Energy Efficiency Recommendations for Heliopolis Residence , Misr Alghad, Egypt

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

September 2120

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Introduction

Background, Objectives and Methodology

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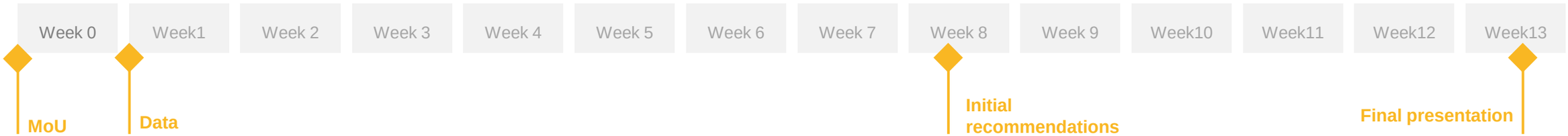
Introduction

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

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

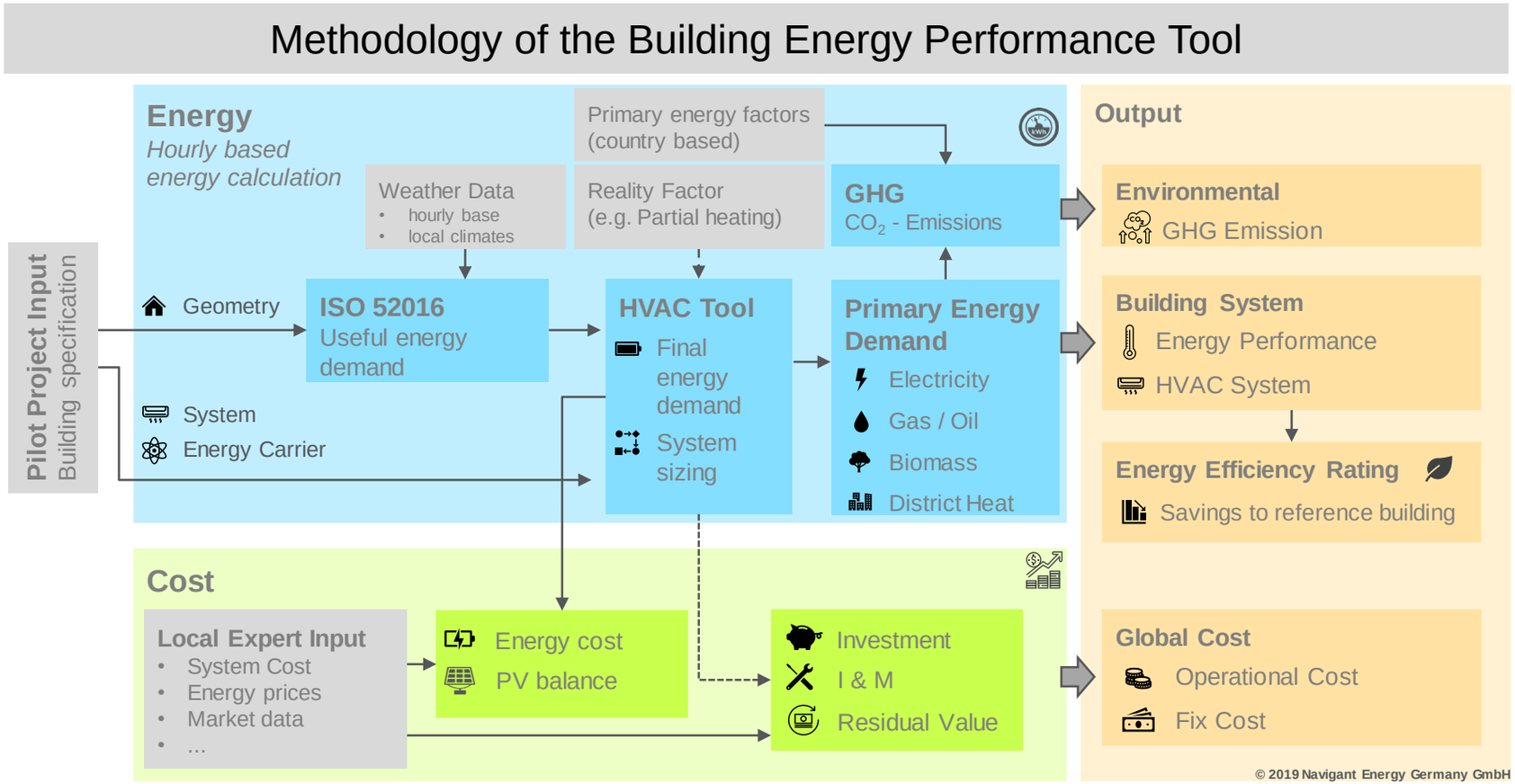
- Calculation of energy cost and investment cost of the systems, based on the HVAC system sized in the energy calculation
- Energy price systematic and PV clearing can be adapted to local situation (here: Jordan)
- Residual values at the end of the calculation period for the systems are considered

