Energy Efficiency Recommendations for Cairo West Residence, Aldau Development Egypt

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

May 2021

Introduction

The IKI project of BUILD_ME “Accelerating 0-emission building sector ambitions in the MENA region” is divided into four work packages as follows:

- WP1: Preparatory Steps for Implementation
- WP2: Support the implementation of pilot projects
- WP3: Framework conditions to increase the EE in the building sector
- WP4: Capacity building and dissemination

WP2 consists of four activities. It starts with updating the pilot projects evaluation matrix that had been developed in the first phase of the project. After the identification and selection of the pilot projects, the project team works closely with the pilot project developers and teams to define the proposed energy efficient measures for each pilot project. Finally, a summary of the Work Package activities and the lessons learned will be summarized in a report. The outcomes and lessons learned of WP2 should benefit and support the activities of WP1 and WP3 as well as WP4 where the results will be disseminated.

Cairo West Residence of Aldau Development had been selected as a pilot project within BUILD_ME in Egypt. This report represents the analysis and recommendations of one of the multi-family buildings of Cairo West Residence. The analysis includes the definition of boundary conditions such as the climate analysis, economic and emissions aspects. The energy efficiency recommendations cover the passive measures, building envelope, renewable energy and building system measures.

Contents

1 Introduction

- Background and project description
- The Cairo West Residence Project Boundary conditions

2 Analysis

- Starting Situation - Baseline and Current planning
- Investigation of Possible Measures

3 Results

- Recommendations
- Comparative overview
- Conclusion

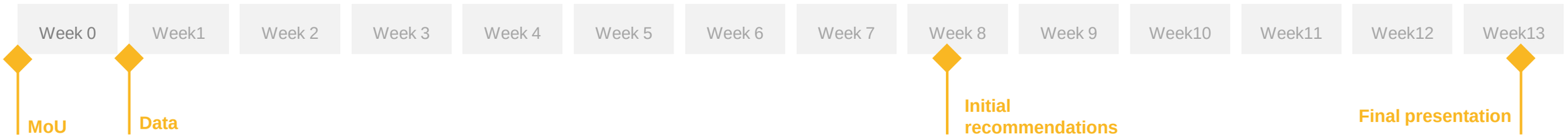
Introduction

BUILD_ME Project and the Objectives of Pilot Projects

Approach and Methodology

Steps Towards a Low Energy Building

1 Starting	2 Boundary Conditions	3 Analysis	4 Development	5 Final Recommendations
▪ Introduction of BUILD_ME ▪ Signing of MoU ▪ Kick-off Meeting (s) ▪ Provide Building Info.	▪ Climate Analysis ▪ Economic Aspects ▪ Building Baseline ▪ Definition of packages	▪ Building Envelope ▪ HVAC I Efficiencies ▪ Renewables ▪ Other Measures	▪ Discussion with Developers ▪ Local and Market inputs ▪ Costs and ROI	▪ Final presentation ▪ Final list of recommendations ▪ Site visits support



Methodology

Cost Benefit Analysis

HIGHLIGHTS

- 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.

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

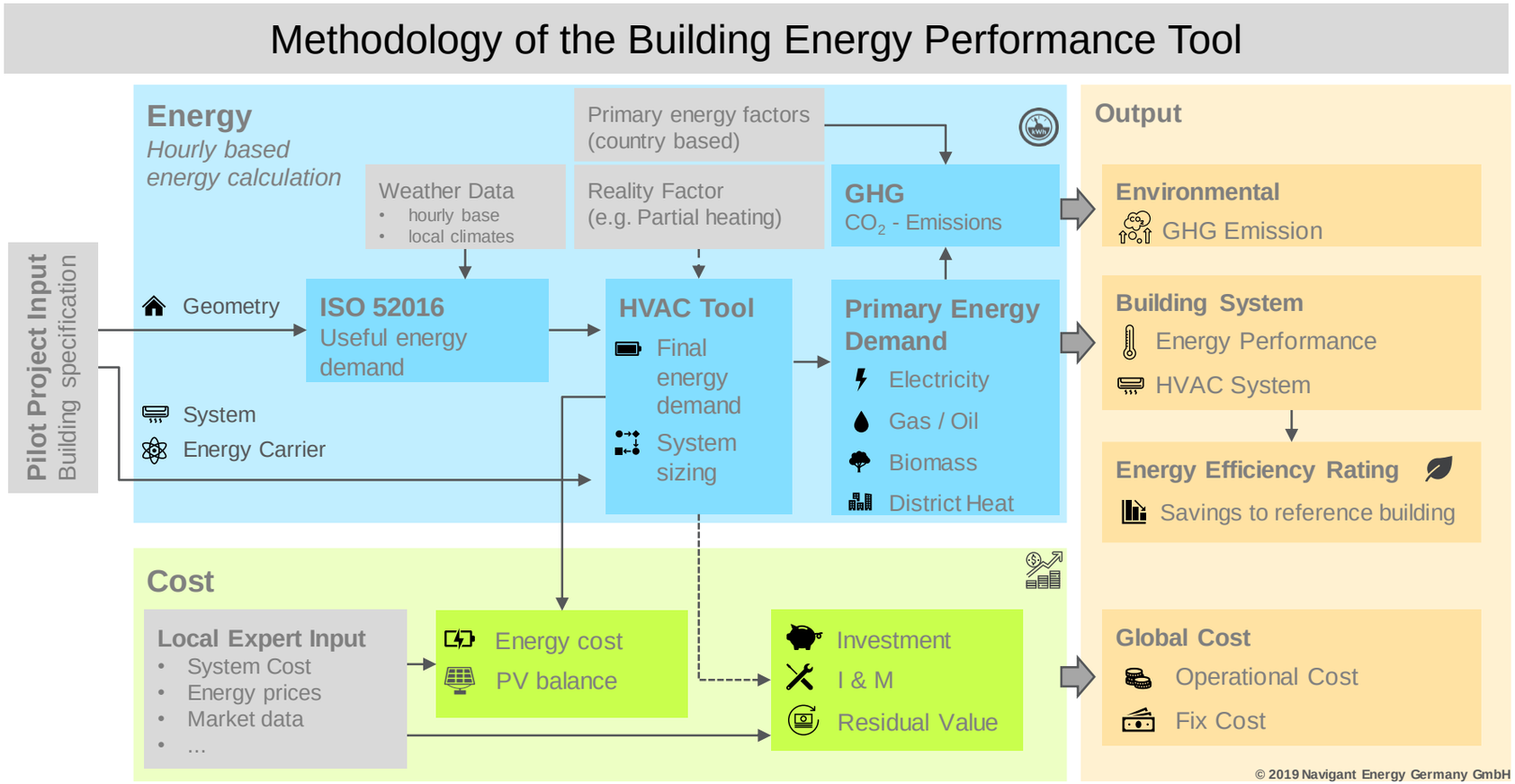
- Calculation of energy cost and investment cost of the systems, based on the HVAC system sized in the energy calculation
- Energy price systematic and PV clearing can be adapted to local situation.
- Residual values at the end of the calculation period for the systems are considered

Methodology

Cost Benefit Analysis

HIGHLIGHTS

- 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.



Introduction

Cairo West Residence

Boundary conditions

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Cairo West Residence

Aims

Creating a place that provides residents with the high levels of comfort based on smart tech solutions facilitated by an advanced internet network for smoother living and entertainment conditions.

Target Groups

Upper middle class housing for families in Greater Cairo.

Function

A diverse range of residential units in multi-family buildings and one boutique hotel. The project will also comprise of several carefully designed services and facilities.

Size

Total compound area is 45,000 sqm including 14 Multi-family houses and one Boutique Hotel.

BUILD_ME will focus on one MFH (Villa 4) of 3000 sqm.

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Boundary conditions

Site : Context matters

City : Giza, Greater Cairo

Location : 25 km west of Tahrir Square

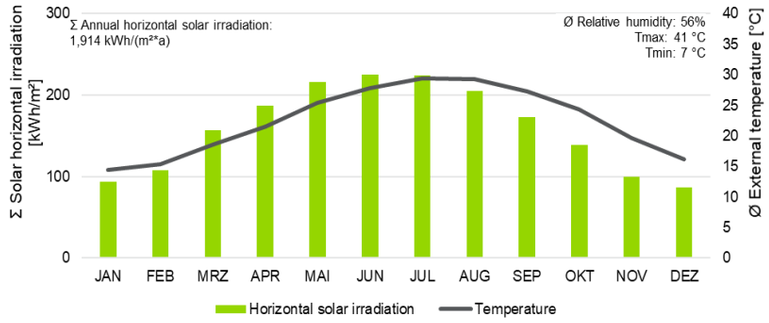
Context

lies on Cairo-Alexandria Desert Road in close proximity to the Grand Egyptian Museum (GEM) and Giza Pyramids. The project is also adjacent to the Sphinx International Airport (SIA) and many of the newly developed urban areas of west Cairo.

Source: Google Maps

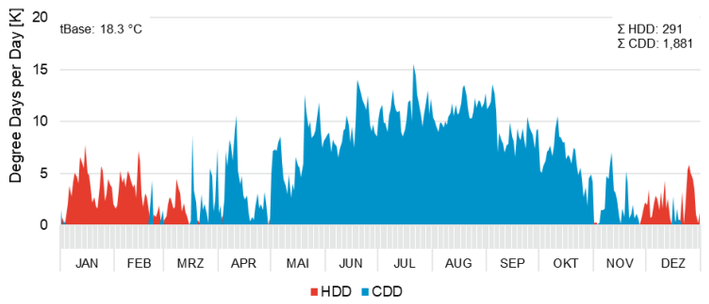
Boundary conditions | Climate Analysis in Cairo

Outdoor temperature



The climate in Cairo is primarily hot and reaches an average humidity rate of 56%. External temperatures range from above 13 to 41°C with average temperatures around 24°C.

