Energy Efficiency Recommendations for Palm Hills Badya,

PH Development Egypt

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

July 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

Royal Scientific Society

LCEC Lebanese Center for Energy Conservation

European Bank for Reconstruction and Development

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EGYPT GBC Egypt Green Building Council

LGBC Lebanon Green Building Council

ALCOR Développeur d'avenir durable

RCREEE Regional Center for Renewable Energy and Energy Efficiency

TRACK

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Introduction

Background, Objectives and Methodology

Photo by Scott Graham on Unsplash

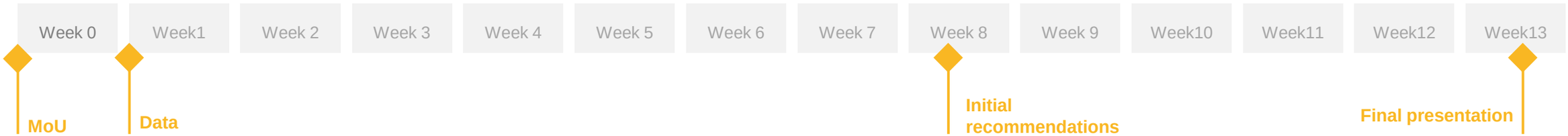
Introduction

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



- **Initial timeline to be adjusted according to the demands and development of the pilot project.**
- **Remain in close exchange of data, information and concepts**
- **Field visits will be coordinated and executed by BUILD_ME National Partners and/or local experts.**

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 (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

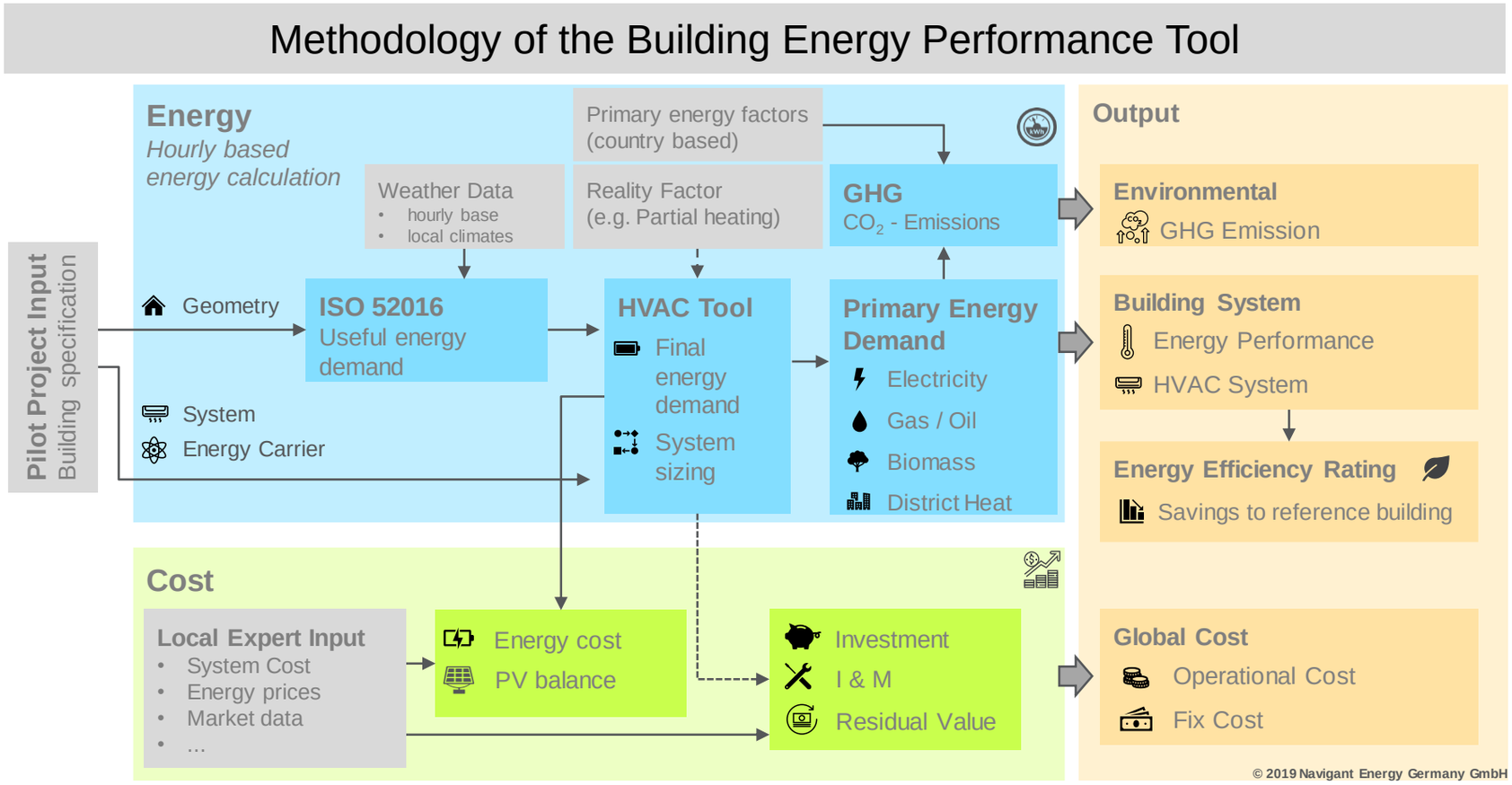
- Calculation of energy cost and investment cost of the systems, based on the HVAC system sized in the energy calculation
- Energy price systematic and PV clearing can be adapted to local situation (here: Egypt)
- Residual values at the end of the calculation period for the systems are considered

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 (Egypt)



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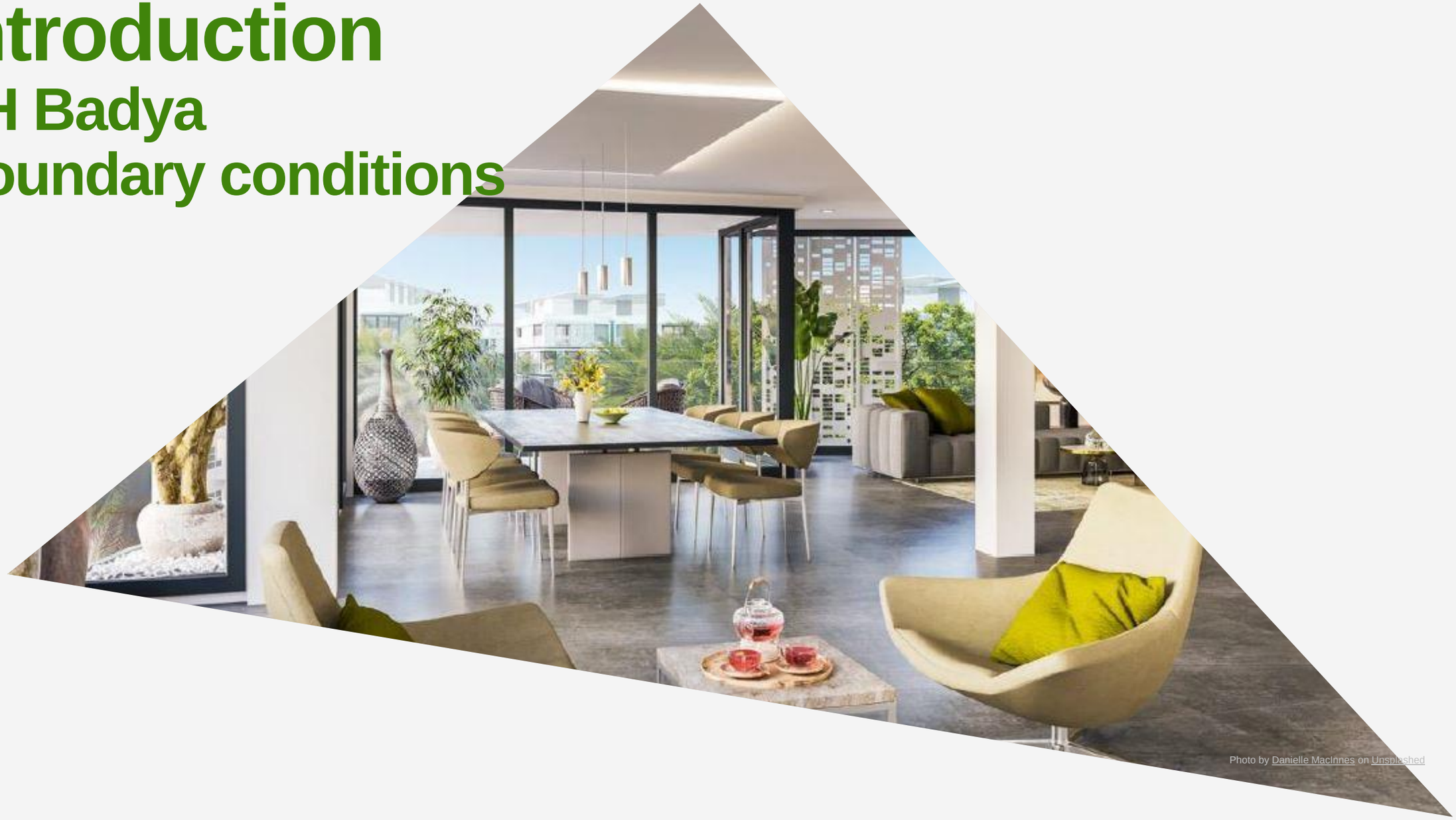
Introduction
PH Badya
Boundary conditions



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Palm Hills Badya

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 including villas and multifamily house, in addition to office parks, retail, hotels, educational, health care & mixed use. The project will also comprise of several carefully designed services and facilities.

Size

7.2 Million sqm residential, 1.5 Million sqm of commercial, retail, educational, hospitality & others.

BUILD_ME will focus on one MFH.

Boundary conditions

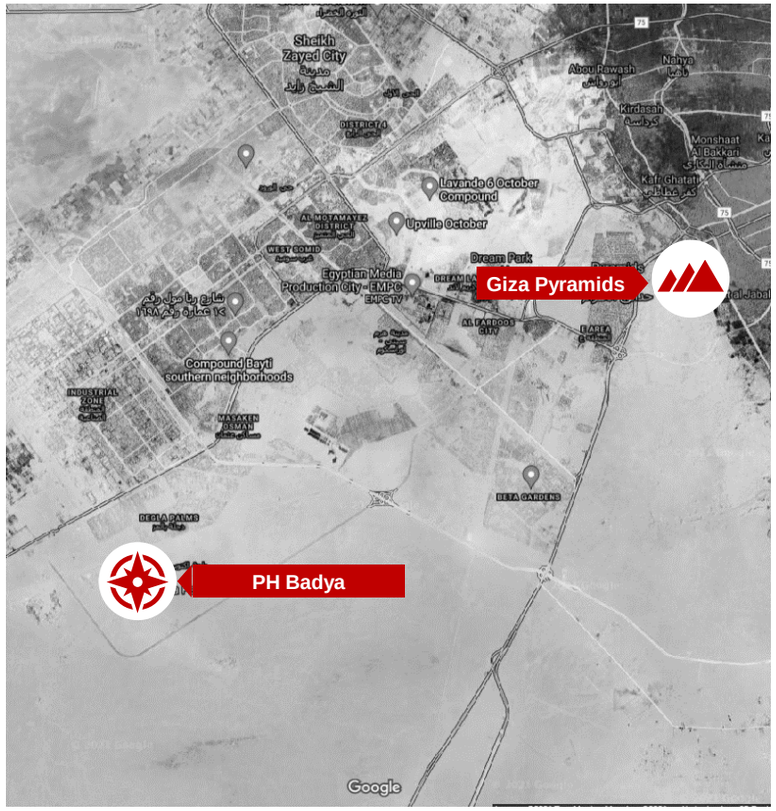
Site : Context matters

City : 6th of October, Greater Cairo

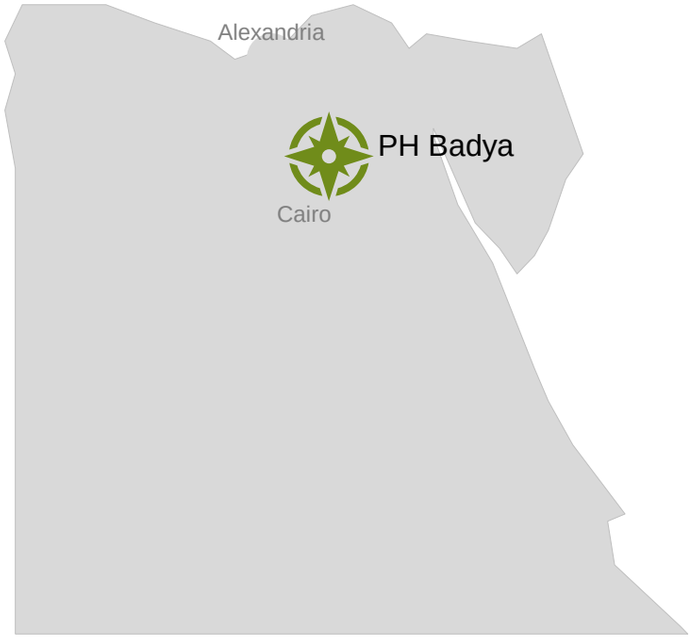
Location: 25 KM west of Tahrir Sq.

