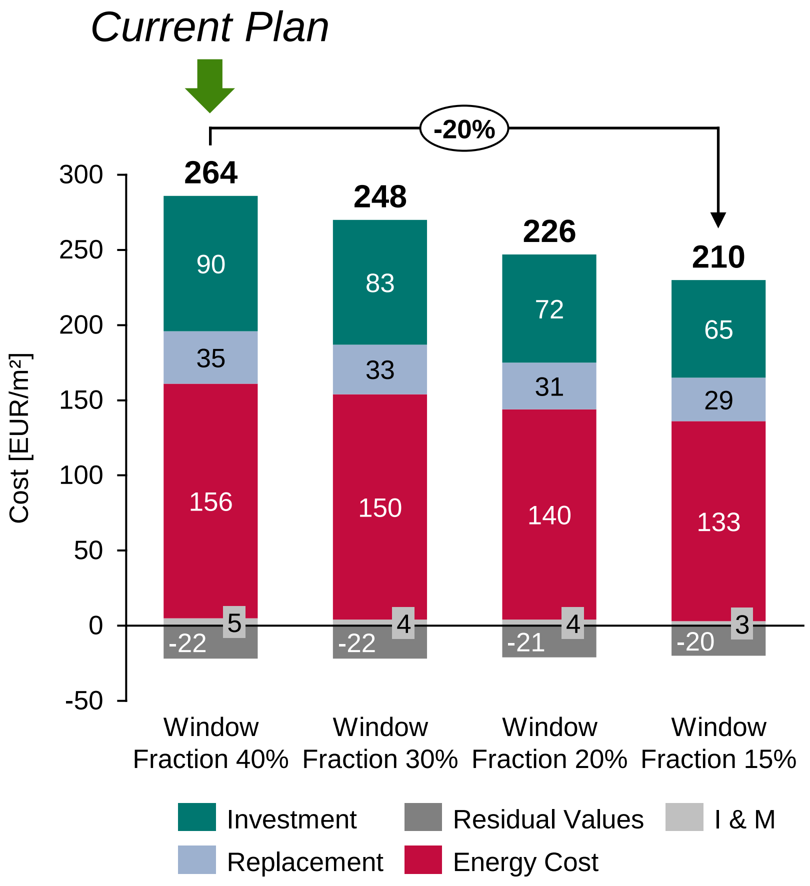
Window fraction 15 %

Reducing the window fraction causes significant reduction in energy demand with negative cost, hence is very cost-effective.