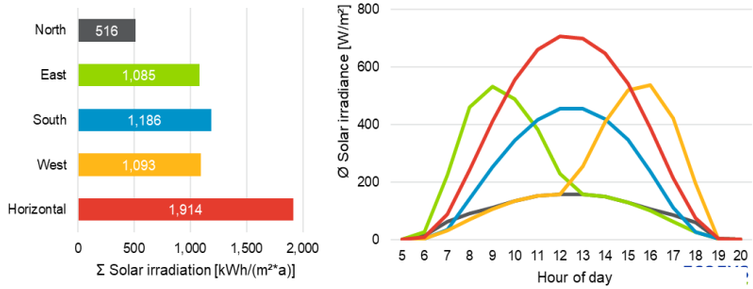
Heating and cooling degree days



High number of >1,800 of CDD cooling degree days and a limited number of 291 of HDD heating degree days.

The amount of cooling degree days is more than six times higher than the heating degree days. Therefore, major share of the energy demand accumulates for cooling.

Solar Irradiation



High horizontal irradiation of > 2,000 kWh/(m²*a) and >1000 kWh/(m²*a) for East, South and West orientation.

Big potentials for energy generation through solar radiation, solar water heaters, PVs and solar cooling could be utilized.

* Calculated according to ASHRAE 2001 methodology

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Boundary conditions | 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 phased out in the near future.

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 | Building

Building Data

Status

A prototype of a multi-family house that will be constructed 14 times in the project of Cairo West Residence.

Specific Challenge

The building will not be operated by the project developers and the concerns of most of the end-user focus on prices of the housing unit not EE measures.

Building Key Information	
Data	Input
Latitude	30.020710
Longitude	31.073575
Elevation [m]	120
Utilization	MFH
Number of floors	5
Number of apartment	45
Conditioned floor area [m²]	3,000
Clear room height [m]	2.8
Conditioned volume [m³]	8,400
Number of inhabitants [#]	150
Year of construction	2020-2023

Analysis

Starting Situation - Baseline and Current planning

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

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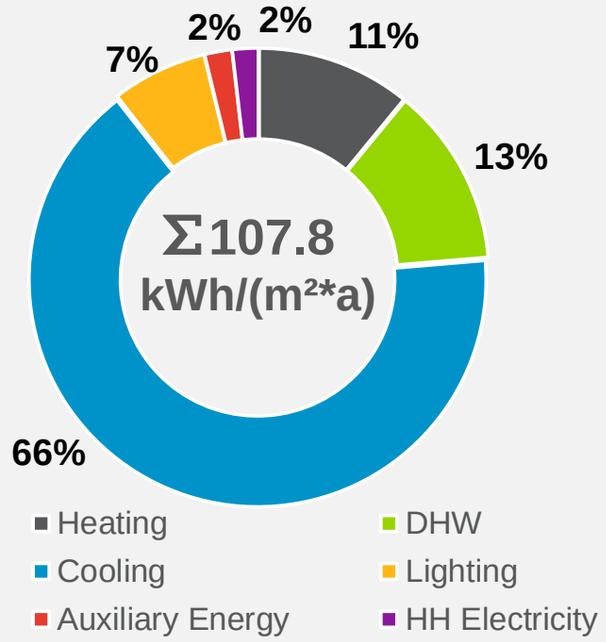
Business as Usual BAU

Based on building typology analysis

The table shows the characteristics of this MFH building in case it would have been constructed according to the BAU in Egypt.

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 current building code. While no special attention is given to use renewable energy sources.

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)	5.8 W/m²K; 0.85
Window fraction	Ø 37%
Shading	No
Air tightness	0.25 1/h
Heat supply	Reversible split unit - COP 2.5
Cold supply	Reversible split unit - COP 2.5
Hot water	Gas instantaneous
Ventilation systems	Natural ventilation
Lighting systems	CFL
Renewable energy	No
Set temperature cooling/heating	23°C / 21°C



Energy Cost
6.8 EUR/(m²a) I 126 EGP/(m²a)

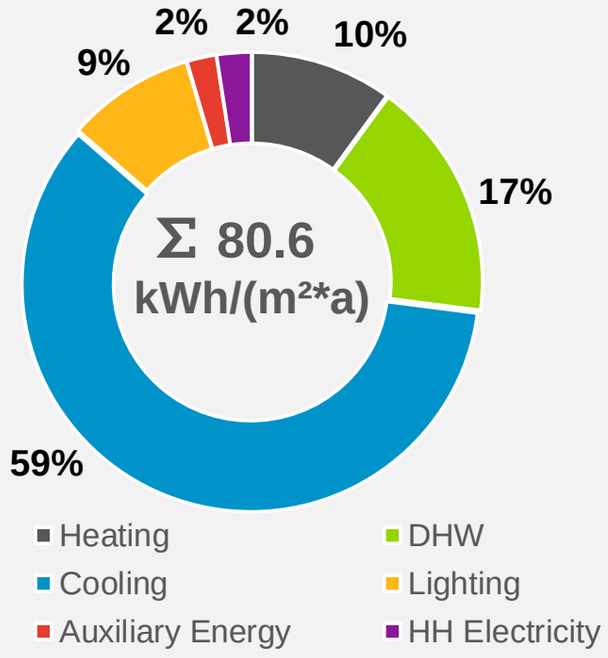
CO2 – Emission
3.4 kg / (m²*a)

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 the thresholds of the current building code. While no special attention is given to use renewable energy sources.

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)	**2.8 W/m²K; 0.7**
Window fraction	Ø 37%
Shading	No
Air tightness	0.25 1/h
Heat supply	**Mini VRF - COP 2.5**
Cold supply	**Mini VRF - COP 2.5**
Hot water	Gas instantaneous
Ventilation systems	Natural ventilation
Lighting systems	CFL
Renewable energy	No
Set temperature cooling/heating	23°C / 21°C



Energy Cost
4,9 EUR/(m²a) I 91 EGP/(m²a)

CO2 – Emission
2.4 kg / (m²*a)

Comparison: BAU and Current Planning

As the global cost of the BAU construction of such a building will be 157 euro/m².

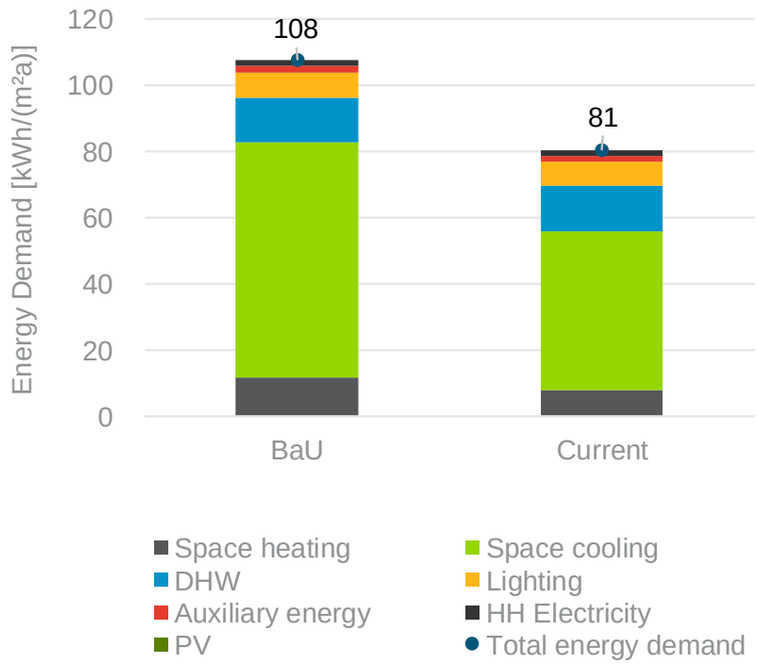
The proposed design cost will be 125 euro/m².

While the proposed design is more energy efficient in comparison to the BAU cases, there is still room for further energy related improvements.