Context

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 in the city of Six of October.



Source: Google Maps

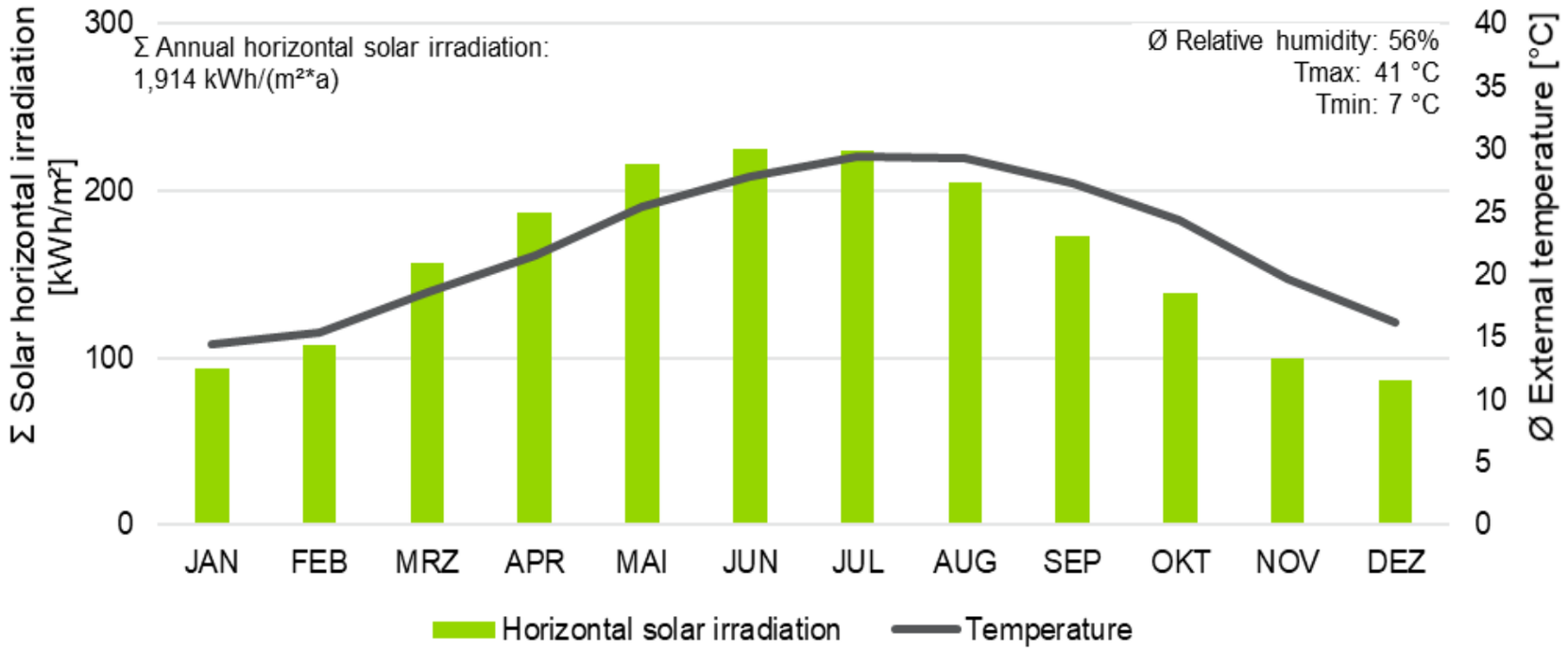


Boundary conditions | Climate Analysis

External temperature and solar radiation in Cairo (Egypt)*

Description

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.



Boundary conditions | Climate Analysis

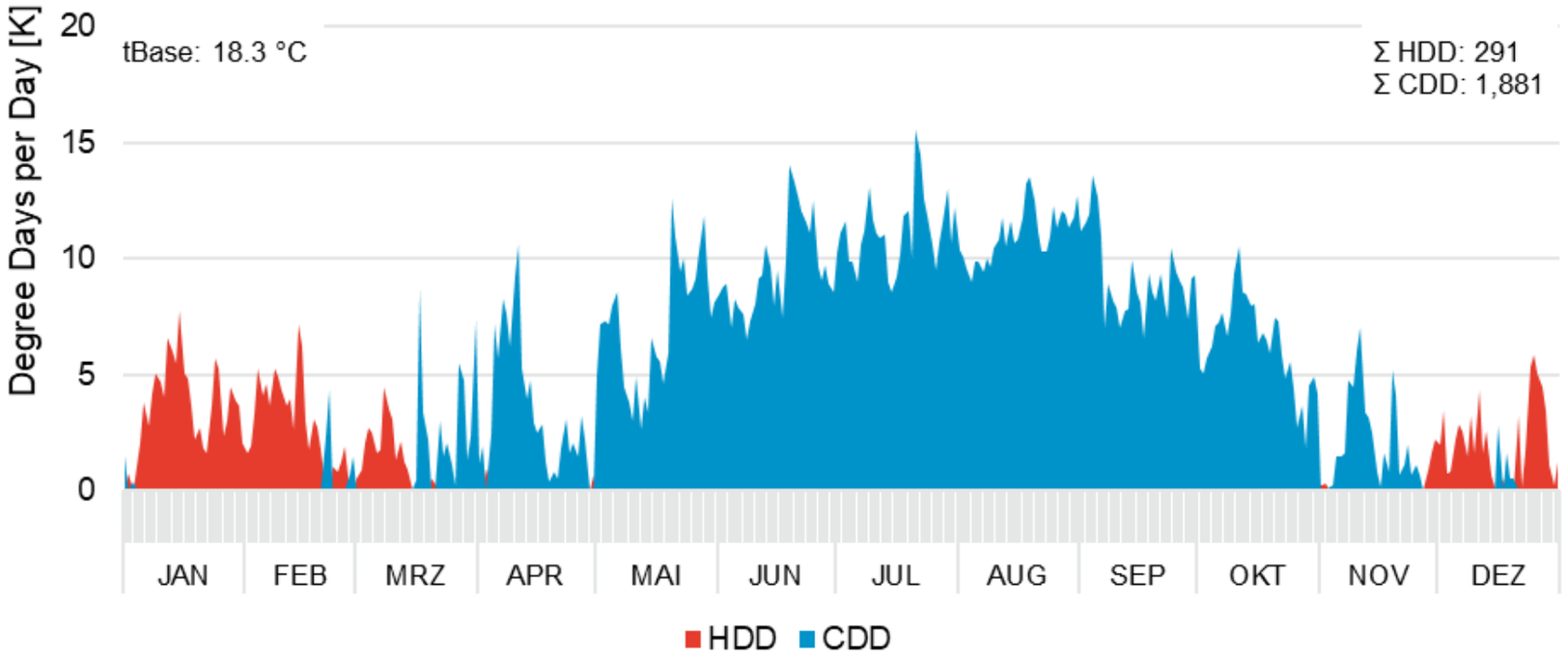
Heating and cooling degree days in Cairo (Egypt)*

Description

High number of >1,800 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 is more than six times higher than the heating degree days. Therefore, major share of the energy demand accumulates for cooling.



* Calculated according to ASHRAE 2001 methodology

Boundary conditions | Climate

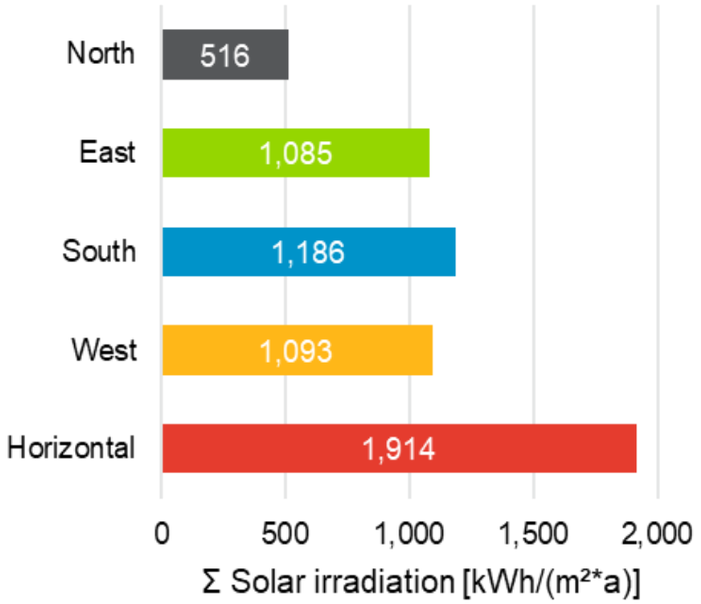
Solar Irradiation in Cairo (Egypt)

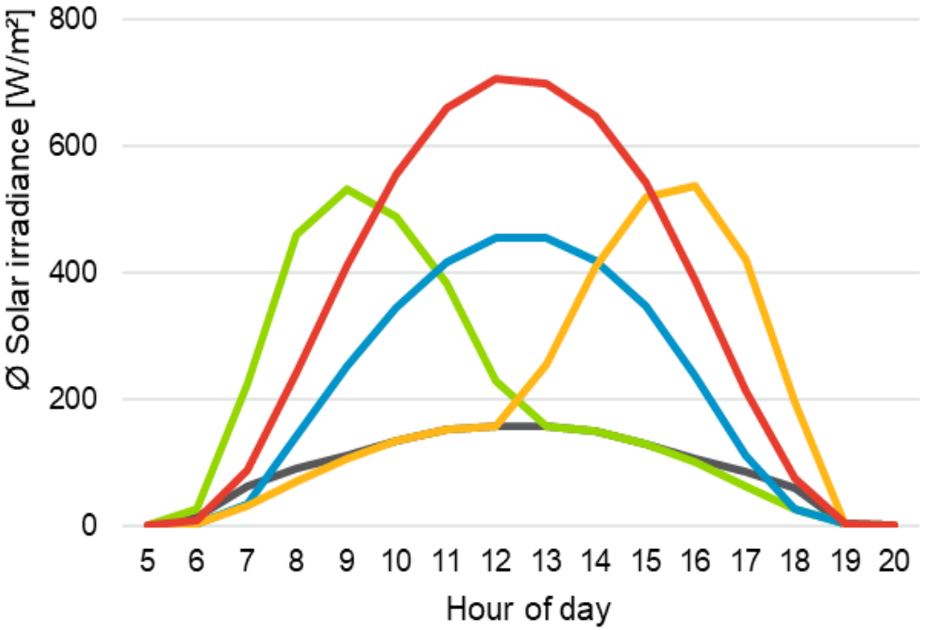
Description

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

Challenges and Potentials

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





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 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	4 per m^3
Energy price	EUR/kWh	0.056 – 0.082	0.18 per m^3E
Energy Price dev. in the last 5 years	%/year	25%	6%
Energy Price dev. next 10 years	%/year	5%	5%
CO2 emission factor	gCO2/kWh	444	220
Economic parameters			
Interest rate (real)	%/year	5	
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 several times in the project of Badya. This may allow for the EE to be multiplied/repeated in the project.