Final Energy Demand



Global Cost



Shading concept

Analysis

BaU
No shading

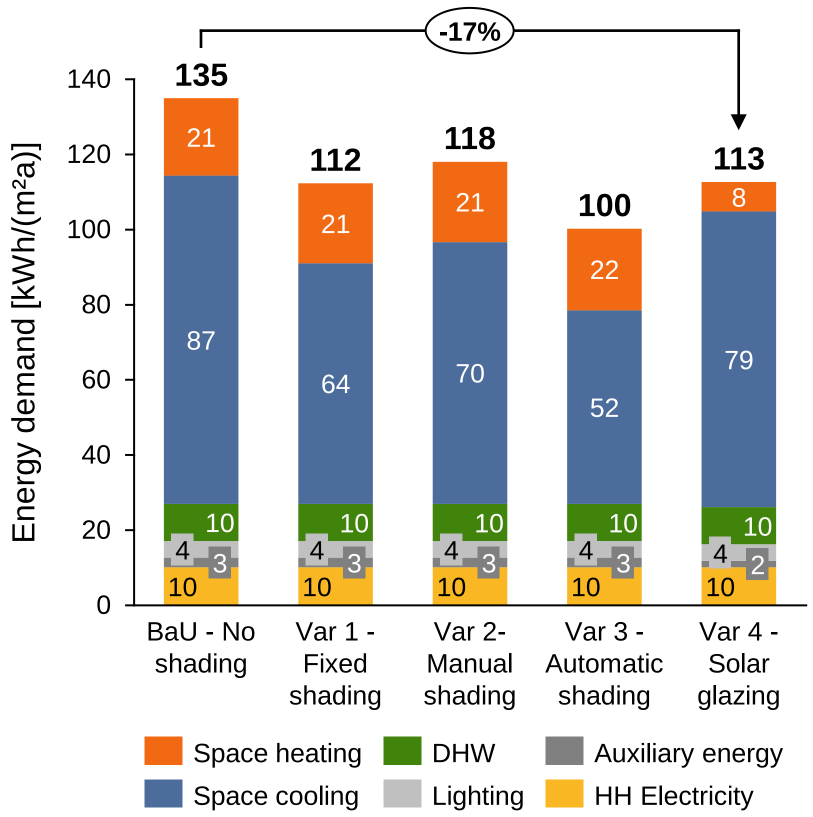
Var 1
Fixed overhangs

Var 2
Manual shading

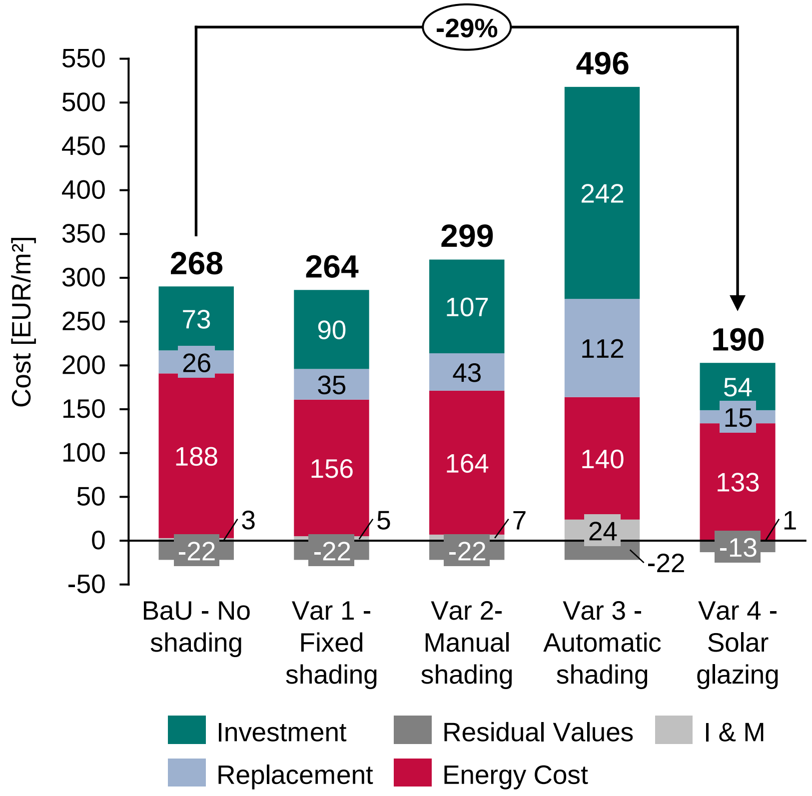
Var 3
Automatic shading

Var 4
Solar glazing

Final Energy Demand



Global Cost



Var 4 is the most cost effective measure.

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Air Tightness

What is the effect of air tightness?