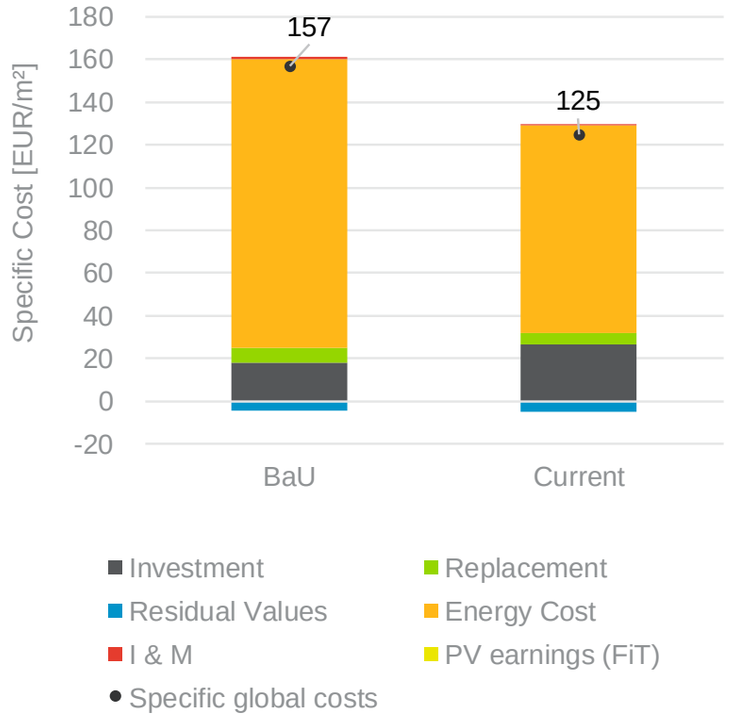
Energy savings: 25%

Global cost savings: 20%

Final Energy Demand



Global Cost



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Analysis

Investigation of Possible Measures

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Overview of Analyzed Measures

Scope of Measures

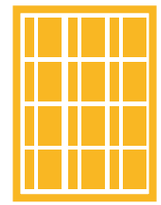
Envelope

- Roof insulation
- External wall insulation
- Low-E glass windows
- Shading
- Air tightness

Systems

- Heating
- Cooling
- Hot water supply
- Ventilation systems
- Lighting systems

Renewable



- PVs, Solar Thermal
- Solar water heaters

Building Envelope | External wall

Results

BaU
No insulation (U-Value = 2.2 W/m²K)

Var 1
Double wall, no insulation (U-Value = 1.1 W/m²K)

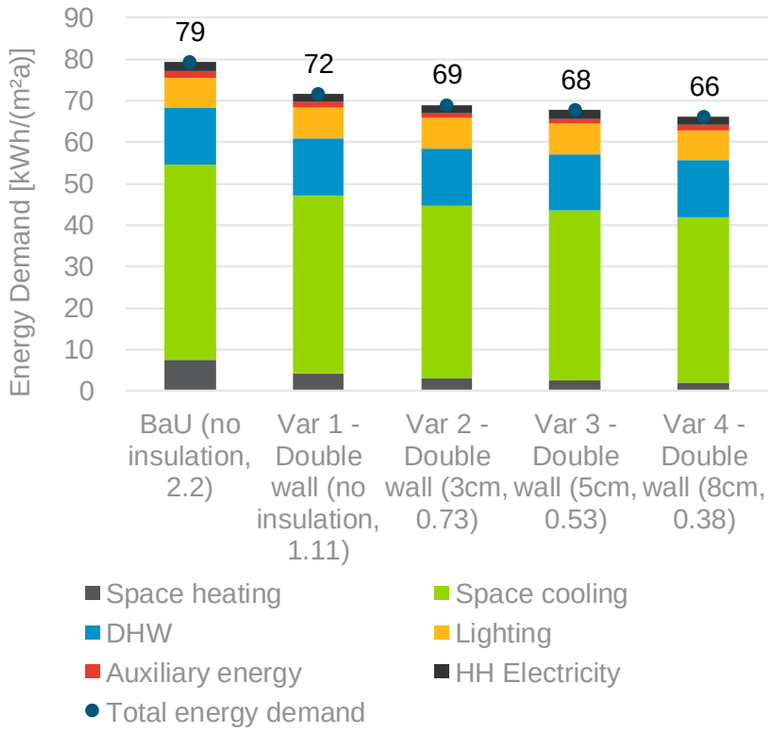
Var 2
3 cm insulation (U-Value = 0.73 W/m²K)

Var 3
5 cm insulation (U-Value = 0.53 W/m²K)

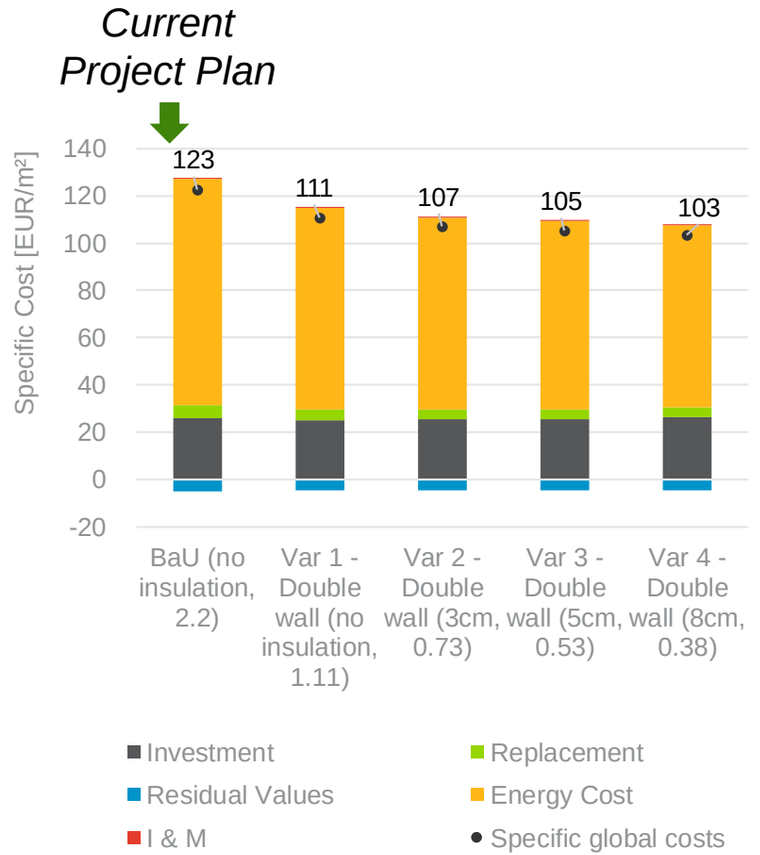
Var 4
8 cm insulation (U-Value = 0.38 W/m²K)

Result: Var 4 is the most cost effective measure

Final Energy Demand



Global Cost



Building Envelope | Roof

Results

BaU

no insulation

Current

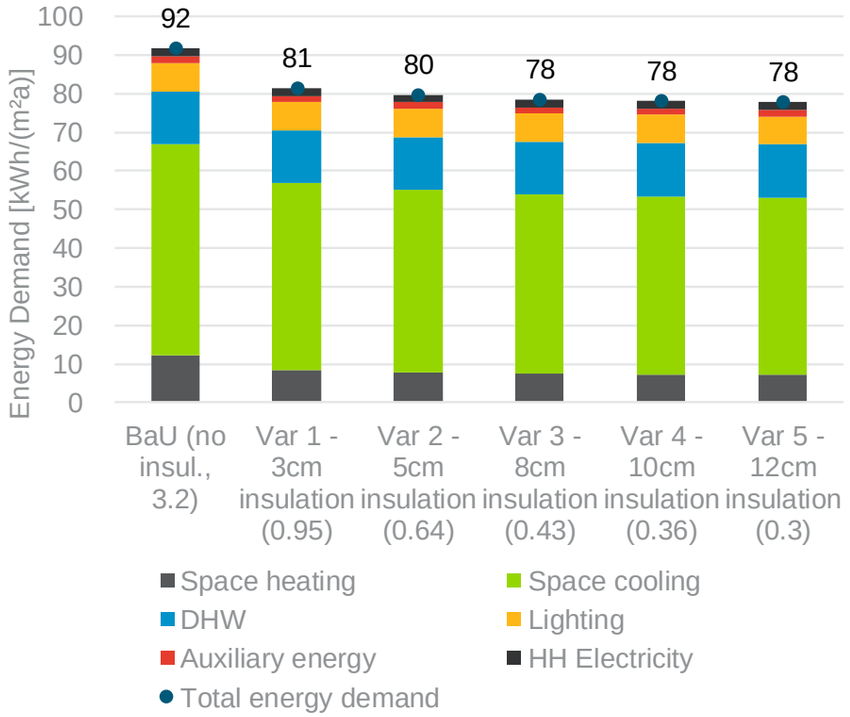
7 cm insulation (U-Value = 0.46 W/m²K

Var 1 - 5

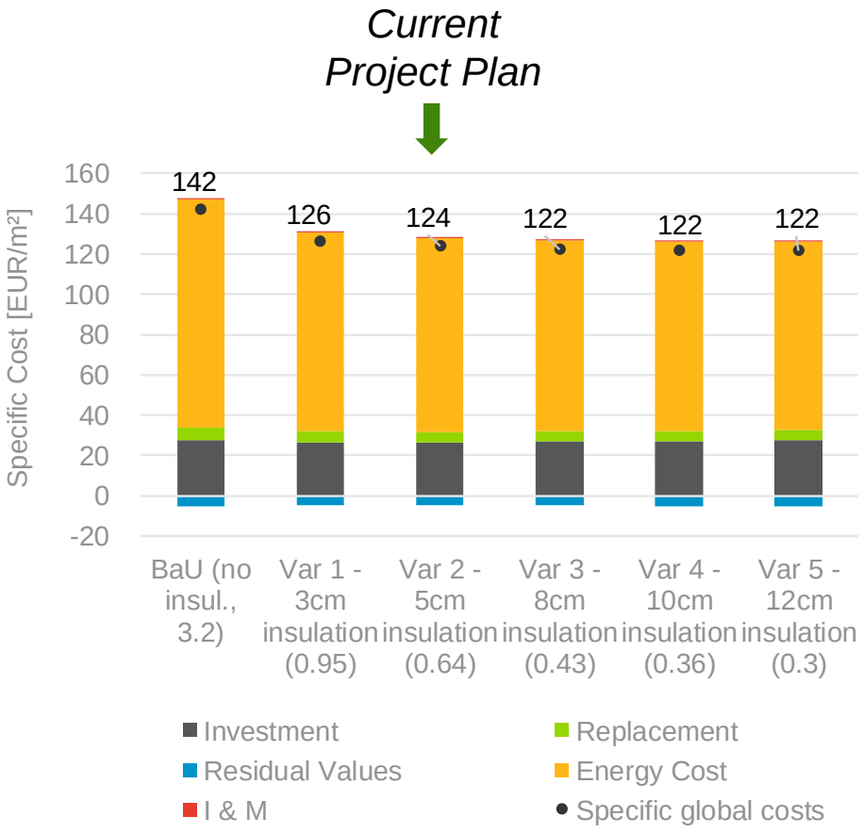
3 – 12 cm insulation (U-Value = 0.95 – 0.23 W/m²K)

Result: Var 4 with 10 cm is the most cost effective measure. However, the current project plan is already close.