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	29.8562
Longitude	30.9015
Elevation [m]	255
Utilization	MFH
Number of floors	6
Number of apartment	11
Conditioned floor area [m²]	2,000
Clear room height [m]	2.7
Conditioned volume [m³]	5,400
Number of inhabitants [#]	42
Year of construction	2020-2023

Analysis

Starting Situation - Baseline and Current planning

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Photo by Dan Dimmock on Unsplash

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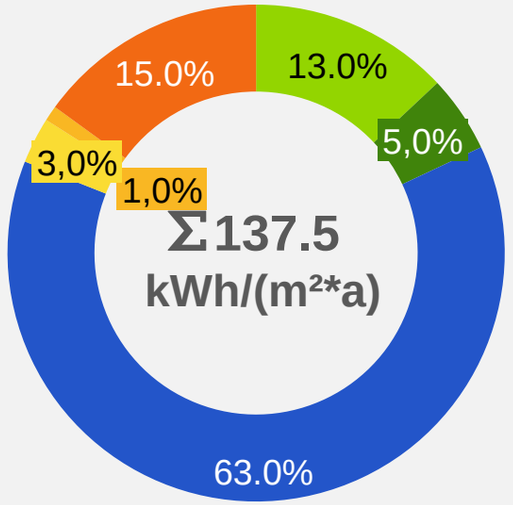
Business as Usual

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

Parameters	Baseline
Roof insulation (U-Value)	0.76 W/m²K
Wall insulation (U-Value)	2.4 W/m²K
Floor insulation (U-Value)	2.2 W/m²K
Windows (U-Value)	5.7 W/m²K, single glazing
Window fraction	Ø 16%
Shading	Fixed Elements
Air tightness	0.25 1/h
Heat supply	Reversible split unit - COP 2.5
Cold supply	Reversible split unit - COP 2.5
Hot water	Electric instantaneous
Ventilation systems	Natural ventilation
Lighting systems	LED
Renewable energy	No
Set temperature cooling/heating	23°C / 20°C



Energy Cost
10.5 EUR/(m²a) | 196 EGP/(m²a)

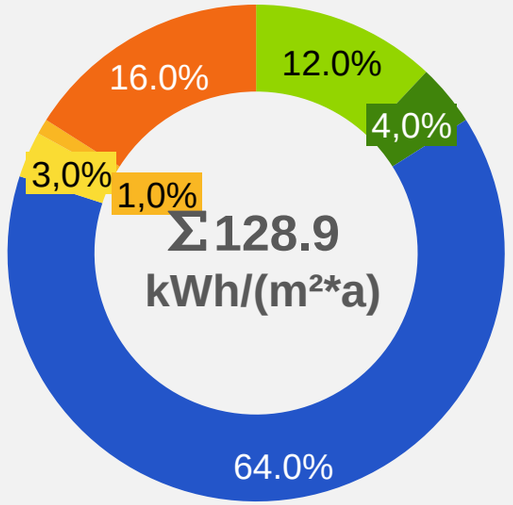
CO2 – Emission
61.1 kg / (m²*a)

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)	**0.7 W/m²K**
Wall insulation (U-Value)	**1.92 W/m²K**
Floor insulation (U-Value)	2.7 W/m²K
Windows (U-Value; G-Value)	5.7 W/m²K; 0.85
Window fraction	Ø 19%
Shading	Fix elements
Air tightness	0.25 1/h
Heat supply	Reversible split unit - COP 2.5
Cold supply	Reversible split unit - COP 2.5
Hot water	Electric instantaneous
Ventilation systems	Natural ventilation
Lighting systems	LED
Renewable energy	No
Set temperature cooling/heating	23°C / 20°C



Energy Cost
9.8 EUR/(m²a) | 183 EGP/(m²a)

CO2 – Emission
56.8 kg / (m²*a)

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Comparison: BAU and Current Planning

As the global cost of the BAU construction of such a building will be 233 euro/m².

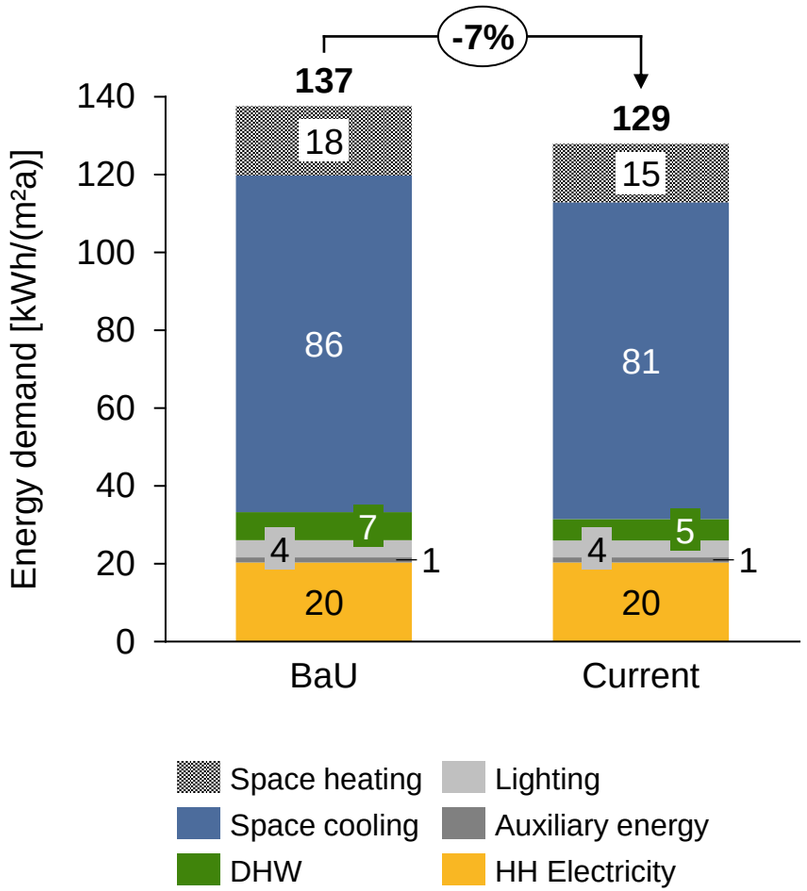
The proposed design cost will be 219 euro/m².

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

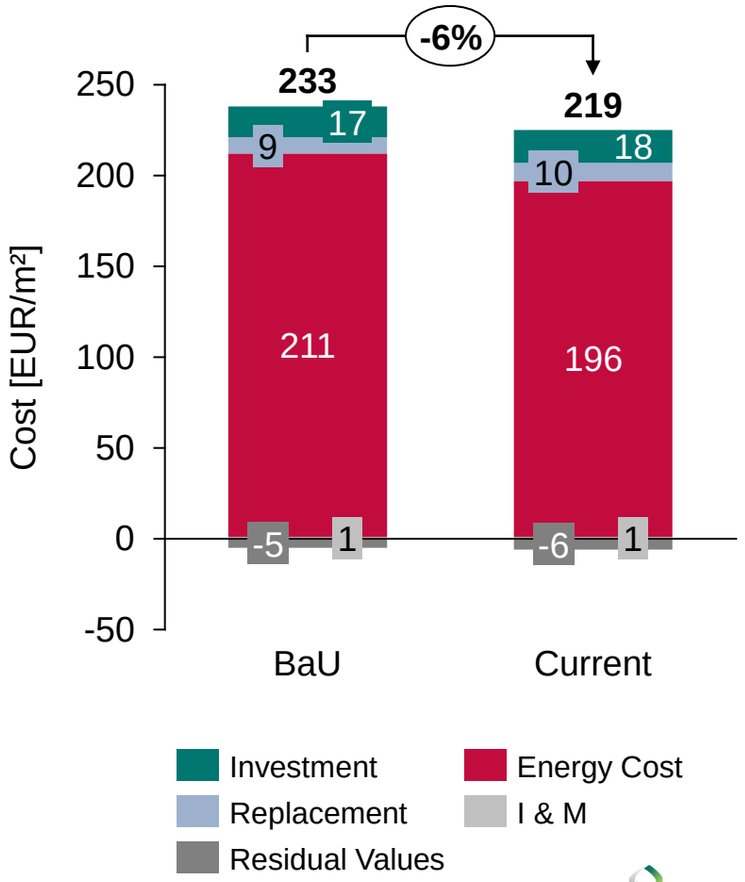
Energy savings: 7%

Global cost savings: 6%

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

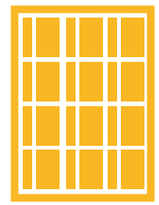
Envelope

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

Systems

- Heating
- Cooling
- Hot water supply

Renewable



- PVs, Solar Thermal
- Solar water heaters

Building Envelope | External wall

Results

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

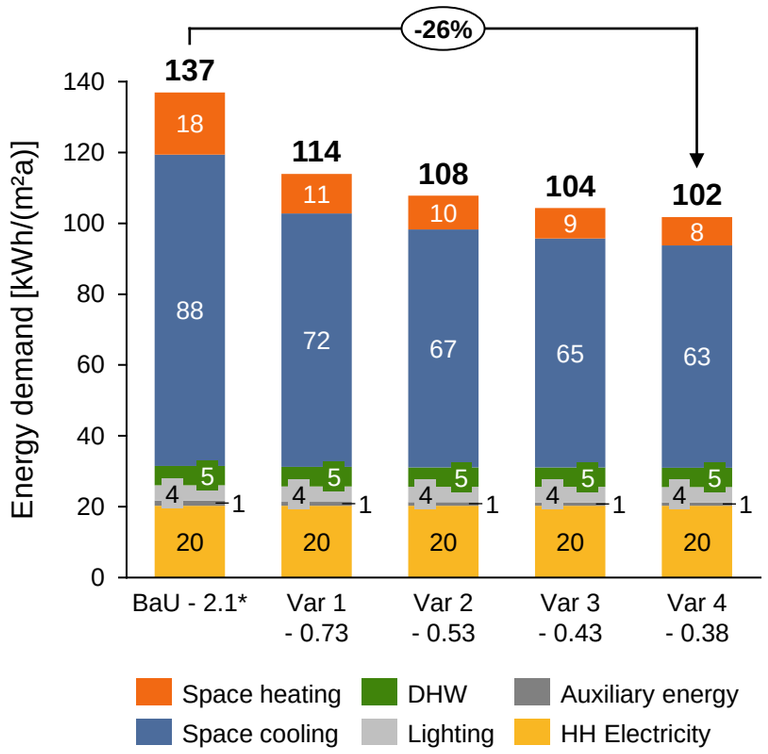
Var 1
Double wall, no insulation (U-Value = 1.1 W/m²K)