BaU
0.25

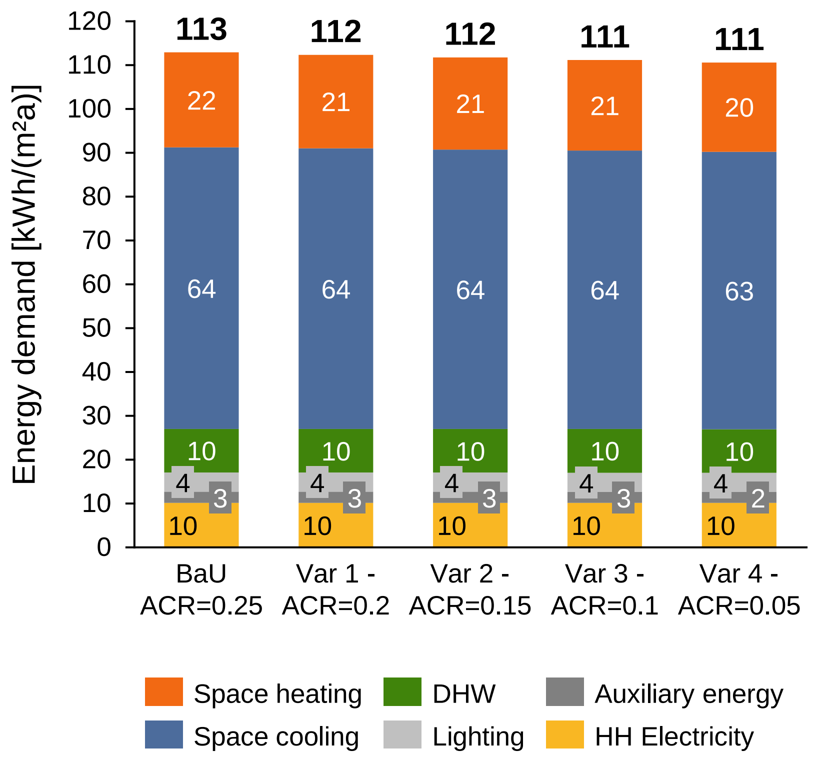
Var 1
0.20

Var 2
0.15

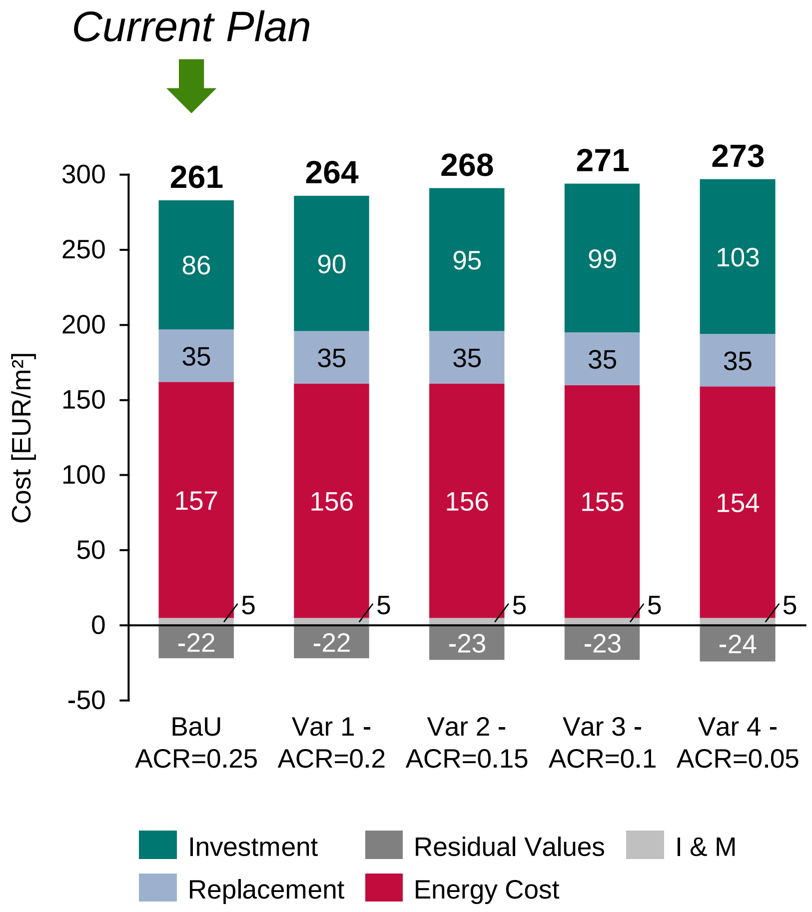
Var 3
0.1

Var 4
0.05

Final Energy Demand



Global Cost



BaU (current) is the most cost effective measure.

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HVAC | Efficiencies

Analysis

BaU

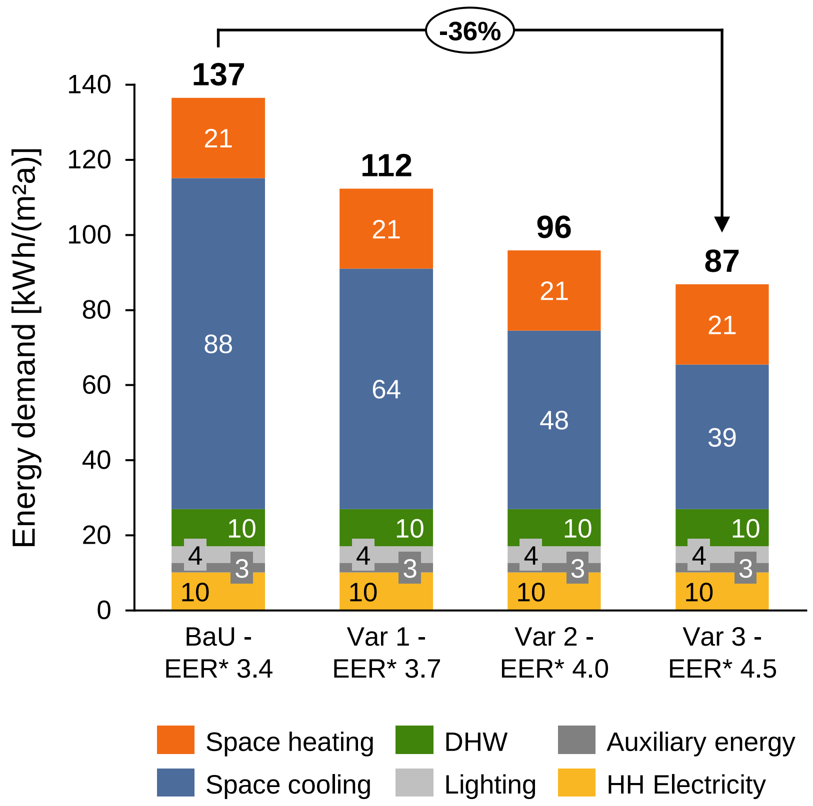
Reversible Split Unit.
Real annual EER: 3.4