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)



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Introduction
Heliopolis Residence
Boundary conditions

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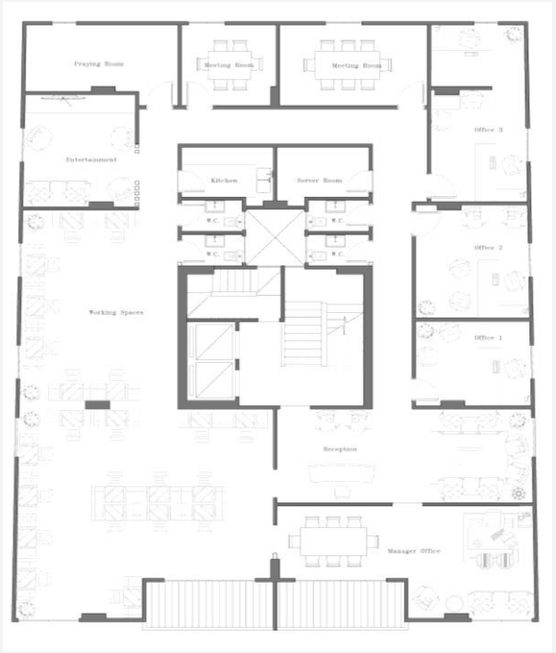


Heliopolis Residence

Aims

To create a mixed-use building that will offer a variety of offices, residential and commercial units of different types.

Target Groups

Upper middle class in Cairo.

Function

A diverse range of residential and commercial units.

Size

Total area of around 2600 m2 on 12 floors. The building has 24 units with more than 170 occupants/users.

Boundary conditions

Site : Context matters

City : Cairo

Location : 12 KM from Cairo Airport.

Context

The building located in the heart of Heliopolis in a very vibrant and dense urban area.