Final Energy Demand



Global Cost



Building Envelope | Windows

Results

BaU – Single glazing

U value 5.7 W/m²K
G-Value 0.85

Double glazing | low E (Var 1|2)

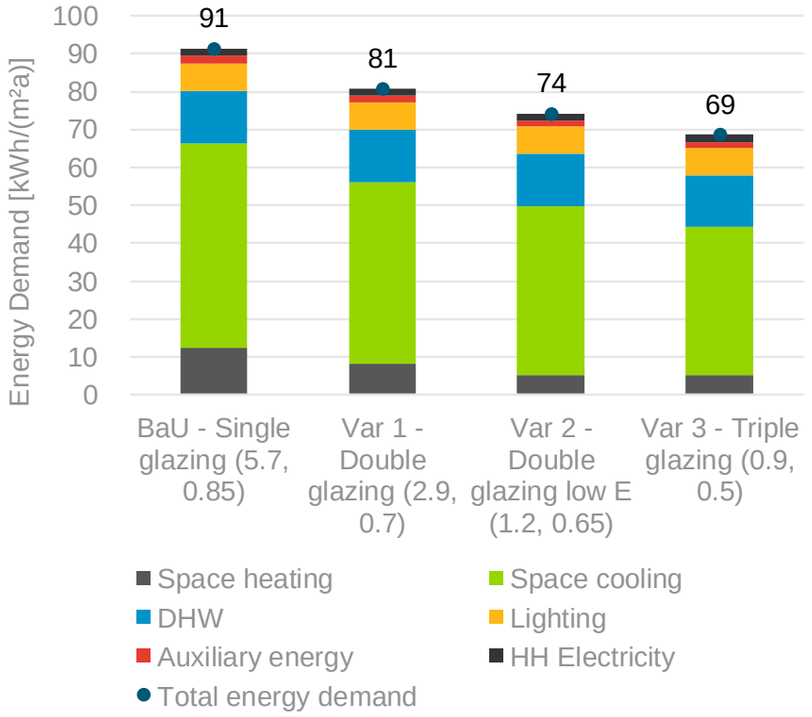
U value 2.9 | 1.2 W/m²K
G-Value 0.7 | 0.65

Triple glazing (Var 2)

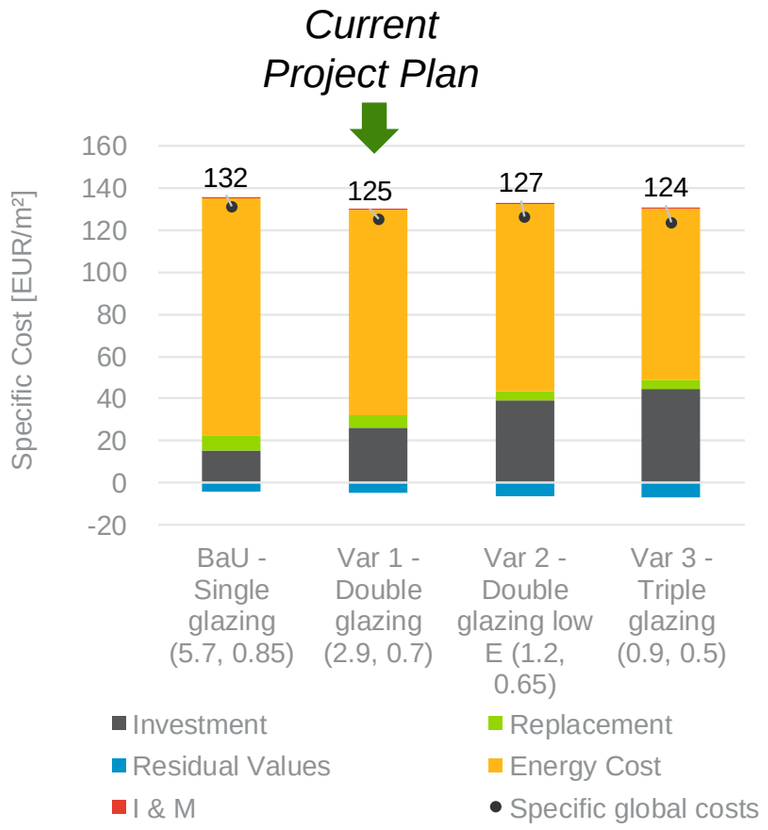
U value 0.9 W/m²K,
G-Value 0.5

Var 2 (current plan) & var 3 are the most cost-effective cases.

Final Energy Demand



Global Cost



Window Fraction

Analysis

Var 1

Window fraction 40 %

Var 2

Window fraction 30 %

Var 3

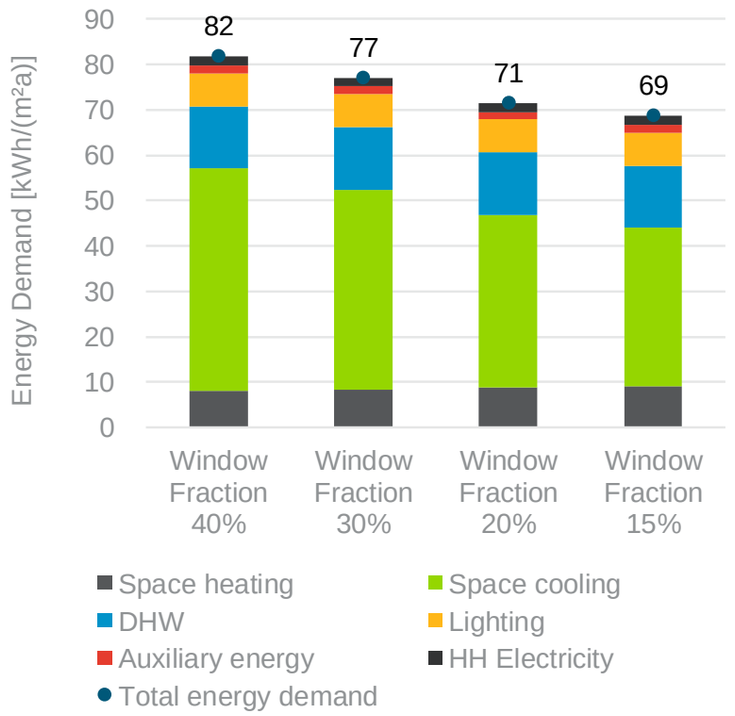
Window fraction 20 %

Var 4

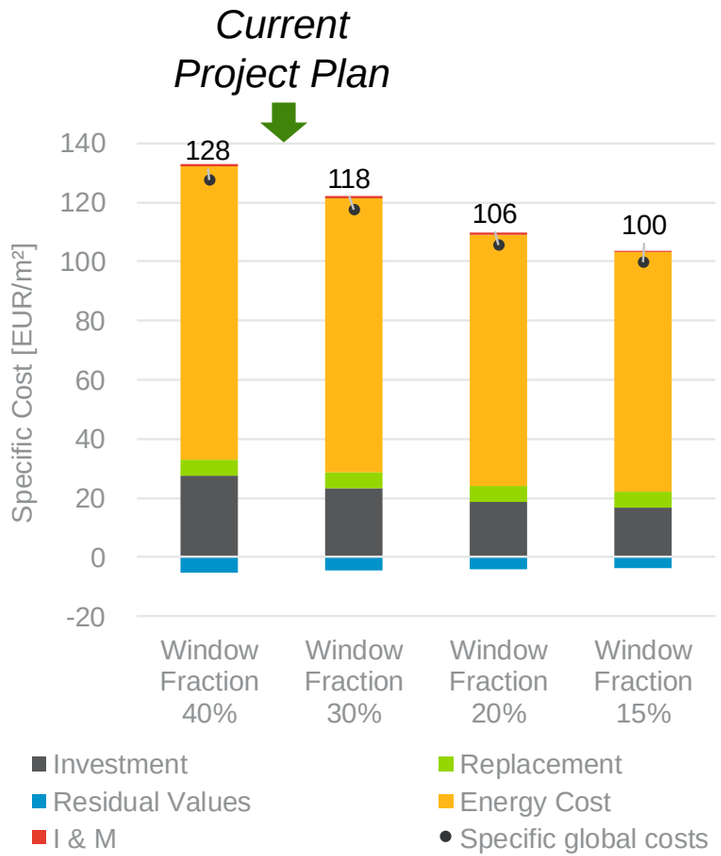
Window fraction 15 %

The Var 4 with the least window fraction has the lowest energy consumption and lowest global cost.