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

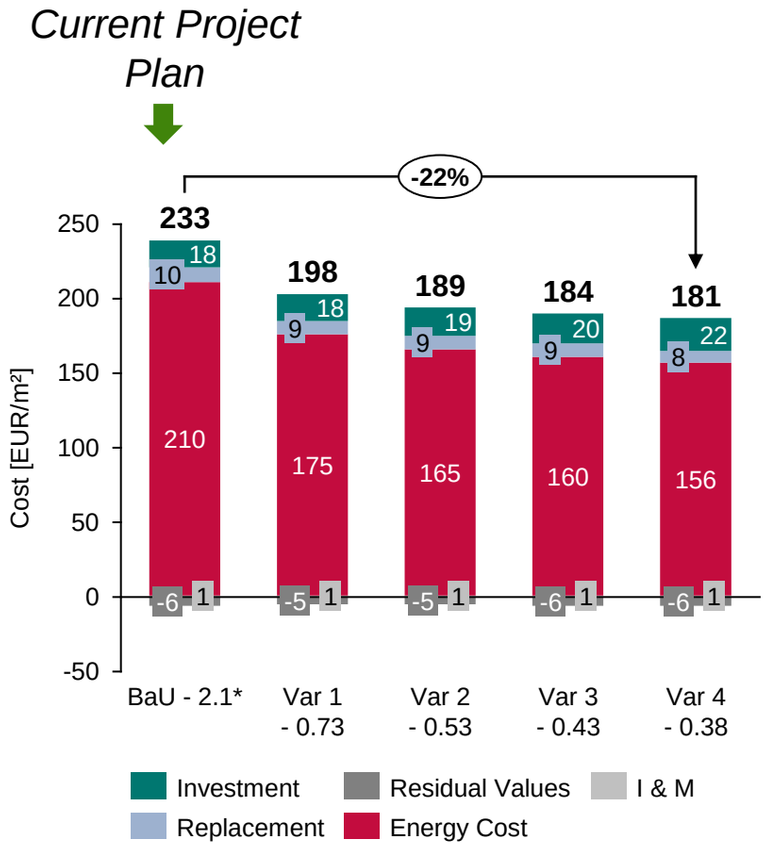
Var 3
5 cm insulation (U-Value = 0.53 W/m²K)

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

Final Energy Demand



Global Cost



Result: Var 4 is the most cost effective measure

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Building Envelope | Roof

Results

BaU

U-Value = 0.76 W/m²K (3 cm insulation)

Current

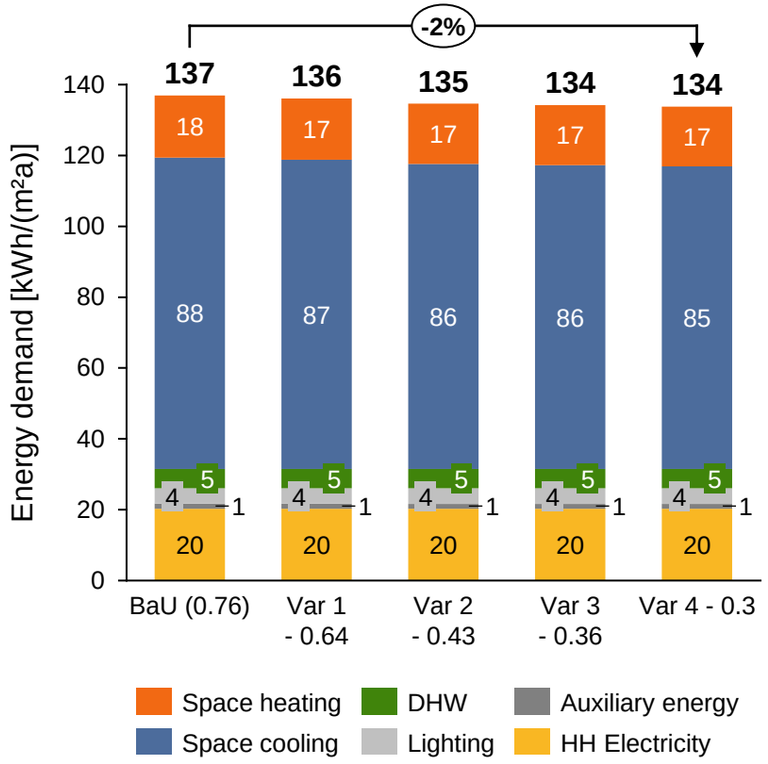
U-Value = 0.7 W/m²K

Var 1 - 4

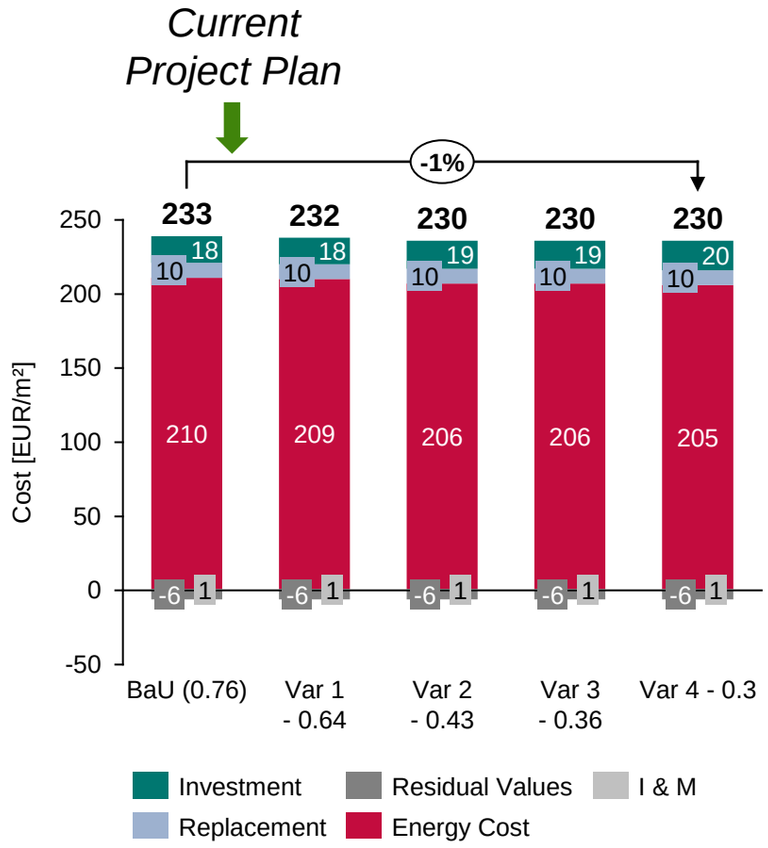
5 - 10 cm insulation (U-Value = 0.64 – 0.3 W/m²K)

Result: Var 2, 3 and 4 with up to 10 cm are the most cost effective measures. However, the current project plan is already close.

Final Energy Demand



Global Cost



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Building Envelope | Windows

Results

BaU – Single glazing

U value 5.7 W/m²K
G-Value 0.85

Double glazing | low E (Var 1|2)

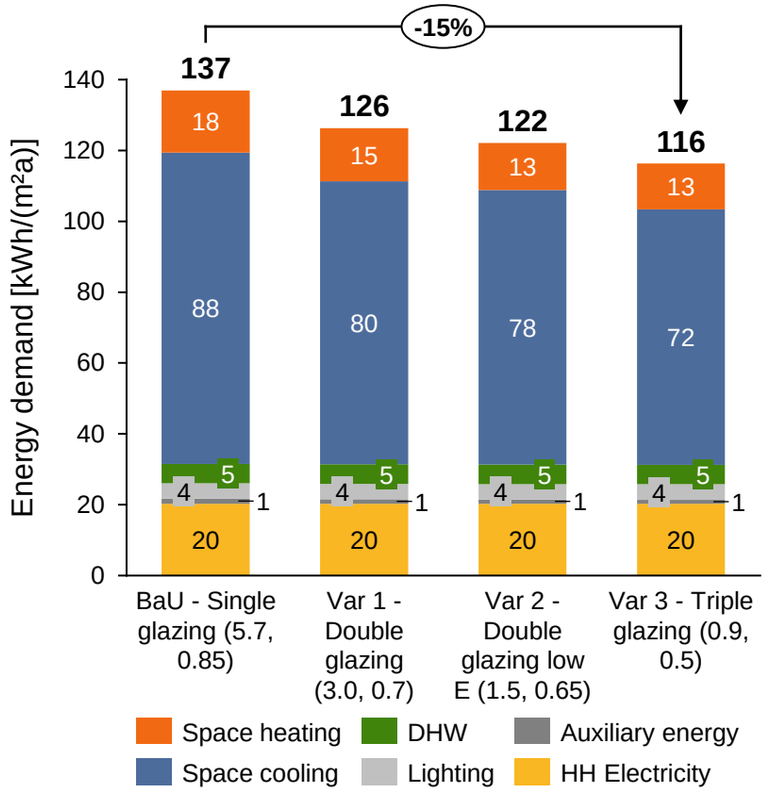
U value 2.9 | 1.2 W/m²K
G-Value 0.7 | 0.65

Triple glazing (Var 3)

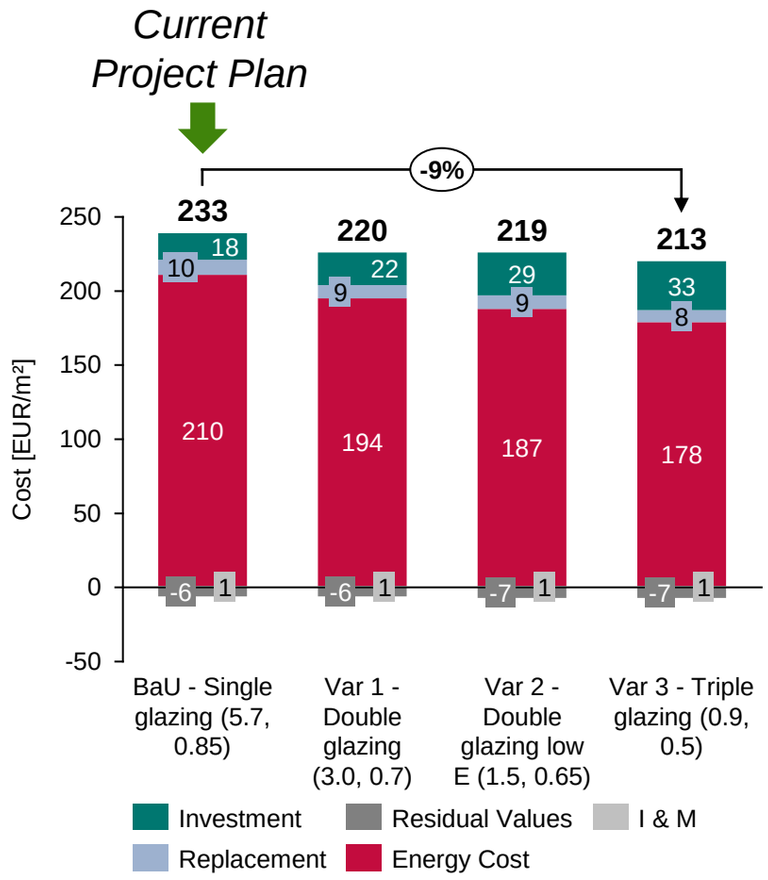
U value 0.9 W/m²K,
G-Value 0.5

Var 3 (triple glazing) is the most cost-effective case.