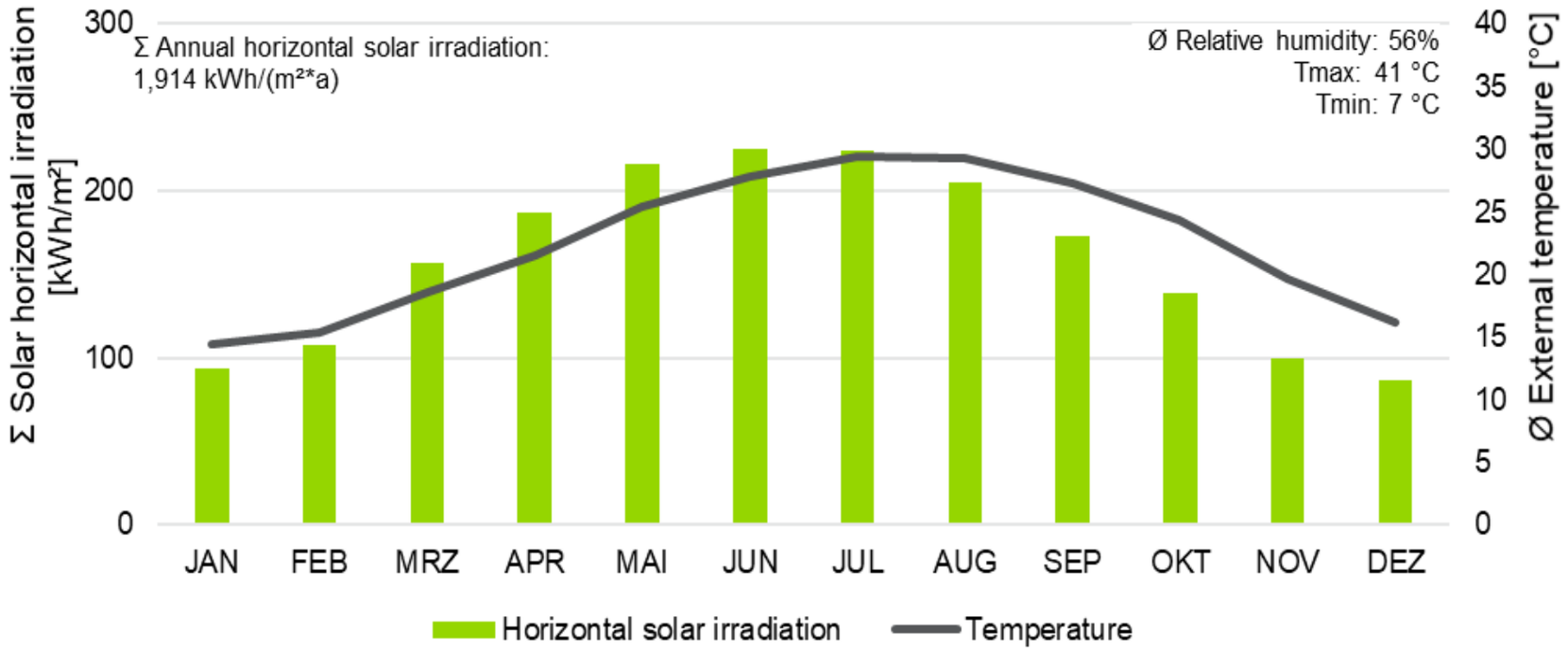
Source: Google Maps

Boundary conditions I Climate Analysis

Outside temperature and Humidity

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 I Climate Analysis

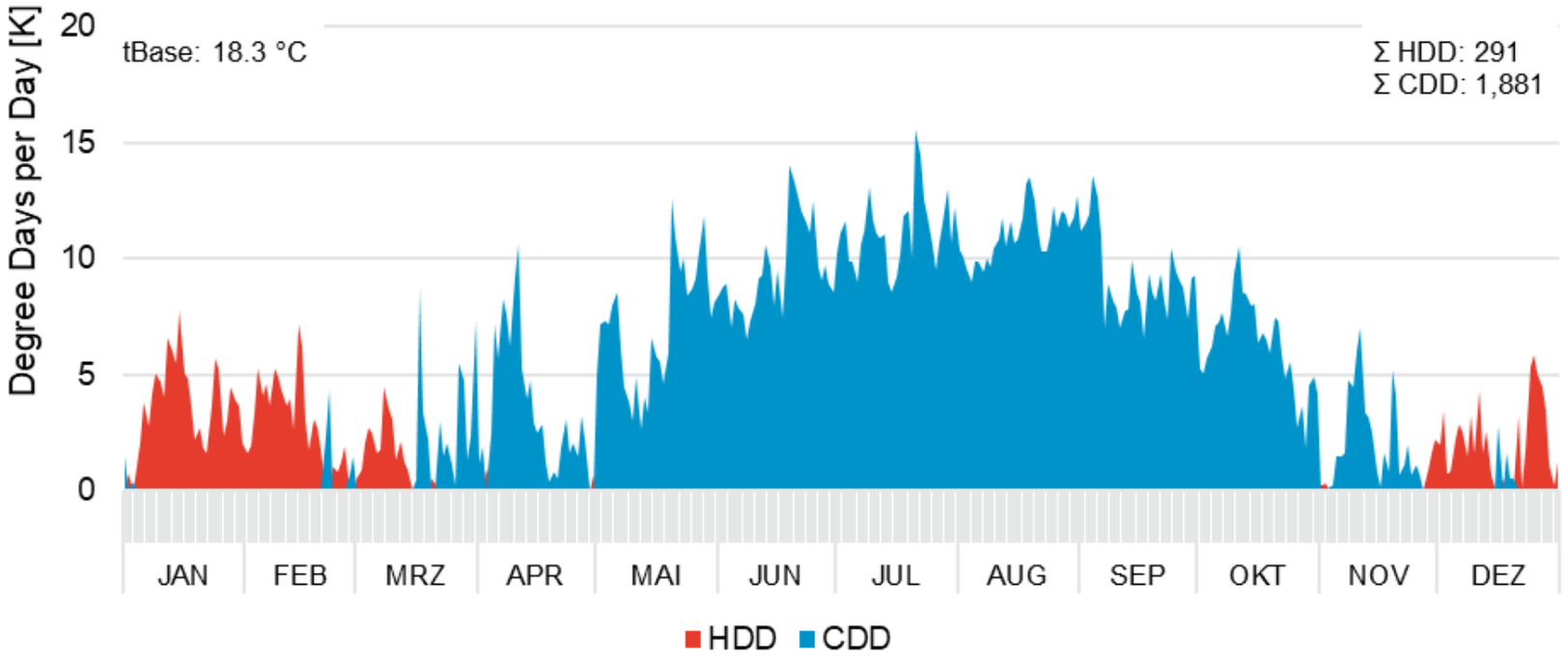
Heating and cooling degree days in Cairo (Egypt)*