Var 1 | 2 | 3

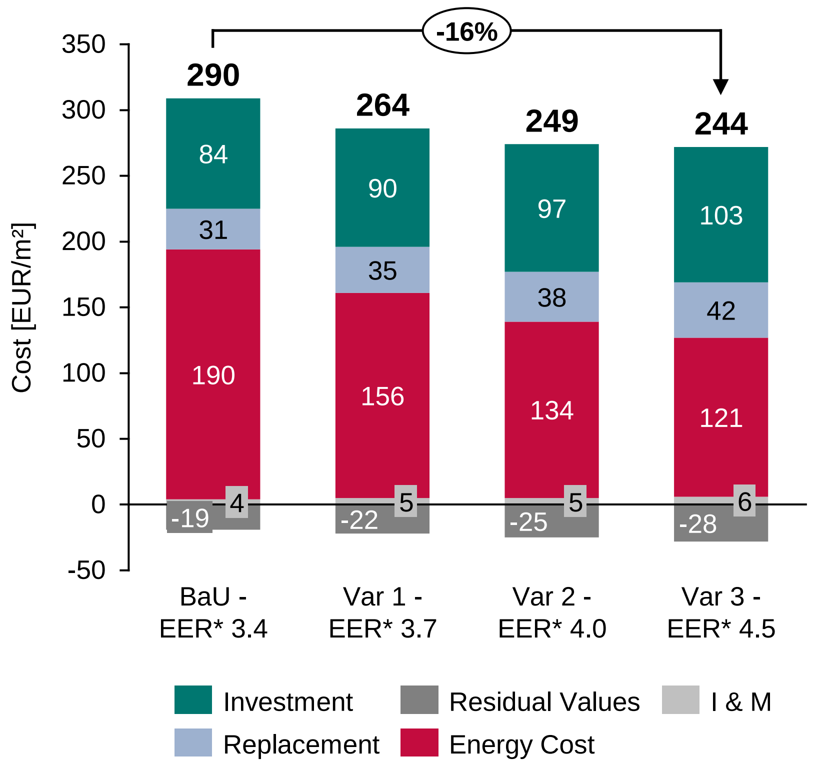
Reversible Split Unit with increased efficiency.
Real annual EER: 3.7 | 4.0 | 4.5

Var 3 (System with best COP) has the highest effect and is cost-effective.

Final Energy Demand



Global Cost



*resulting EER over year

Operational Temperatures

Analysis

BaU

Cooling Temperature: 23°C
(Heating Temperature: 20°C)

Var 1 - 3

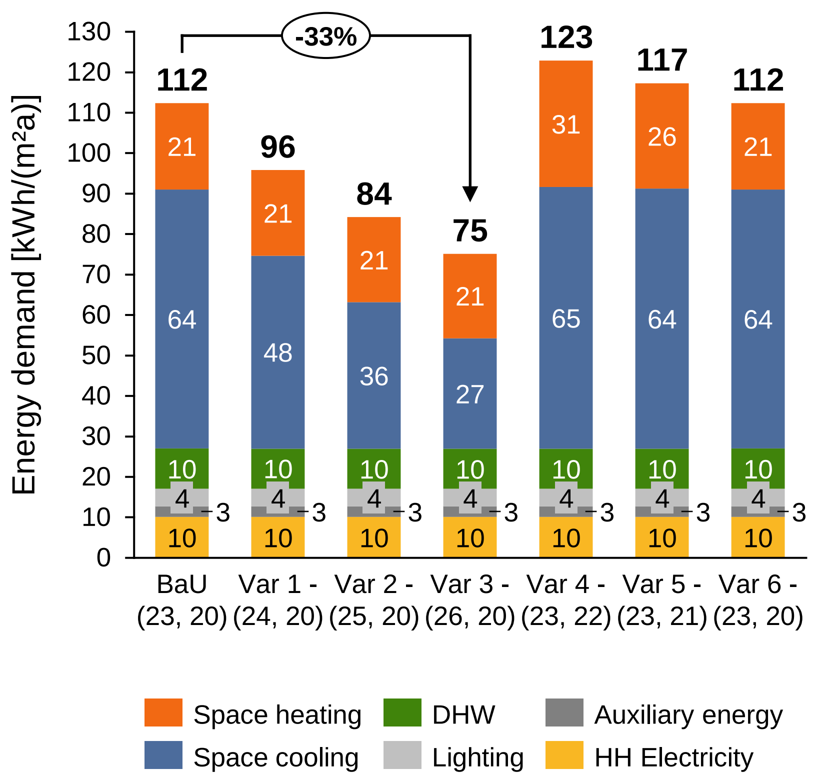
Cooling Temperature adapted
(24°C - 26°C)

Var 4 - 6

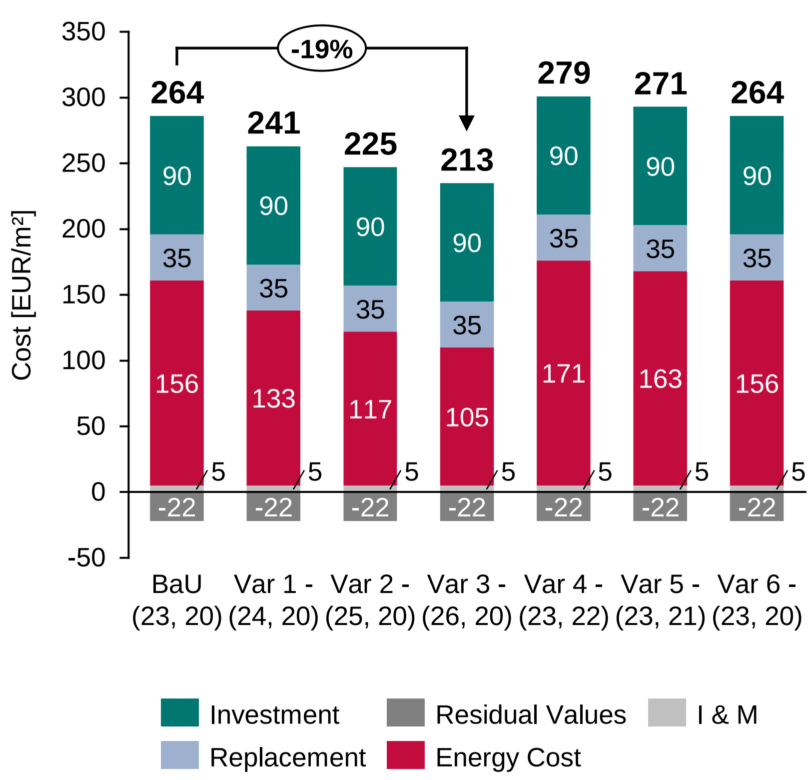
Heating Temperature adapted
(22°C - 20°C)