Final Energy Demand



Global Cost



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Shading concept

Analysis

BaU
No shading

Var 1
Fixed Overhangs

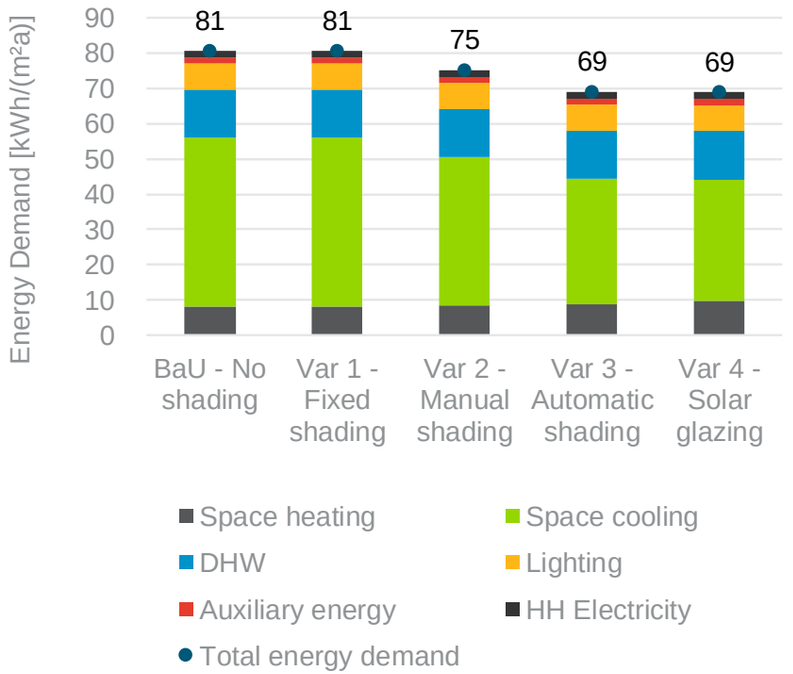
Var 2
Manual Shading

Var 3
Automatic Shading

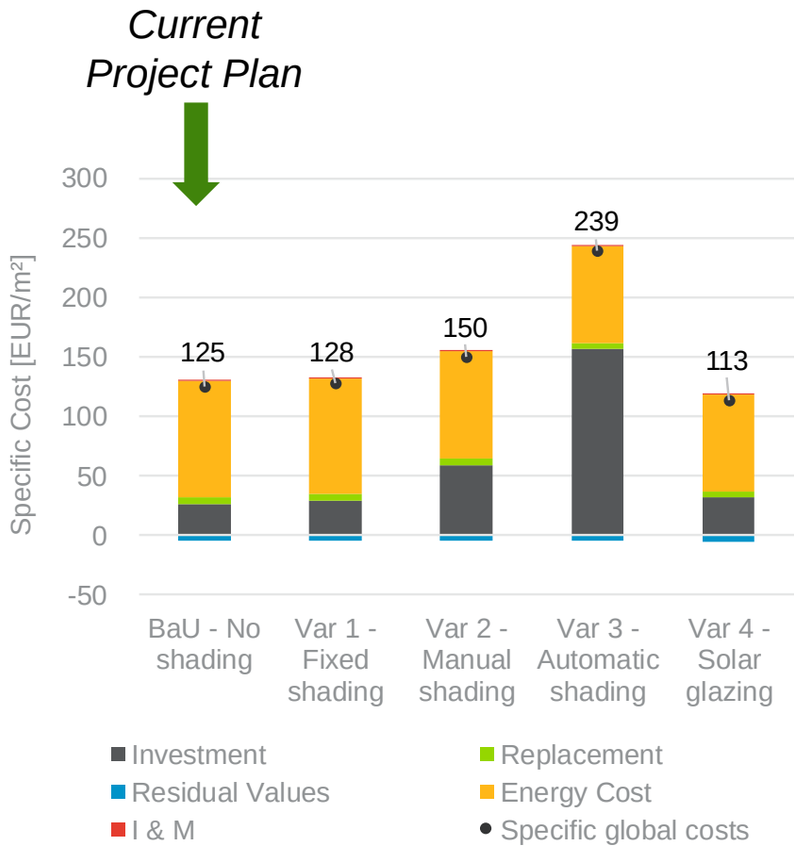
Var 4
Solar Glazing

Var 4 is the most cost effective measure.

Final Energy Demand



Global Cost



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Air Tightness

What is the effect of air tightness?

BaU
0.25

Var 1
0.20

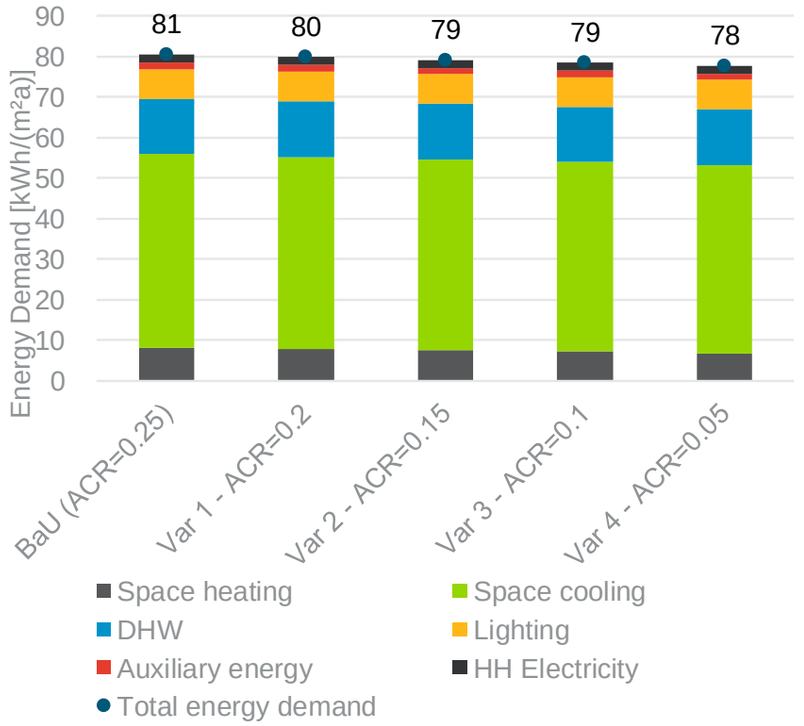
Var 2
0.15

Var 3
0.1

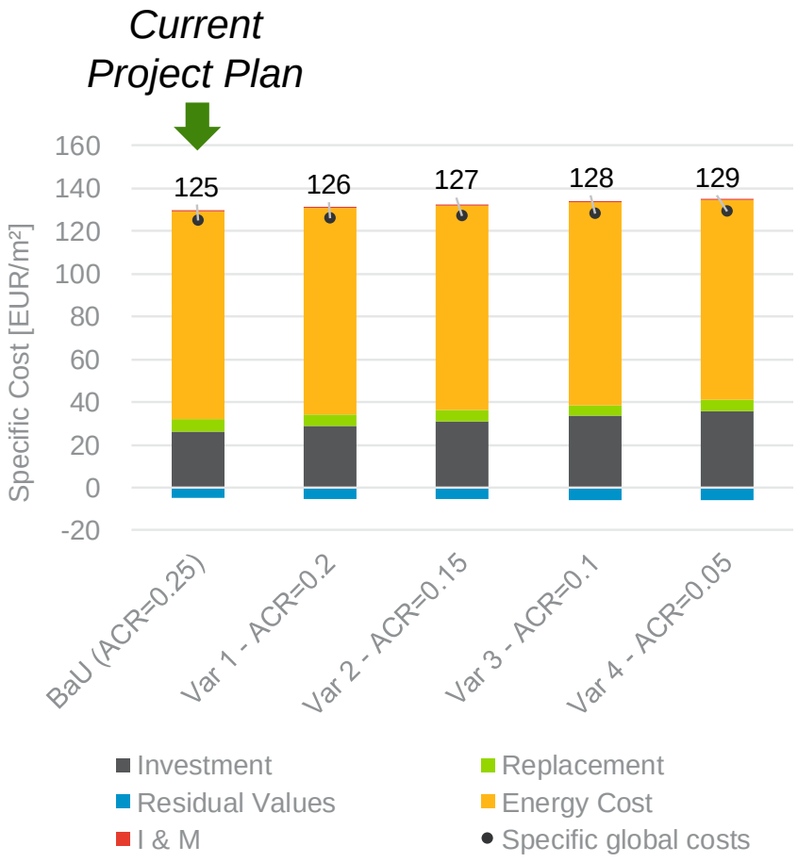
Var 4
0.05

BaU (current) is the most cost effective measure.