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 I Climate

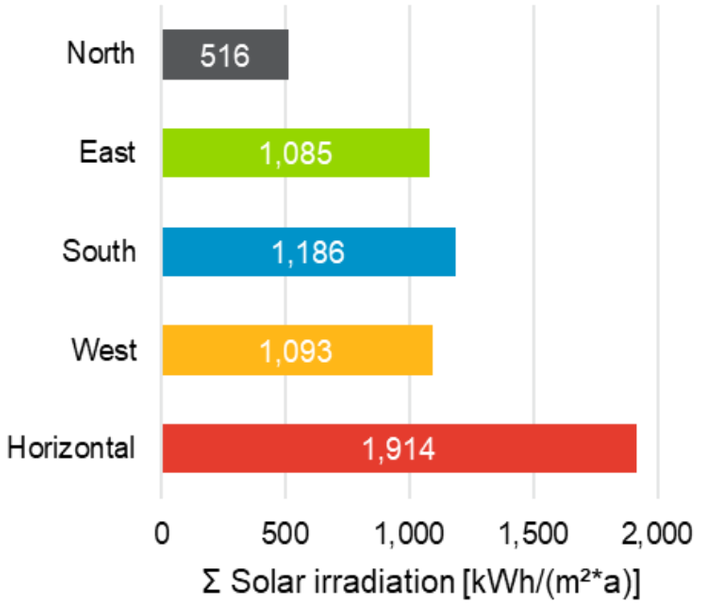
Solar Irradiation in Cairo (Egypt)

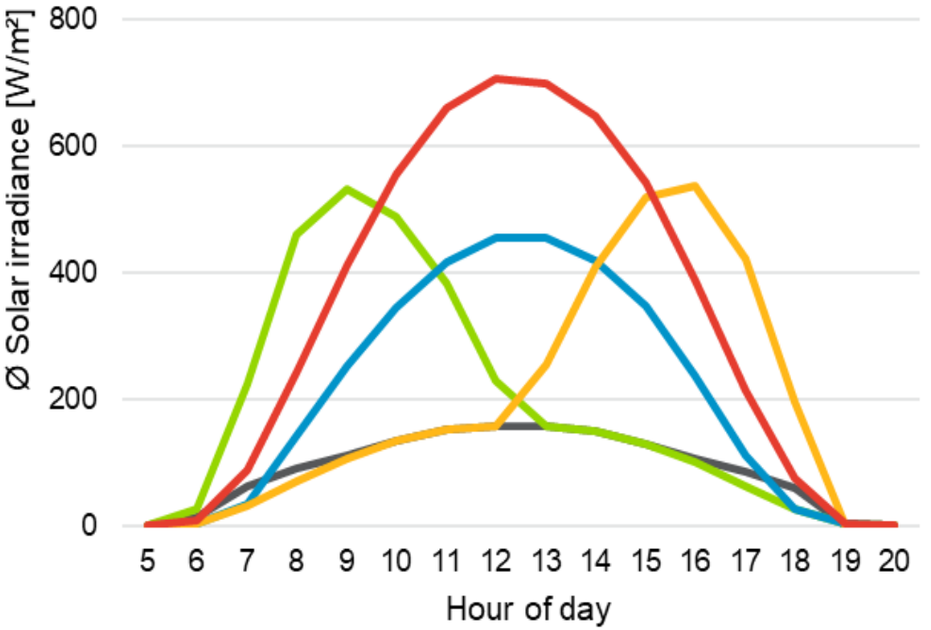
Description

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 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