This measure is very effective and not related to any cost

Final Energy Demand



Global Cost



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Renewables | Solar

Analysis

Sizing of solar for domestic hot water

BaU / Current

No solar installed.

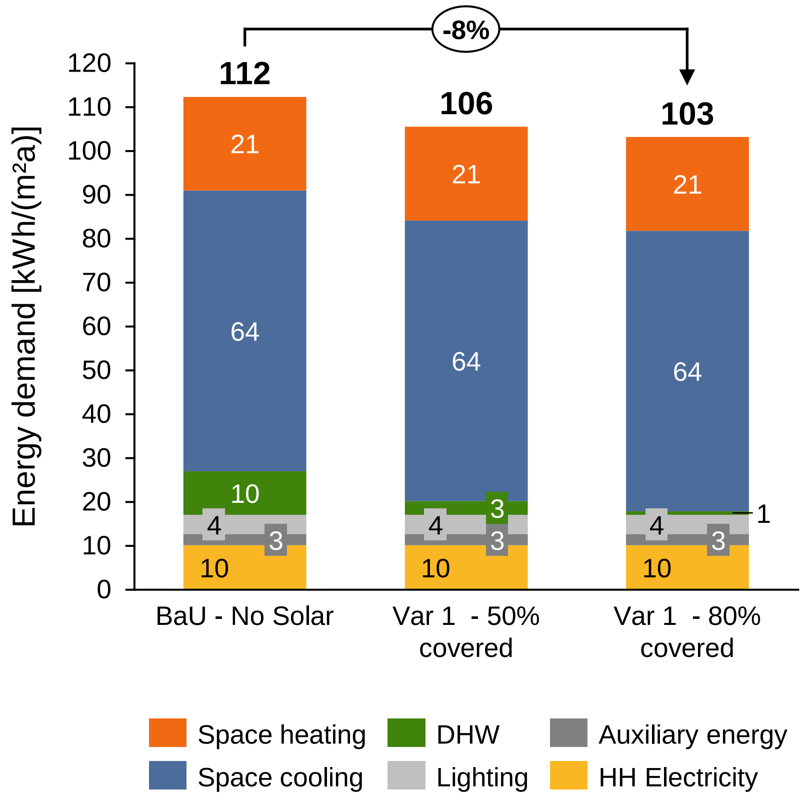
Var 1 | 2

Collector area: 4 m² | 8 m²

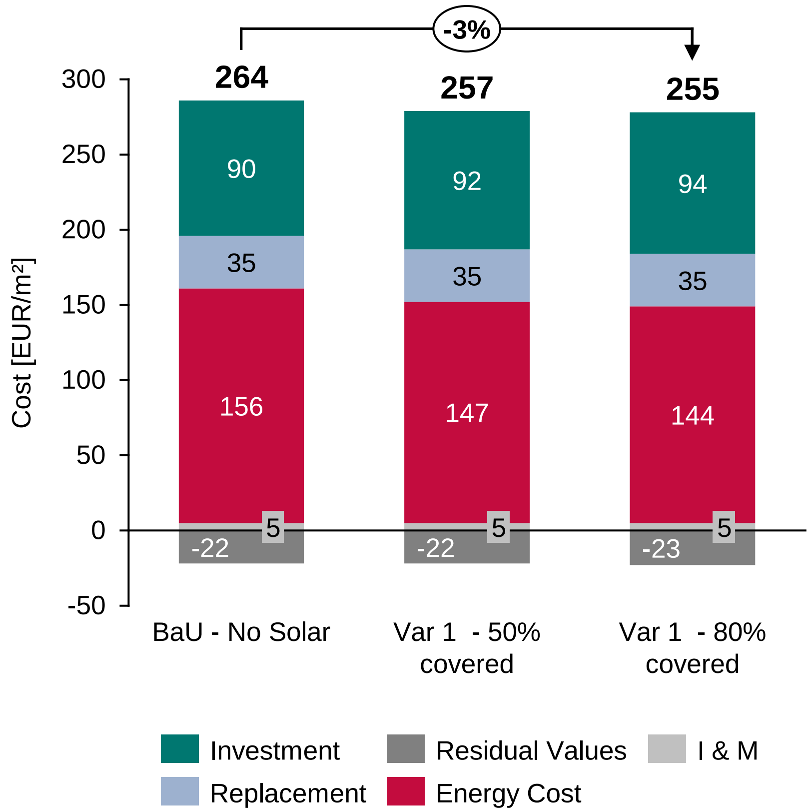
(Thermosyphon system)

Use of solar collectors for DHW is cost effective.