Final Energy Demand



Global Cost



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Window Fraction

Analysis

Var 1

Window fraction 40 %

Var 2

Window fraction 30 %

Var 3

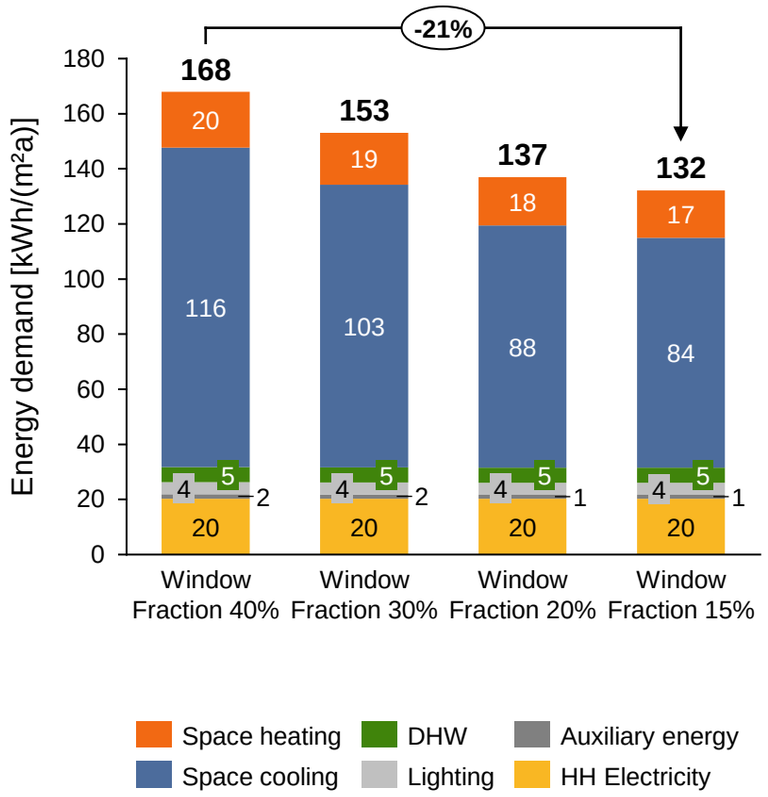
Window fraction 20 %

Var 4

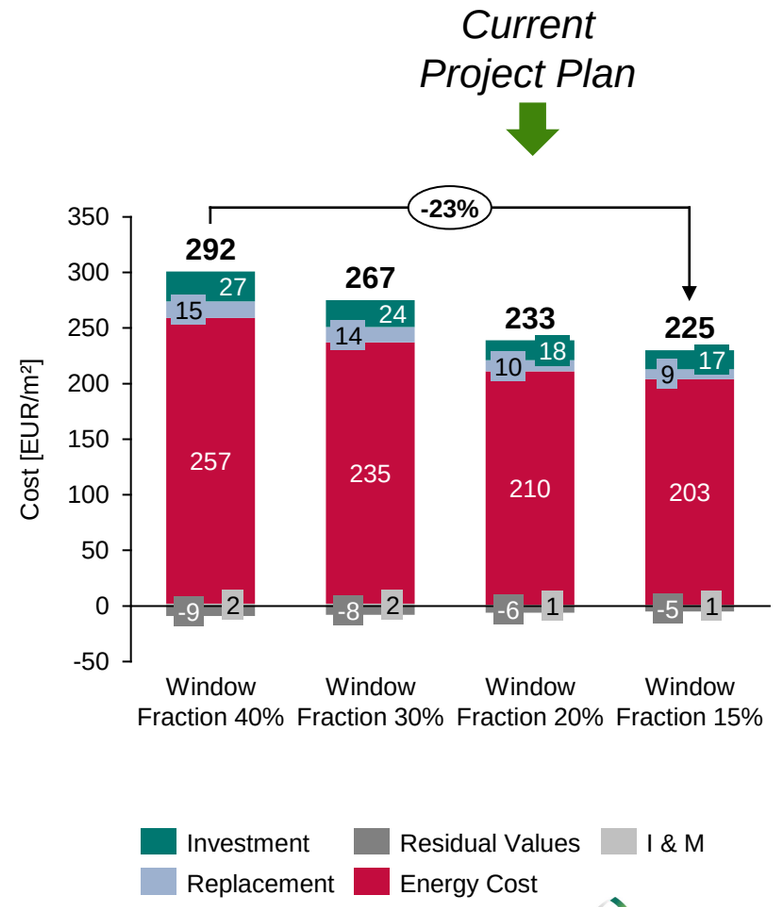
Window fraction 15 %

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 (South)

Analysis

BaU
Fixed shading (0.3 m overhang)

Var 1
Fixed Overhangs (0.7 m balcony)

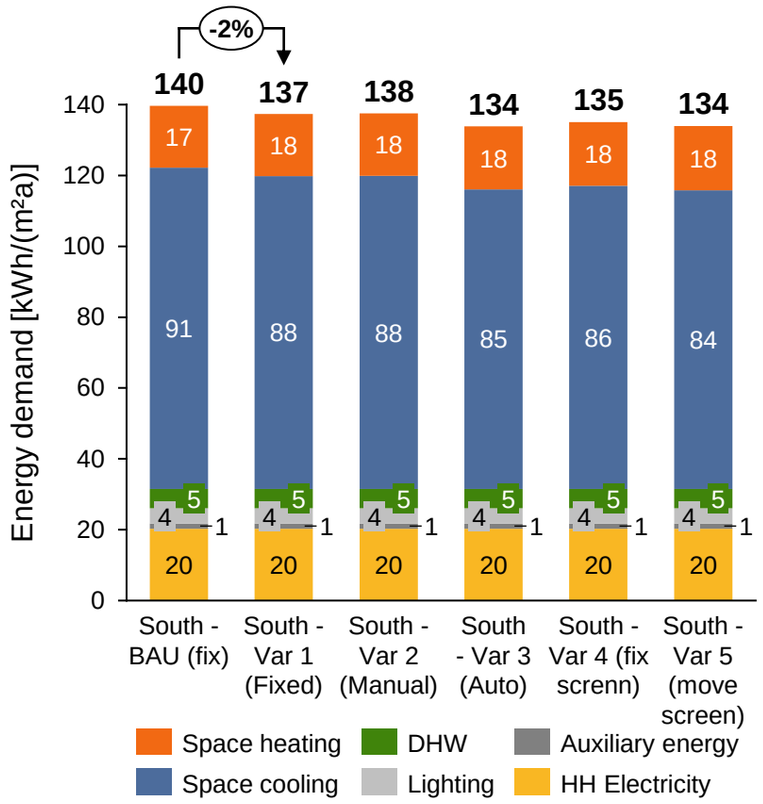
Var 2 & 3
Manual & automatic shading

Var 4
Fixed screens

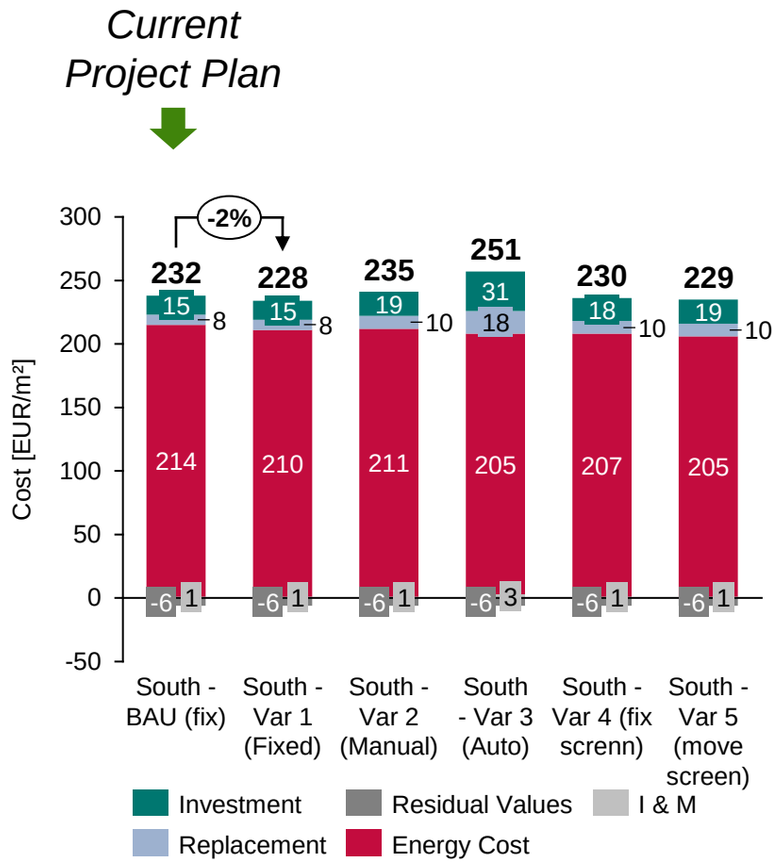
Var 5
Moveable screens

Var 1 is the most cost effective measure.

Final Energy Demand



Global Cost



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Shading concept (East/West)

Analysis

BaU
Fixed shading (0.3 m overhang)

Var 1
Fixed Overhangs (0.7m balcony)

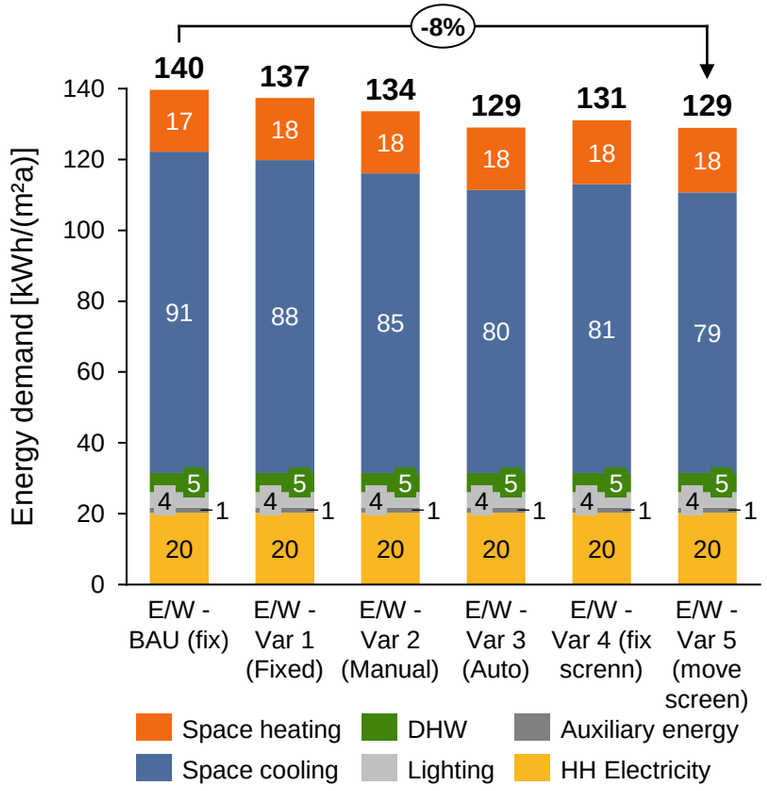
Var 2 & 3
Manual & automatic shading

Var 4
Fixed screens

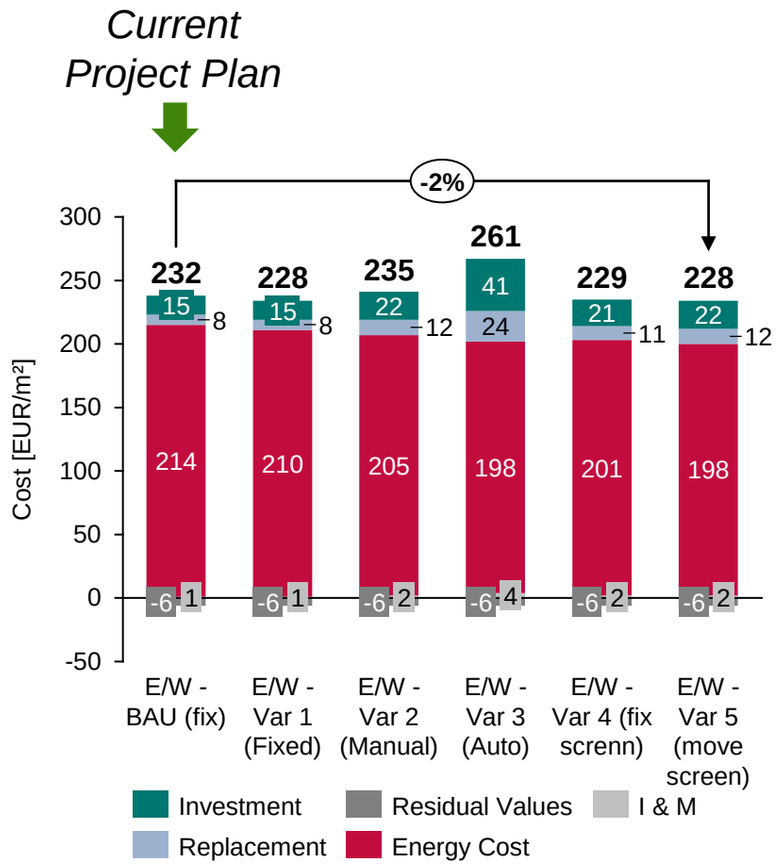
Var 5
Moveable screens

Var 5 is the most cost effective measure and has the highest energy savings.