Final Energy Demand



Global Cost



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HVAC | Efficiencies

Analysis

BaU

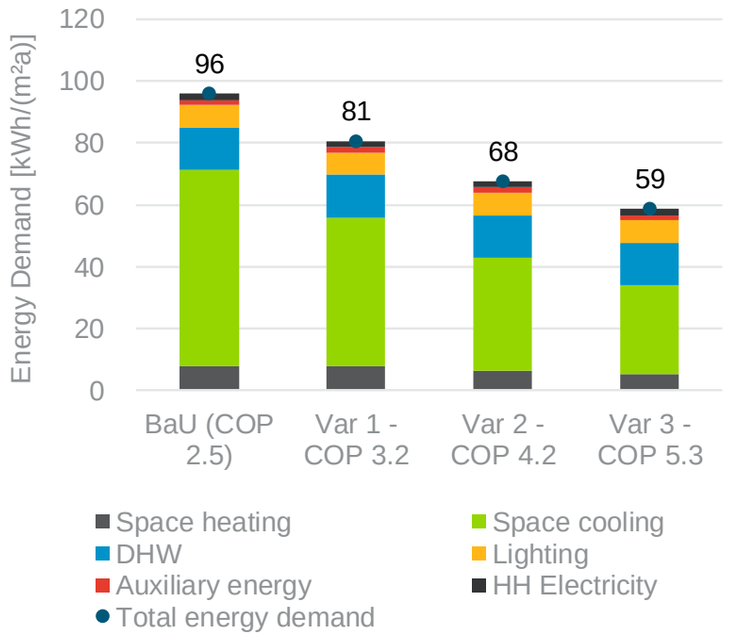
Cooling/Heating: 2.5 COP

Var 1 | 2 | 3

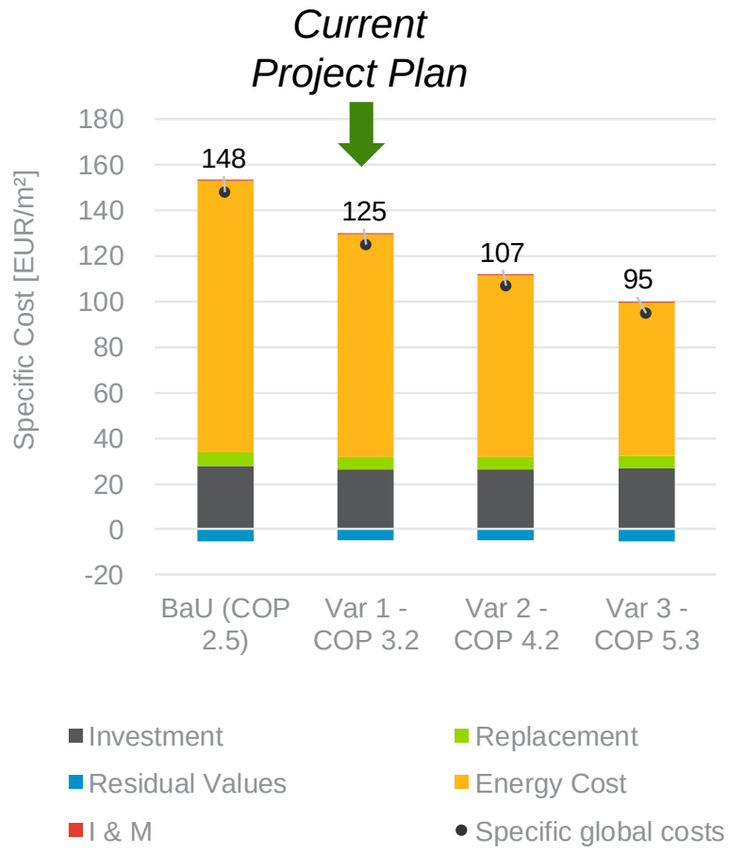
Reversible Split Unit with increased efficiency (COP: 3.2 | 4.2 | 5.3)

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

Final Energy Demand



Global Cost



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Operational Temperatures

Analysis

BaU

Cooling Temperature: 23°C
Heating Temperature: 23°C

Var 1 - 3

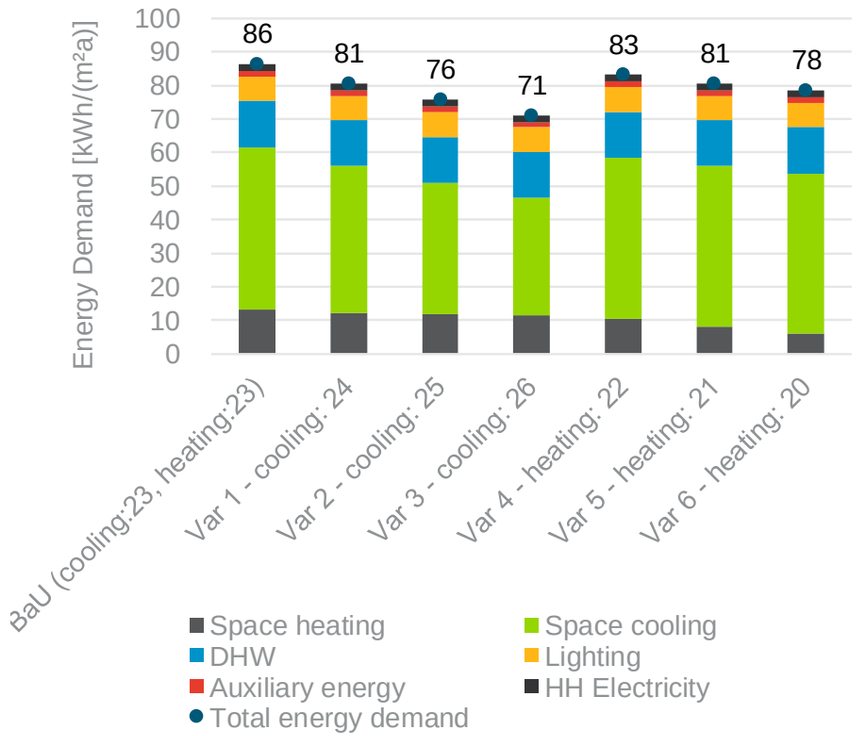
Cooling Temperature adapted (24°C - 26°C)

Var 4 - 6

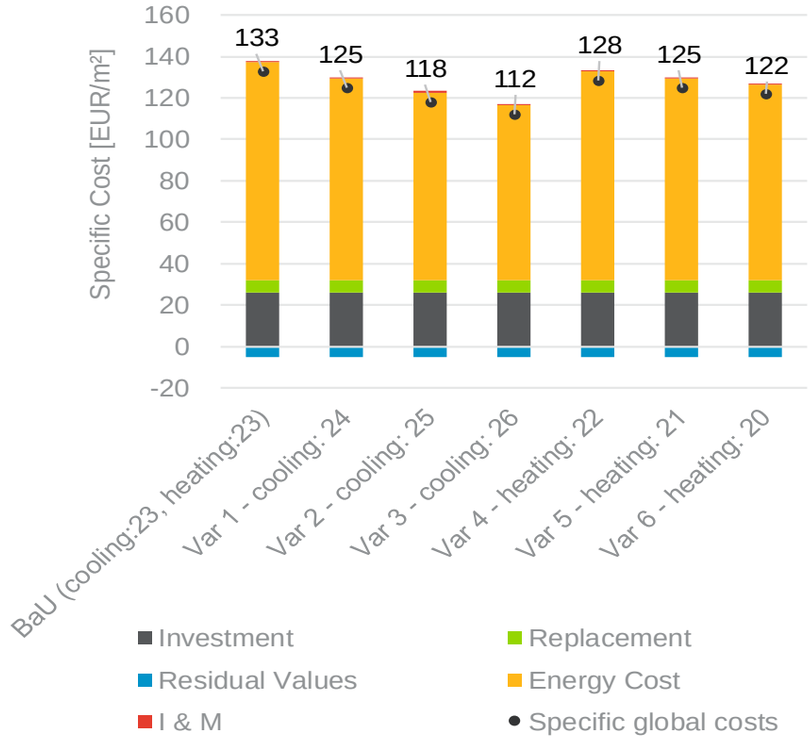
Heating Temperature adapted (22°C - 20°C)