Final Energy Demand



Global Cost



Renewables | PV
Analysis

Sizing (net metering as assumption)

BaU / Current

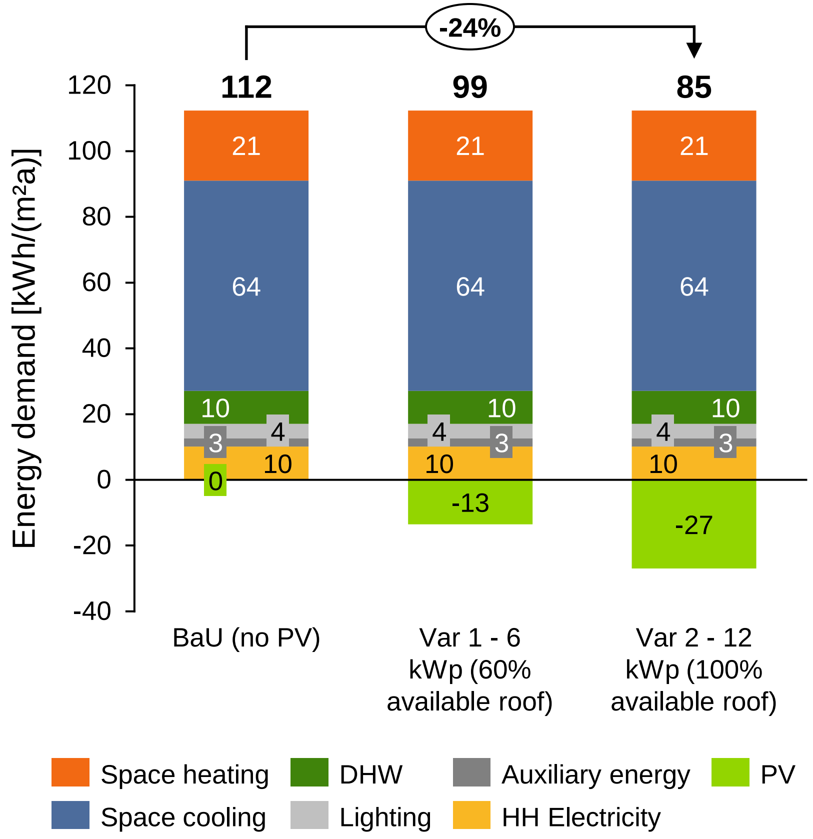
No PV installed.

Var 1 | 2

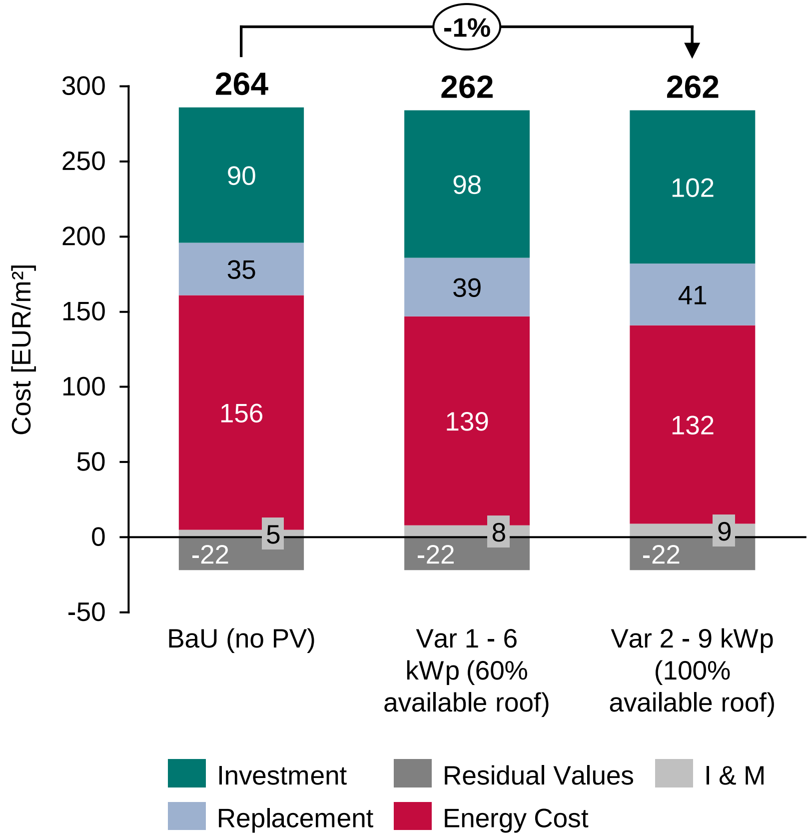
PV 6 | 9 kWp
(Roof area 42 | 60 m²)

Var 1 & 2 with **6 & 9 kWp** PV are cost effective measure. Additional FiT would favour Var 2 with more capacity.