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

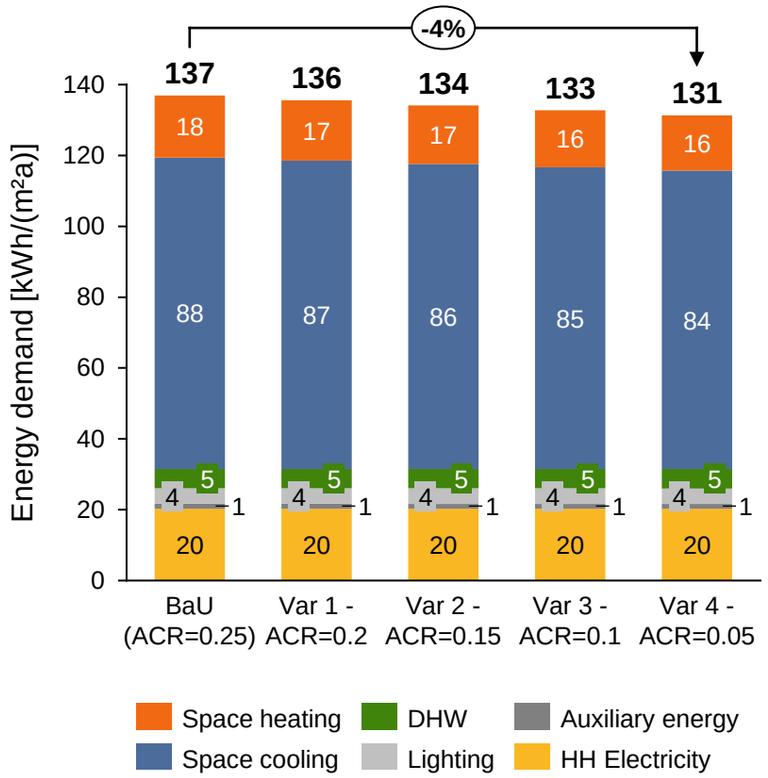
Var 2
0.15

Var 3
0.1

Var 4
0.05

Var 4 is the most cost effective measure.

Final Energy Demand



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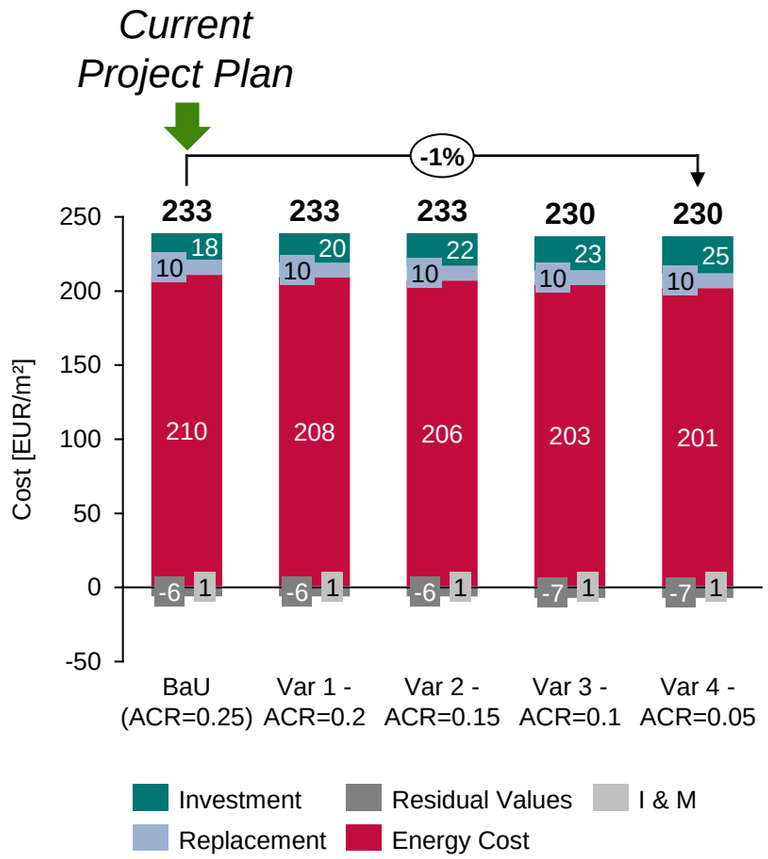

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HVAC | Efficiencies

Analysis

BaU

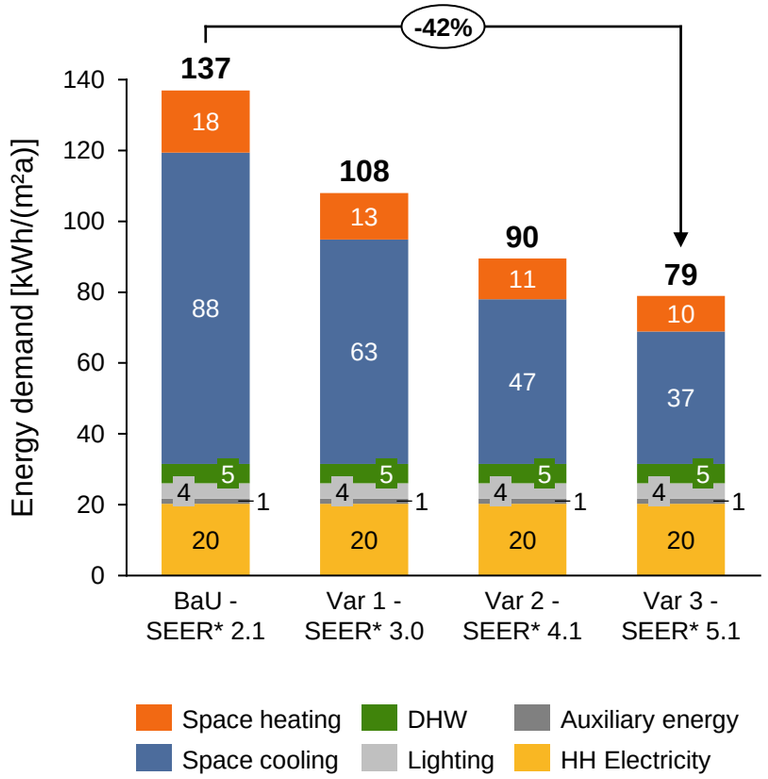
Cooling/Heating: 2.5 COP

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 cost-effective.

Final Energy Demand



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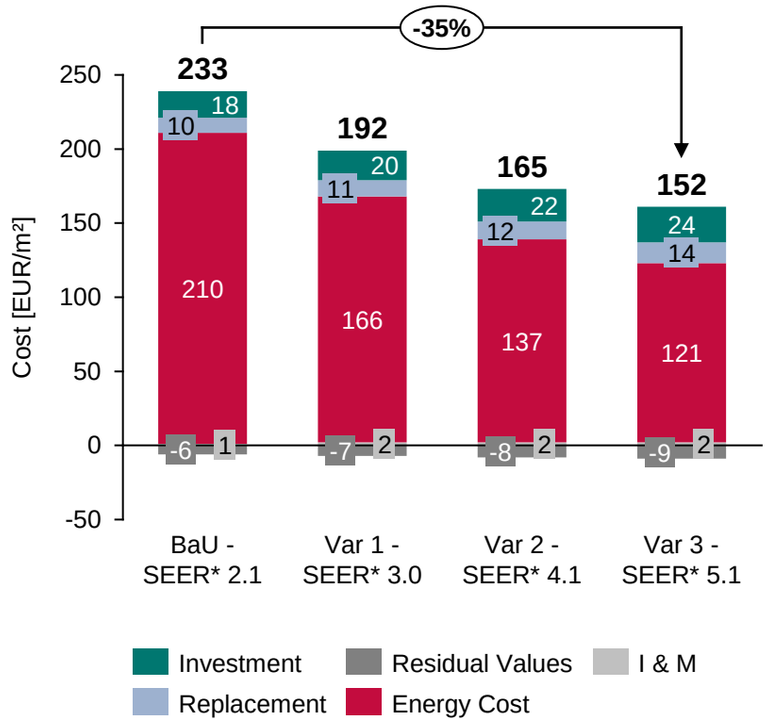

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Operational Temperatures

Analysis

BaU

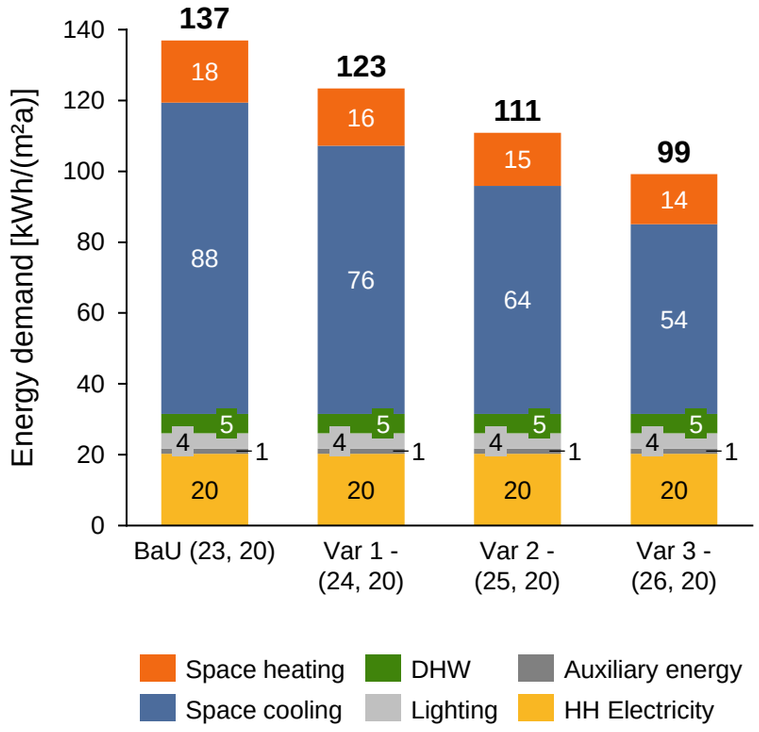
Cooling Temperature: 23°C
Heating Temperature: 20°C

Var 1 - 3

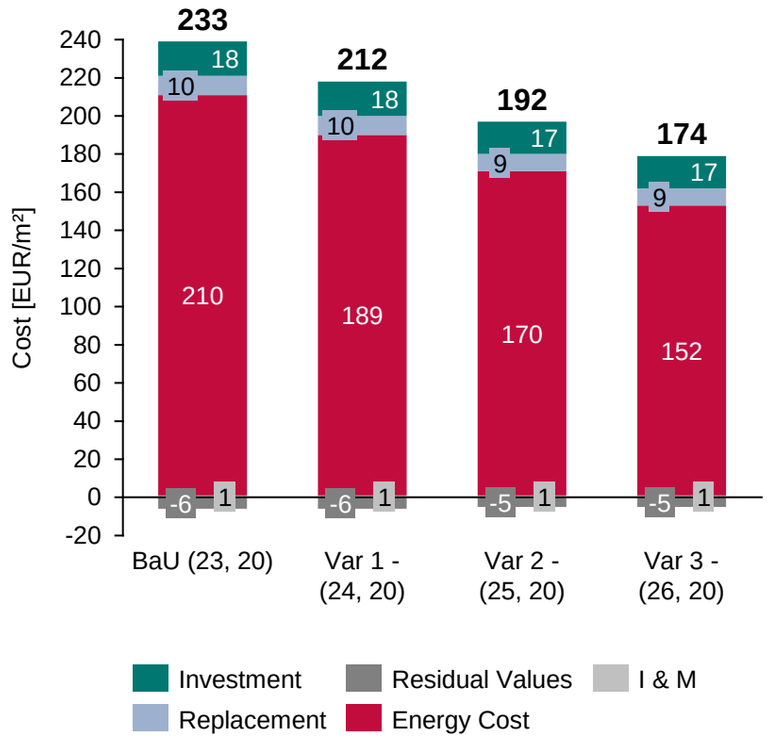
Cooling Temperature adapted (24°C - 26°C)