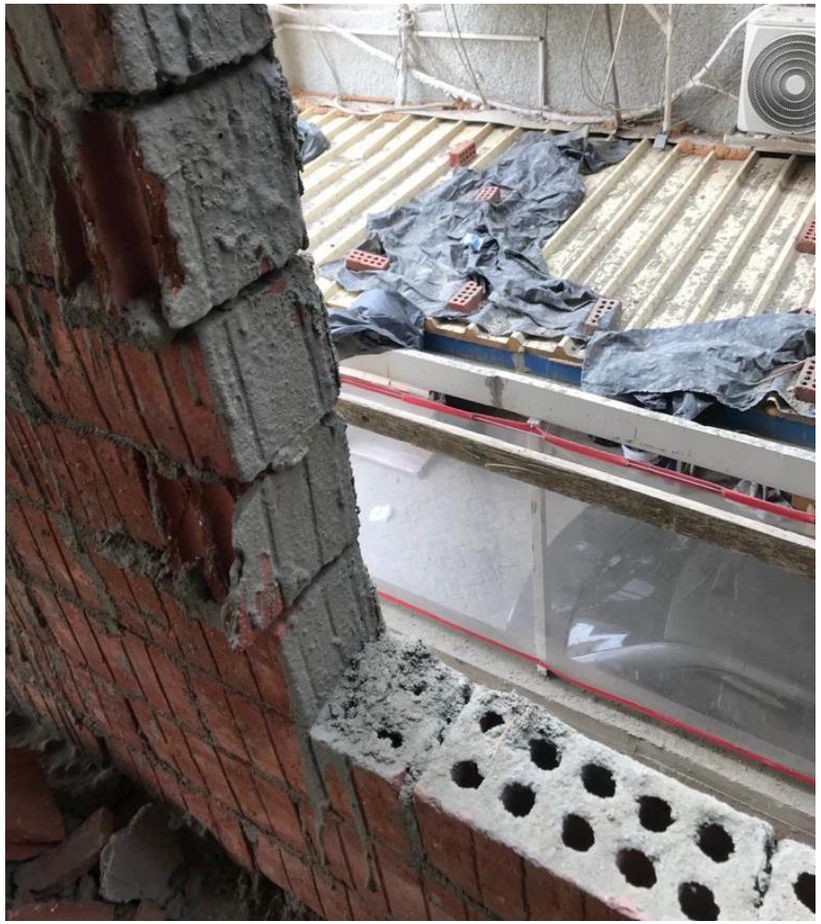
Building Data

Status

The multi-family is under construction and it is planned to be delivered before end of 2021.

Specific Challenge

The building in the final phases of construction which leaves a limited room for intervention.



Building Key Information	
Data	Input
Latitude	30.082407
Longitude	31.344887
Elevation [m]	97
Utilization	MFH
Number of floors	12
Number of units	24
Conditioned floor area [m²]	2580
Clear room height [m]	3,1
Conditioned volume [m³]	6900
Number of inhabitants/users [#]	170
Year of construction	2018-2021

Analysis

Starting Situation - Baseline and Current planning

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

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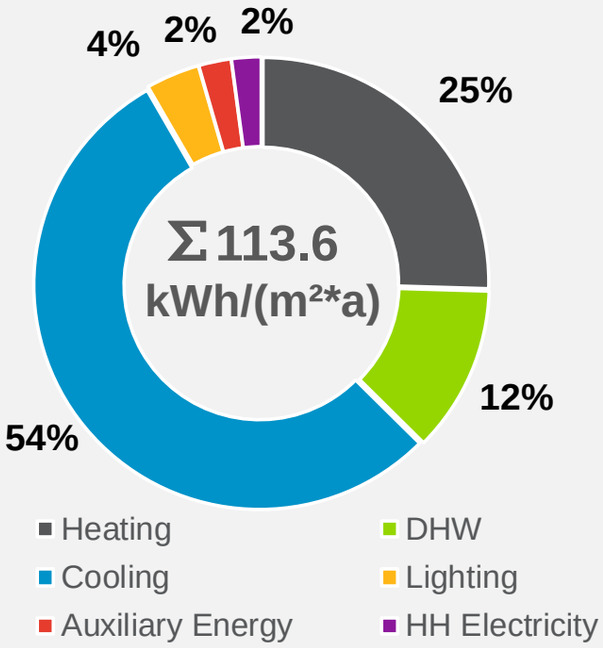
Business as Usual

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)	3.2 W/m²K
Wall insulation (U-Value)	2.2 W/m²K
Floor insulation (U-Value)	2.2 W/m²K
Windows (U-Value; G-Value)	5.8 W/m²K; 0.85
Window fraction	Ø 24%
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	LED
Renewable energy	No
Set temperature cooling/heating	23°C / 23°C



Energy Cost
7.2 EUR / (m²*a)

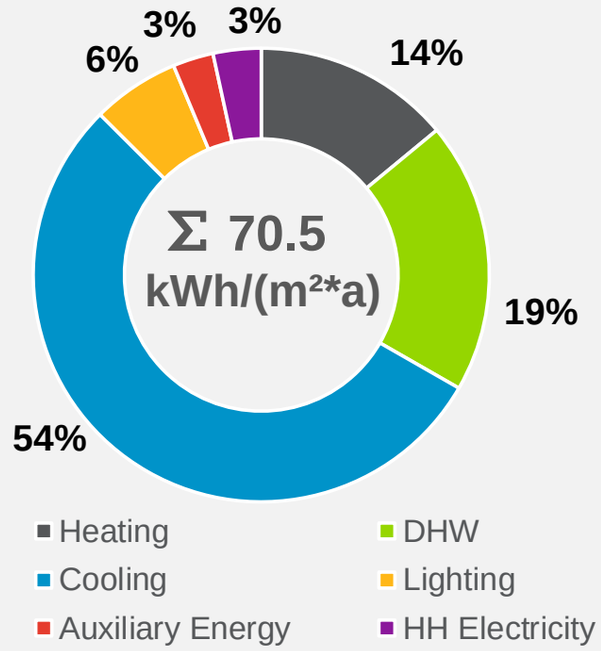
CO2 - Emission
3.6 kg / (m²*a)