Final Energy Demand



Global Cost



X% = Share of total roof area necessary for PV

Results & Conclusion

Photo by Xan Griffin on Unsplash

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Overview of recommended measures

Four steps to reduce energy demand significantly

Building envelope

- External wall -> U-Value 0.38
- Roof -> U-Value 0.38 (as planned)
- Windows -> double glazing (U-Value 3.0 W/m²K, G-Value 0.7)
- Shading -> additional solar glazing (G-Value 0.3)

HVAC

- Reversible Split Unit heating / cooling with high efficiency (EER >4)
- Fan coil distribution as cost-effective variant

Renewable (Solar) Energy

- PV 8 kWp (ca. 50 m², instead of 60 m² to leave space for solar hot water collectors)
- Solar: 8 m² collector area

Behavior

- Change set temperature from Cooling 24°C to Cooling 26°C

Optimized Solution

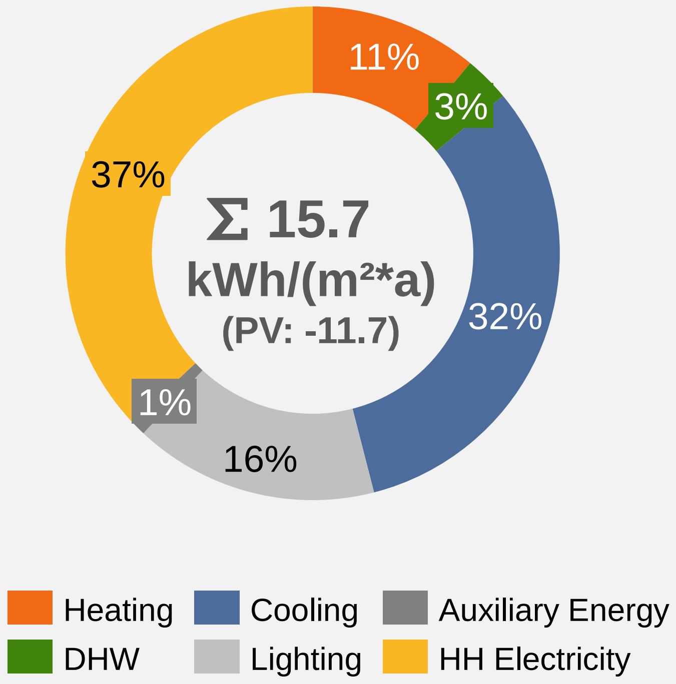
Results

The key components of the energy concept are illustrated in this table, it shows that the building envelope is significantly enhanced to the current building code.

Special attention is given to the use of renewable energy sources in terms of PV (for electricity).

This leads to energy savings and emission reduction.

Parameters	Optimized Building
Roof insulation (U-Value)	**0.31** W/m²K
Wall insulation (U-Value)	**0.38 W/m²K**
Floor insulation (U-Value)	2.2 W/m²K
Windows (U-Value; G-Value)	**3.0 W/m²K**; **0.3**
Window fraction	Ø 36%
Shading	**Solar Glazing**
Air tightness	0.25 1/h
Heat supply	Reversible split unit - **COP 3.7**
Cold supply	Reversible split unit - **EER 4.5**
Hot water	Direct electric
Ventilation systems	Free ventilation
Lighting systems	LED
Renewable energy	**8 kWp (PV), 8 m² (solar)**
Set temperature cooling/heating	**26°C** / 20°C



Energy Cost
1.1 EUR / (m²*a)

CO_2 - Emission
0.6 kg / (m²*a)

Comparative overview

BaU vs. Current vs. Optimized

Conclusion

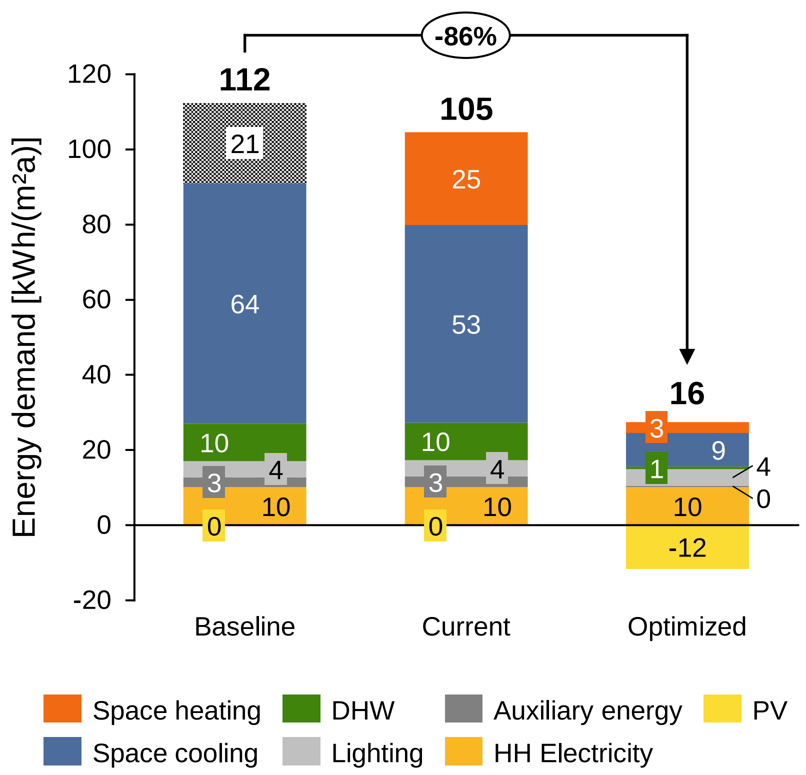
- The suggested measures and the current situation lead to a **significant decrease in energy demand**
- The optimized solution, detected **the most cost effective efficiency measures**