This measure is very effective and not related to any cost

Final Energy Demand



Global Cost



Renewables | Solar Thermal

Analysis

Current

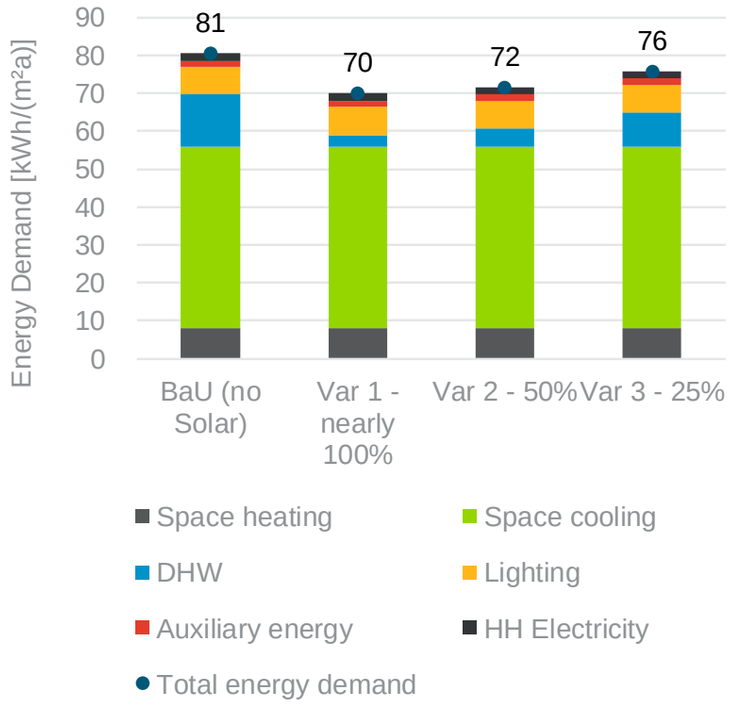
No solar hot water generation

Var 1 | 2 | 3

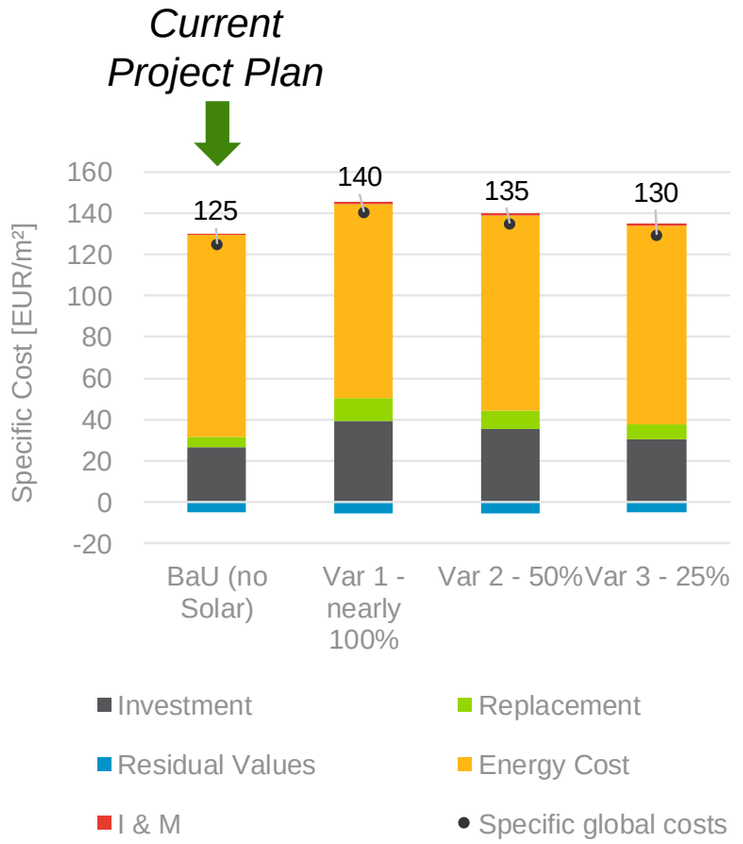
70 | 35 | 20 m² solar collector area installed, which is about 100% | 50% | 25% of the DHW demand covered by solar.

BaU with **no use of solar thermal** is the most cost effective measure.

Final Energy Demand



Global Cost



Renewables | PV

Analysis

Sizing (net metering as assumption)

Current

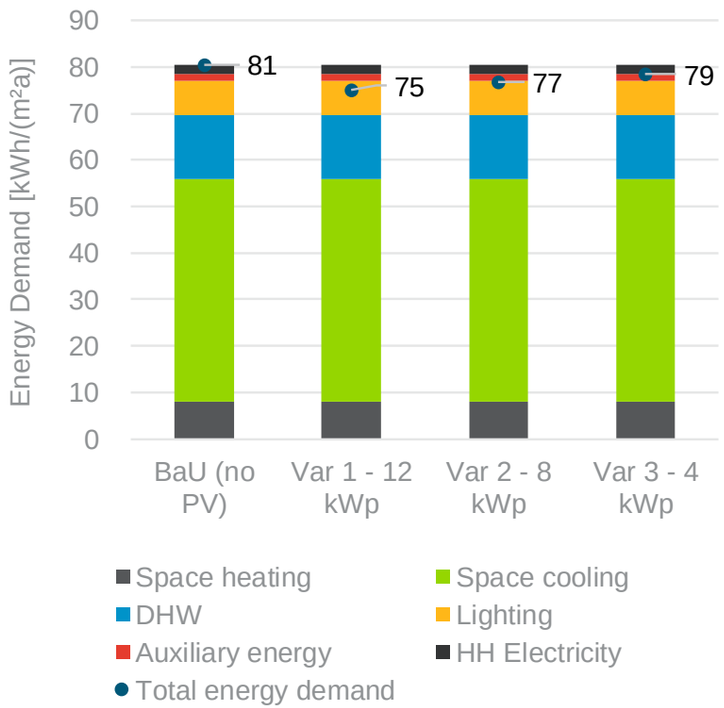
no PV

Var 1 | 2 | 3

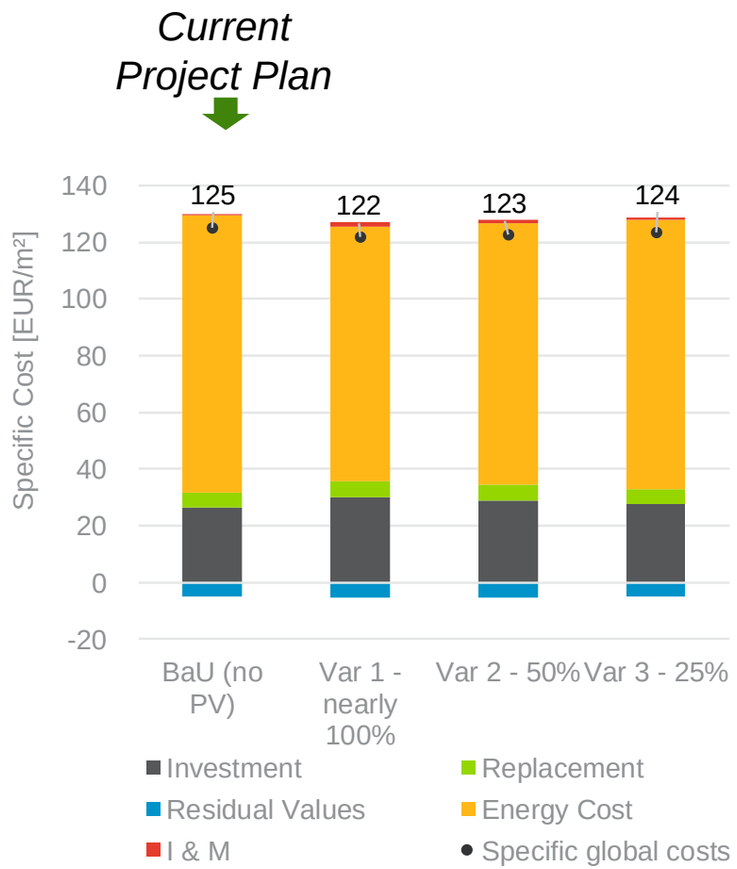
PV 12 | 8 | 4 kWp
(Roof area 175 | 84 | 42 m²)

Var 1 with **12 kWp** PV is the most cost effective measure. (based on the electricity consumption of the Current!)

Final Energy Demand



Global Cost



Results & Conclusion

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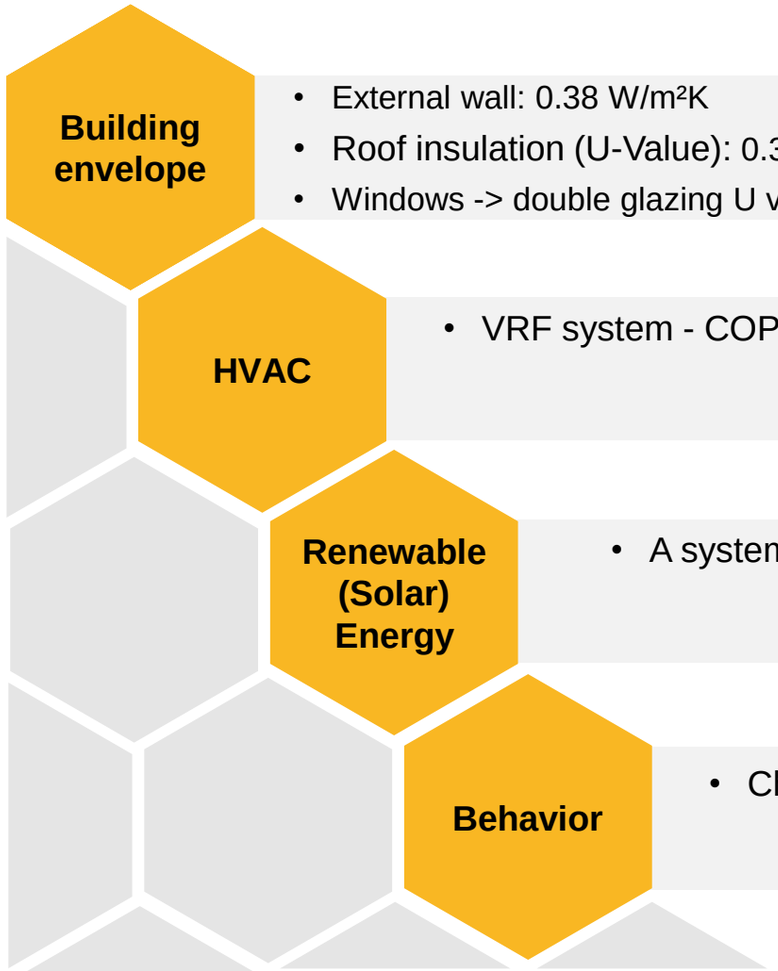
Overview of recommended measures

Four steps to reduce energy demand significantly



Building envelope

- External wall: 0.38 W/m²K
- Roof insulation (U-Value): 0.36 W/m²K
- Windows -> double glazing U value of 2.9 W/m²K and G value of 0.3 (solar glazing)

HVAC

- VRF system - COP 5

Renewable (Solar) Energy

- A system of 12 kWp (PV) will be the most cost effective size.