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 not 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)	**2.0 W/m²K**
Wall insulation (U-Value)	**2.0 W/m²K**
Floor insulation (U-Value)	2.2 W/m²K
Windows (U-Value; G-Value)	**2.88 W/m²K; 0.7**
Window fraction	Ø 24%
Shading	No
Air tightness	0.25 1/h
Heat supply	Reversible split unit - **COP 3.2**
Cold supply	Reversible split unit - **COP 3.2**
Hot water	Gas instantaneous
Ventilation systems	Natural ventilation
Lighting systems	LED
Renewable energy	No
Set temperature cooling/heating	**24°C / 21°C**



Energy Cost
4.2 EUR / (m²*a)

CO2 - Emission
2.1 kg / (m²*a)

Comparison: BaU and Current Planning

The proposed design is more energy efficient in comparison to the BAU cases.

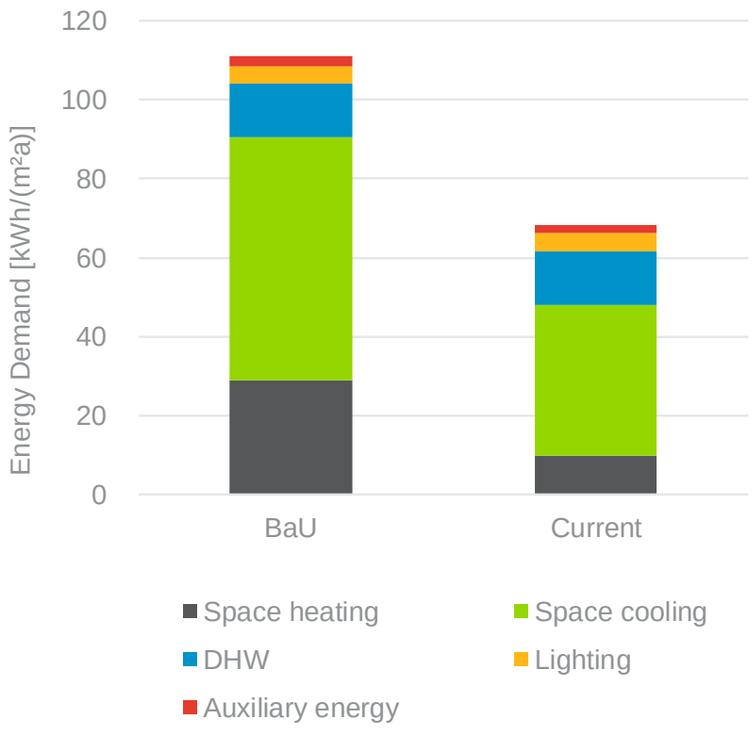
In terms of global cost, the proposed measures will also result in a cost decrease due to the significantly lower energy cost.

However, the proposed measures do not hit the cost optimal point.

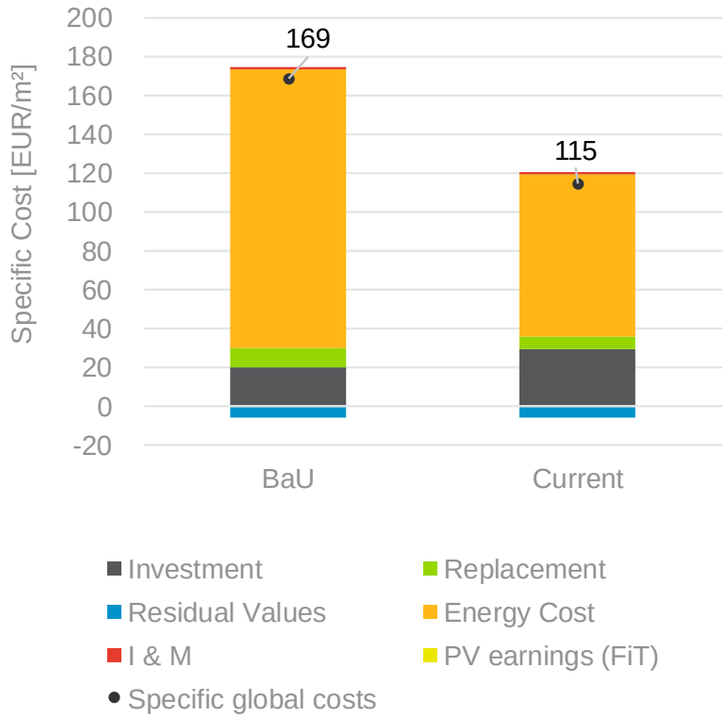
Energy savings of appr. 40%

Global costs of appr. 30%

Final Energy Demand



Global Cost



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Analysis

Investigation of Possible Measures

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Building Envelope | External wall