Savings

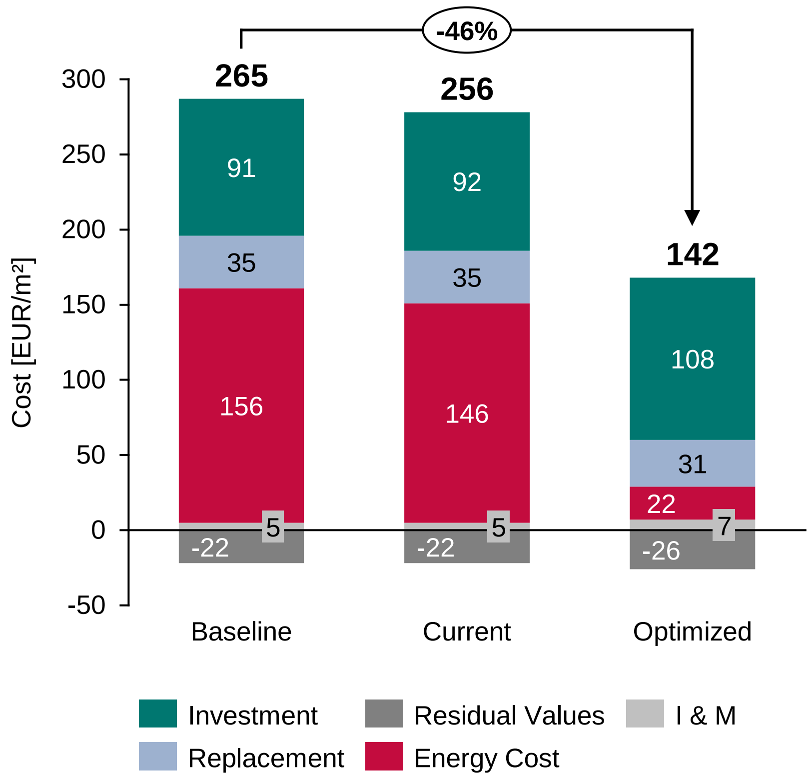
Energy: - 86%

Cost: - 46%

Final Energy Demand



Global Cost



Optimized vs. current

Payback of single measures and whole package

Parameters	Optimized	Investment (optimized-current) [EUR]	Energy cost savings* [EUR / year]	Payback [years]	Lifetime [year]
Wall insulation (U-Value)	0.38 W/m²K	5,800	-850	7	40
Windows (U-Value; G-Value)	0.9 W/m²K; 0.5	11,100	-1,000	12	30
Shading	Solar glazing	13,500	-1,500	9	30
Heat/Cold supply	reversible split unit - COP 5.3	15,000	-3,300	5	15
Renewable: Solar energy for DHW	8 m²	2,900	-614	5	15
Renewable: PV	8 kWp	8,000	-1,050	9	15
Total (current to optimized)**		**56,300 (+7- 10%)*****	**-8,314 (-36%)**	**7**	

* Remark: The energy cost savings have been calculated conservatively based on the current electricity starting price (appr. 8 Cent/kWh).

** Remark: Investment and savings of single measure savings cannot be summed up due to synergies between the measures (e.g. lower window fraction leads to lower cooling supply costs).

*** Remark: Compared to costs of current case and overall construction costs assumptions of 700 or 1000 Euro/m² (10 or 7 % additional costs).

Key conclusion

Main takeaways for the Mansoura Library Project

Improve further the building envelope

- Increase the thermal insulation for the external wall and roof -> **energy savings up to 36 % / 15 % are possible**
- Utilize double-glazed Windows with a U-Value around 3.0 W/m²K -> **energy savings over 15 % are possible**
- Solar glazing could reduce “unwanted” solar gains -> -> **energy savings over 17 % are possible**

Use Top performer - HVAC

- Use Top performer in the market as the price increase compared to inefficient, cheaper appliances will be recompensated throughout is lifetime **-> PBP 5 years**

Size renewable (Solar) to demand

- Make use Solar Thermal System to supply hot water
- The use of a PV system on the available roof area is cost effective.
- Enable one clearly defined area for PV + ST on the roof (avoid distorted small areas)

Behavior – Buy in User

- Buy in the user to utilize the appropriate set temperature, too low set temperature in the summer could consume too much energy -> 1K equals roughly 10% of energy

Contact

Riadh Bhar
Managing Consultant
riadh.bhar@guidehouse.com

Eslam Mahdy
Senior Consultant
eslam.mahdy@guidehouse.com

Rana Abouzeid
Researcher
rana.abouzeid@idg.com.eg