This measure is very effective and not related to any cost

Final Energy Demand



Global Cost



Renewables | Solar Thermal

Analysis

Current

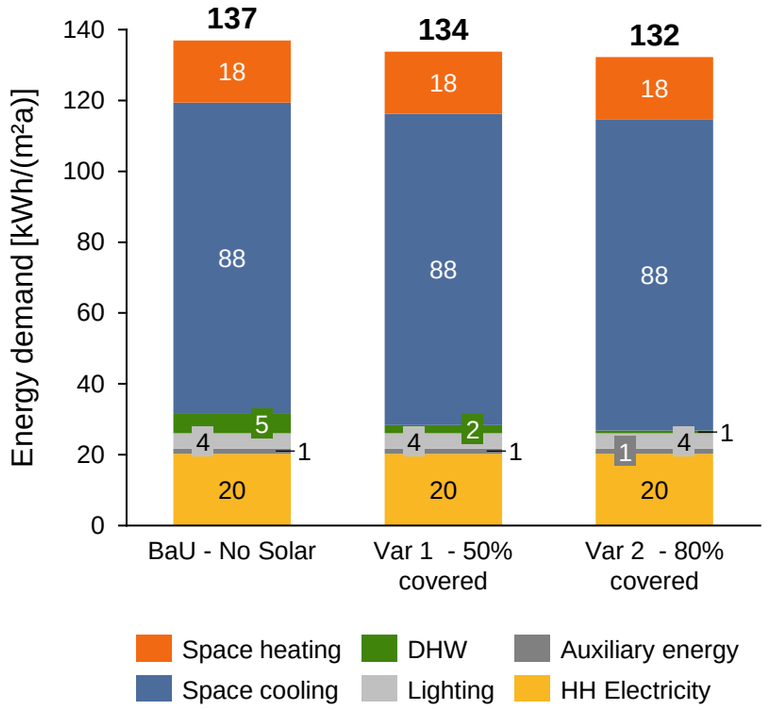
No solar hot water generation

Var 1 | 2

8 | 15 m² solar collector area installed, which is about 50% | 80% of the DHW demand covered by solar.

Var 1 with **hot water 50% covered** with **solar thermal** is the most cost effective measure.

Final Energy Demand



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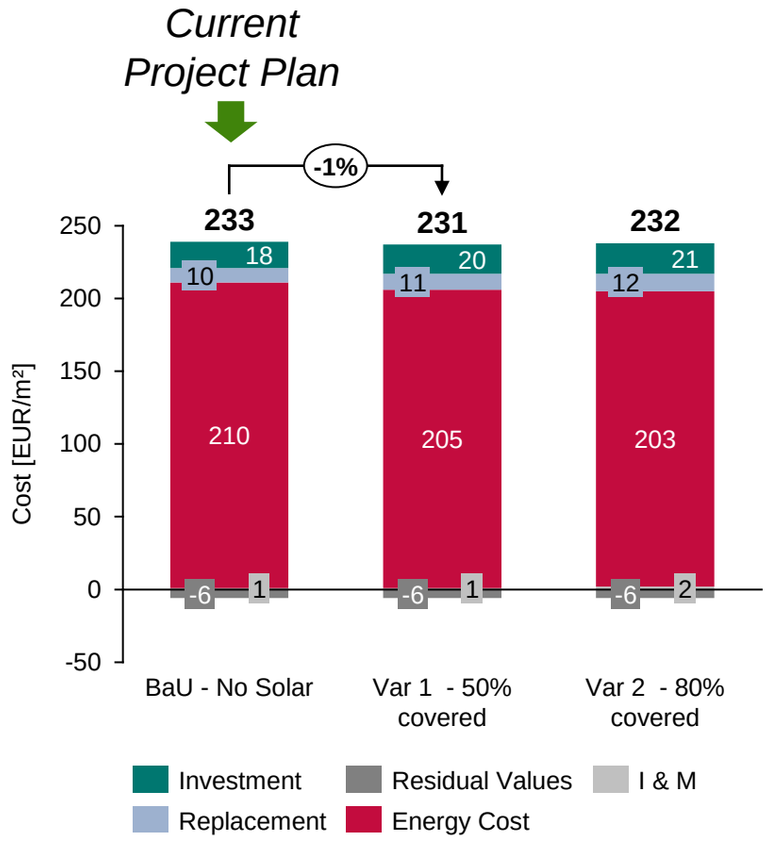


Renewables | PV

Analysis

Sizing (net metering as assumption)

Current

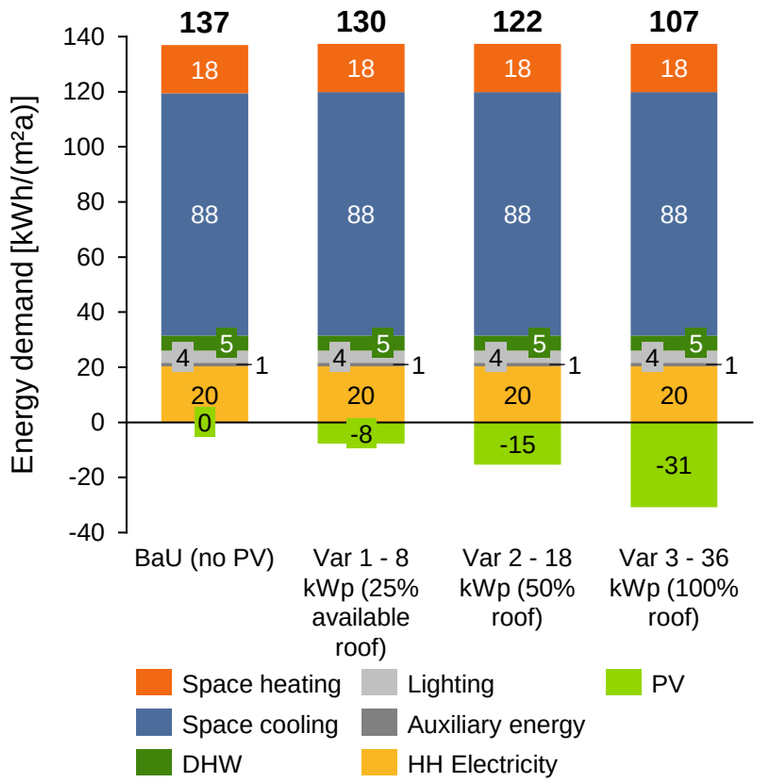
no PV

Var 1 | 2 | 3

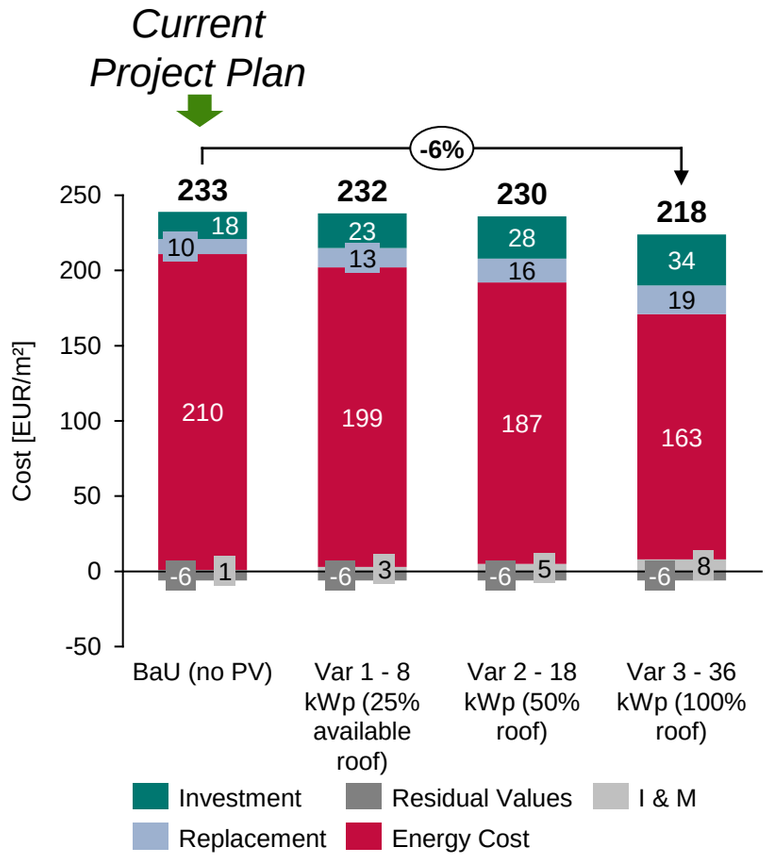
PV 8 | 18 | 36 kWp
(Roof area 63 | 126 | 252 m²)

Var 3 with **36 kWp** PV is the most cost effective measure. (the available roof area is the limit, but PV is cost-effective)

Final Energy Demand



Global Cost



Results & Conclusion

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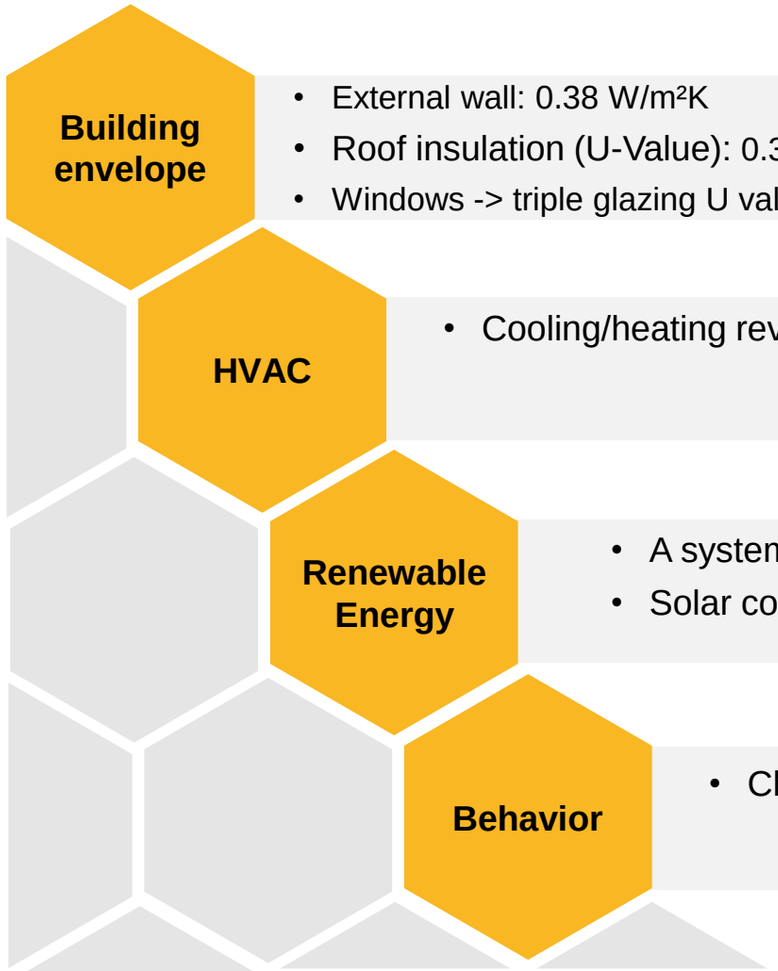
Overview of recommended measures

Four steps to reduce energy demand significantly



- External wall: 0.38 W/m²K
- Roof insulation (U-Value): 0.3 W/m²K
- Windows -> triple glazing U value of 0.9 W/m²K and G value of 0.5

- Cooling/heating reversible split system with highest COP (COP ~ 5)