Results

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

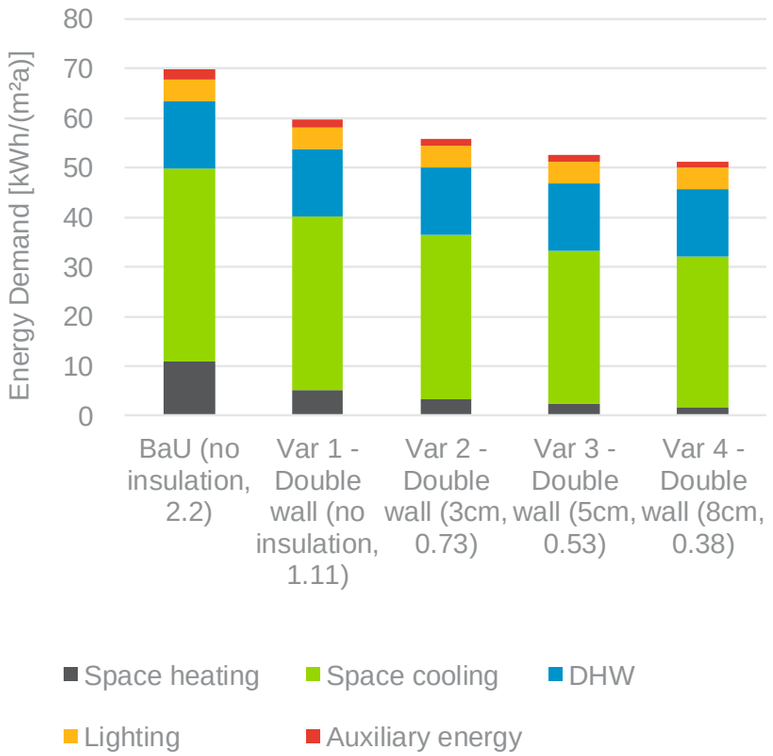
Var 1
Double wall, no insulation (U-Value = 1.1 W/m²K)

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

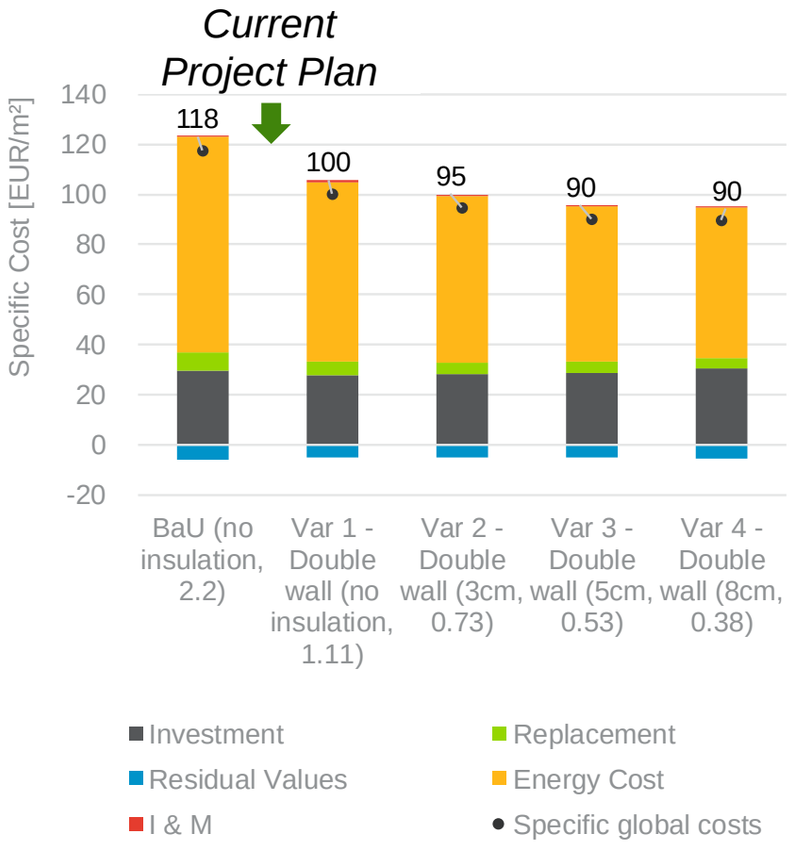
Var 3
5 cm insulation (U-Value = 0.53 W/m²K)