Behavior

- Change set temperature from Cooling 26°C/ Heating 20°C to Cooling 26°C/ Heating 20°C

Optimized Solution

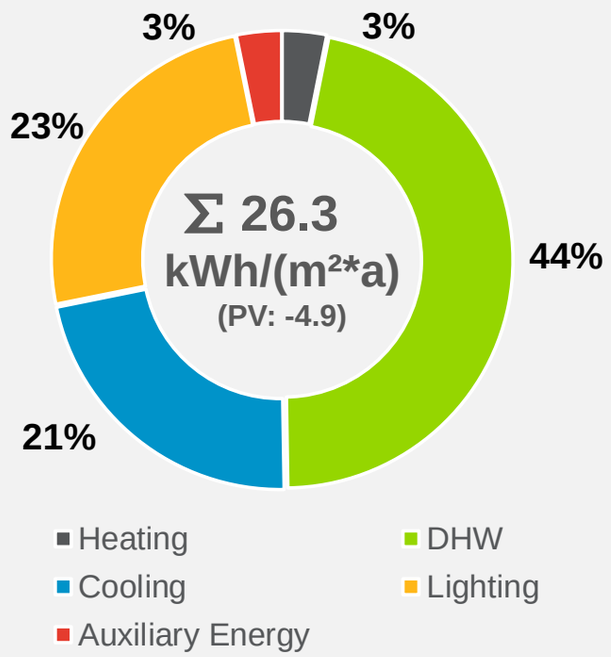
Results

The key components of the energy concept are illustrated in this table, it shows that the building envelope is significantly enhanced compared to the business as usual and current plan.

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)	**0.4 W/m²K**
Wall insulation (U-Value)	**0.38 W/m²K**
Floor insulation (U-Value)	2.2 W/m²K
Windows (U-Value; G-Value)	2.8 W/m²K**; 0.3**
Window fraction	**Ø 15%**
Shading	**Solar Glazing**
Air tightness	0.25 1/h
Heat supply	VRF - **COP 5**
Cold supply	VRF - **COP 5**
Hot water	Gas instantaneous
Ventilation systems	Natural ventilation
Lighting systems	CFL
Renewable energy	**12 kWp (PV)**
Set temperature cooling/heating	**26°C / 20°C**



Energy Cost
1.1 EUR/(m²a) | 20 EGP/(m²a)

CO2 - Emission
0.6 kg / (m²*a)

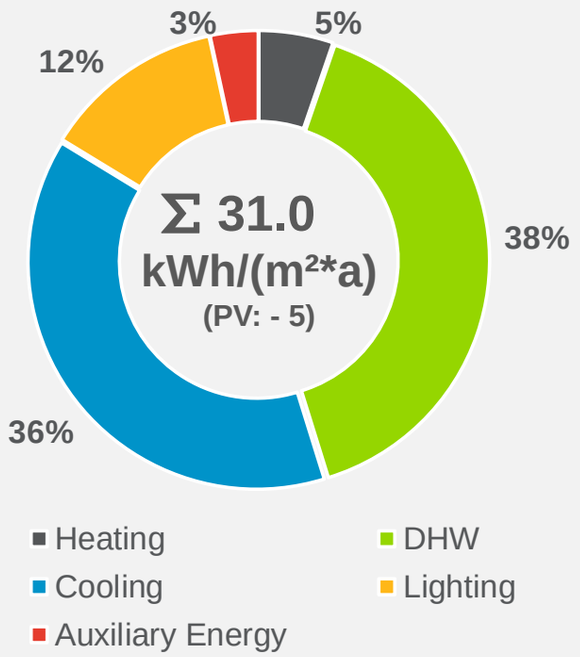
Selected Solution

Results

After the exchange with the project developer, the following components have been assessed as feasible and will be taken into account in the further planning:

- Improvement of the building envelope
- Solar Glazing
- Higher efficient VRF system
- PV on the roof

Parameters	Optimized Building
Roof insulation (U-Value)	**0.40 W/m²K**
Wall insulation (U-Value)	**0.50 W/m²K**
Floor insulation (U-Value)	2.2 W/m²K
Windows (U-Value; G-Value)	2.8 W/m²K**; 0.3**
Window fraction	Ø 37%
Shading	**Solar Glazing**
Air tightness	0.25 1/h
Heat supply	VRF - **COP 3.2**
Cold supply	VRF - **COP 3.2**
Hot water	Gas instantaneous
Ventilation systems	Natural ventilation
Lighting systems	**LED**
Renewable energy	**12 kWp (PV)**
Set temperature cooling/heating	**26°C / 20°C**



Energy Cost
1.4 EUR/(m²a) I 26 EGY/(m²a)

CO2 - Emission
0.7 kg / (m²*a)

Comparative Overview

Current vs. Optimized

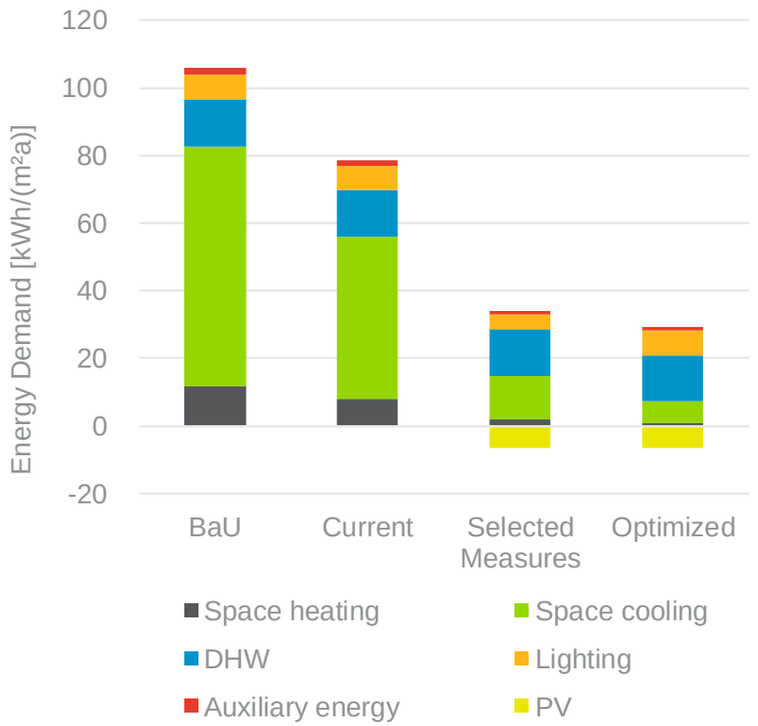
Conclusion

- The suggested measures of the selected package and the optimized lead to a **significant decrease in energy demand and cost savings.**

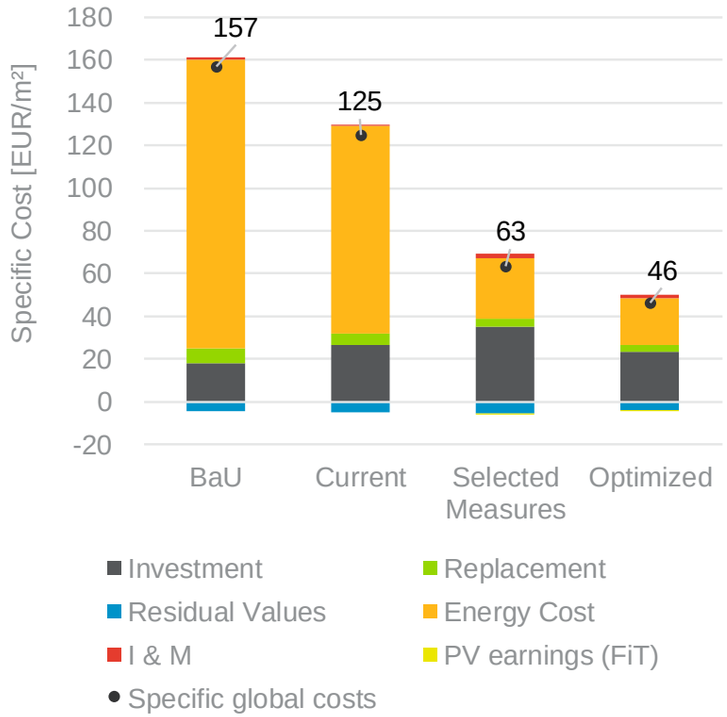
Savings compared to BaU

Variants	Energy	Costs
Selected	66%	60%
Optimized	72%	71%

Final Energy Demand



Global Cost



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Selected package vs. current

Payback of single measures and whole package

Parameters	Selected measures	Investment (selected - current) [EUR]	Energy cost savings* [EUR / year]	Payback [years]	Lifetime [year]
Roof insulation (U-Value)	0.53 W/m²K	6,000	-3,000	2	40
Wall insulation (U-Value)	0.43 W/m²K	4,000	-3,500	2	40
Shading	Solar glazing	16,500	-3,000	6	30
Heat/Cold supply	reversible split unit - COP 3.2	1,500	-3,000	1	20
Renewable energy	12 kWp (PV)	12,000	-1,700	7	20
Set temperature cooling/heating	26°C / 20°C	0	-2,000	Immediately	-
Total (current to optimized)**		**40,000 (+2-3%)*****	**-16.200**	**3**	

* 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 400 or 800 Euro/m² (3 or 2 % additional costs).

Key Conclusion

Main Take Aways for Cairo West ResidenceProject

1

- Energy savings in the range of 60 -70% are possible

2

- The selected package is also attractive in economic terms with a payback below 5 years

3

- Additional costs per appartement of 1,000 € / 17,000 EGP looks appealing for a low energy building

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