- A system with maximum available area on roof is cost-effective (-> 18 kWp)
- Solar collectors for 50% of the hot water supply (8 m²)

- Change set temperature from Cooling to 26°C

Optimized Solution

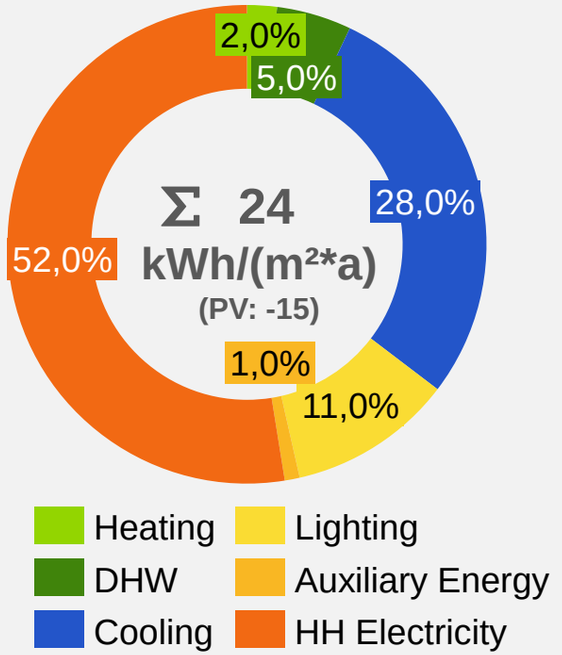
Results

The key components of the energy concept are illustrated in this table, it shows that the building envelope is significantly enhanced 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)	**0.3 W/m²K**
Wall insulation (U-Value)	**0.38 W/m²K**
Floor insulation (U-Value)	2.2 W/m²K
Windows (U-Value; G-Value)	**0.9 W/m²K; 0.5**
Window fraction	Ø 19%
Shading	**Shading elements**
Air tightness	**0.05 1/h**
Heat supply	VRF - **COP 5**
Cold supply	VRF - **COP 5**
Hot water	Direct electric & **8 m² solar**
Ventilation systems	Natural ventilation
Lighting systems	LED
Renewable energy	**18kWp (PV)**
Set temperature cooling/heating	**26°C** / 20°C



Energy Cost
0.6 EUR/(m²a) | 11 EGP/(m²a)

CO2 - Emission
4.3 kg / (m²*a)

Comparative Overview

BaU, Current vs. Optimized

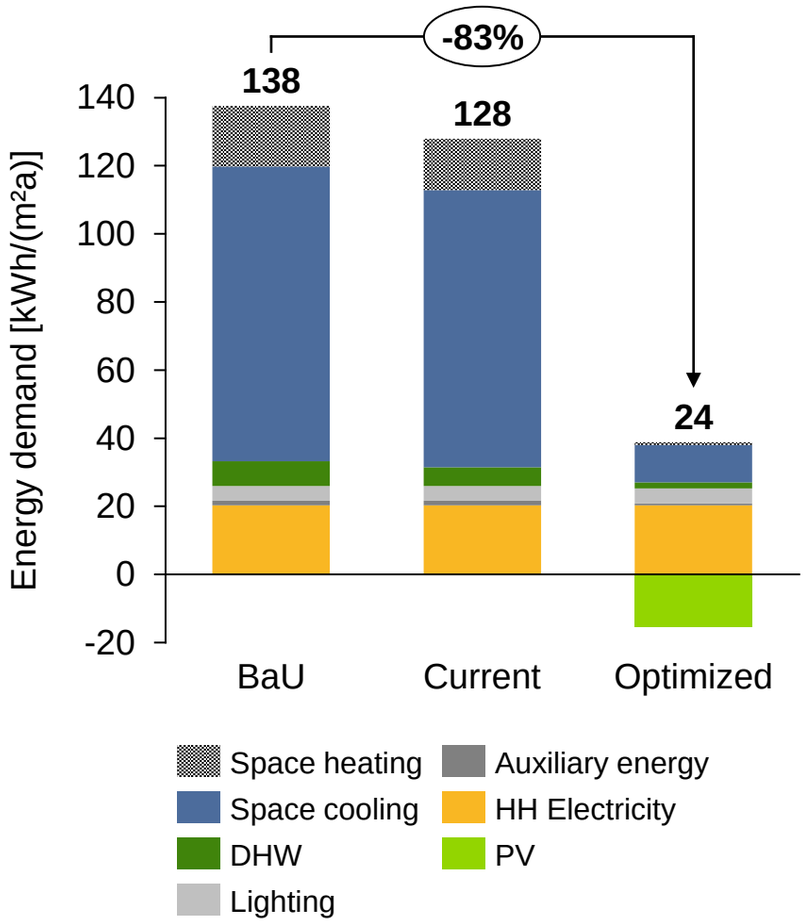
Conclusion

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

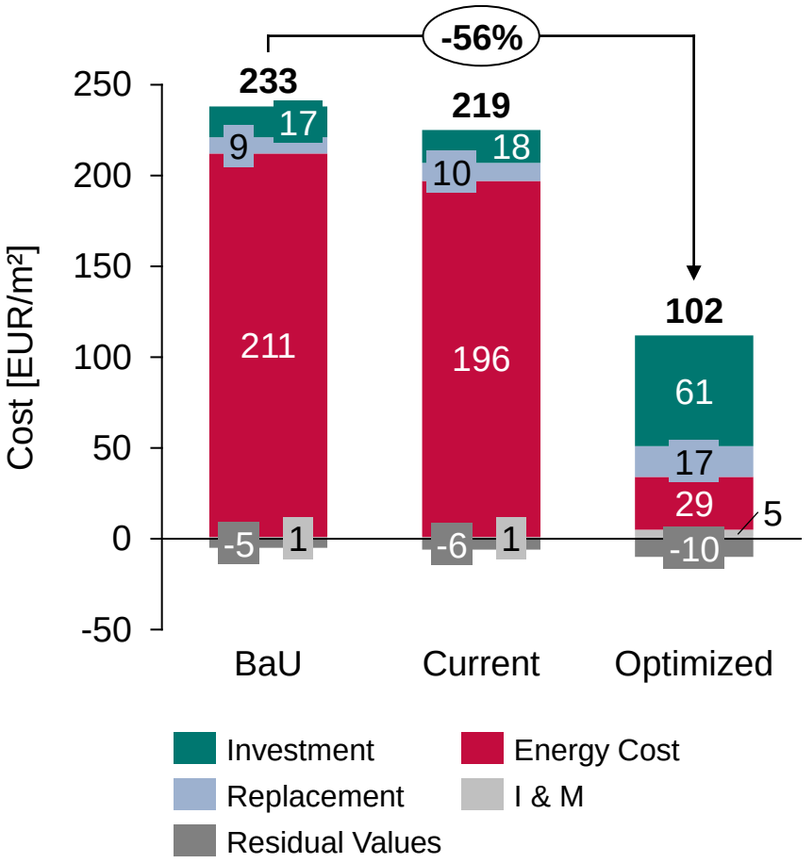
Savings compared to BaU

	Energy	Costs
Optimized	83%	56%

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)	0.3 W/m²K	3,200	-700	5	40
Wall insulation (U-Value)	0.38 W/m²K	12,000	-8,000	2	40
Shading	Moveable elements (East/West)	13,500	-2,500	6	30
Windows	Triple glazing	35,000	-4,500	8	30
Heat/Cold supply	reversible split unit - COP 5.0	12,000	-13,000	2	15 – 20
Renewable energy (solar)	8 m² solar collectors	2,800	-1,100	3	15 – 20
Renewable energy (PV)	18 kWp (PV)	19,000	-3,500	6	15 – 20
Set temperature cooling/heating	26°C / 20°C	0	-8,000	Immediately	-
Total (current to optimized)**		**97,500 (+2-3%)*****	**-41.300**	**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 the MFH in the Badya Project

1

- Energy savings in the range of 80% are possible

2

- The selected package is also attractive in economic terms with a payback around 3 years

3

- Additional costs per apartment of 9,000 € seems to be a burden, but considering the fast PBP and the increase of the assest value, the optimized package remains attractive

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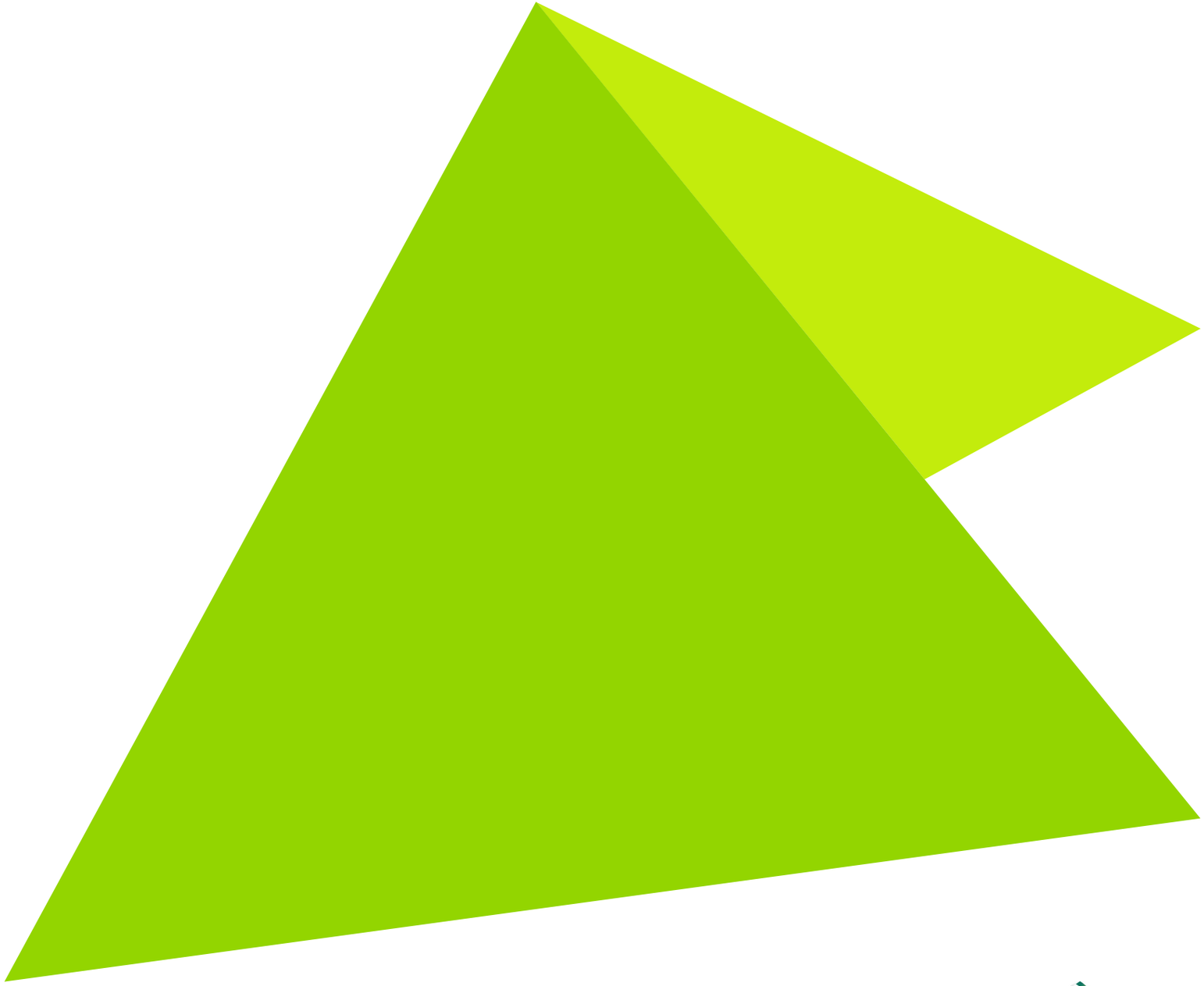

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