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

Final Energy Demand



Global Cost



Result: Var 3 is the most cost effective measure

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Building Envelope | Roof

Results

BaU

no insulation

Current

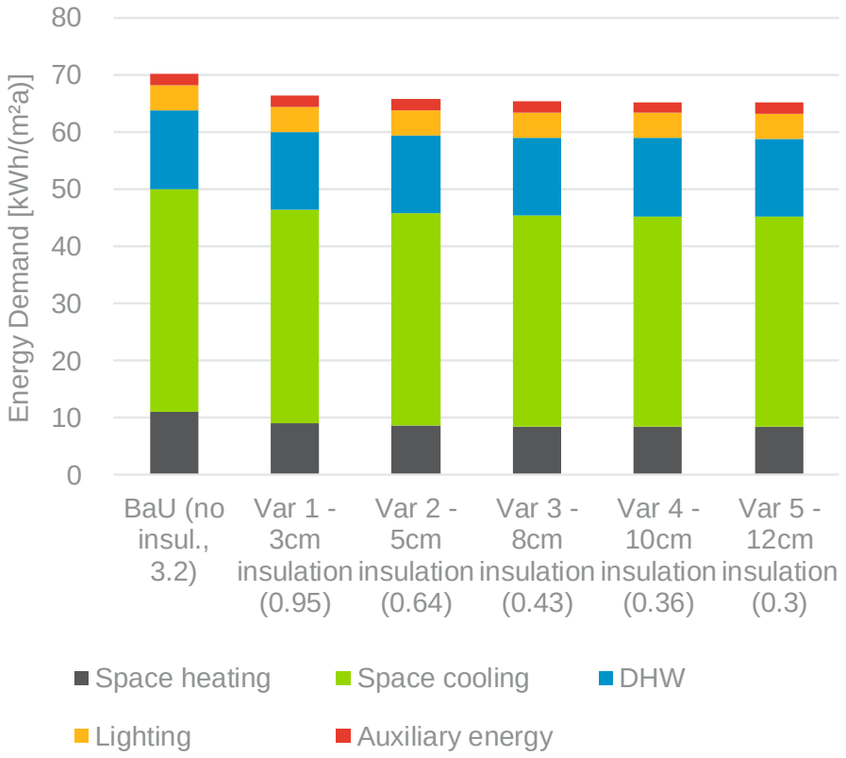
7 cm insulation (U-Value = 0.46 W/m²K)

Var 1 - 5

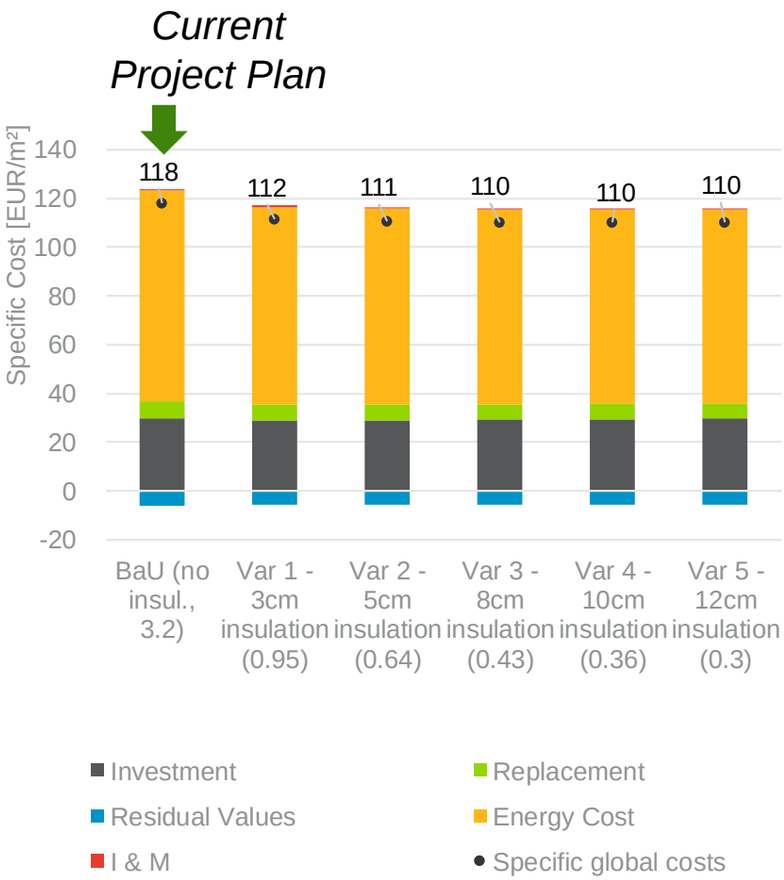
3 – 12 cm insulation (U-Value = 0.92 – 0.25 W/m²K)

Result: Var 3 with 8 cm is the most cost effective measure. 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)

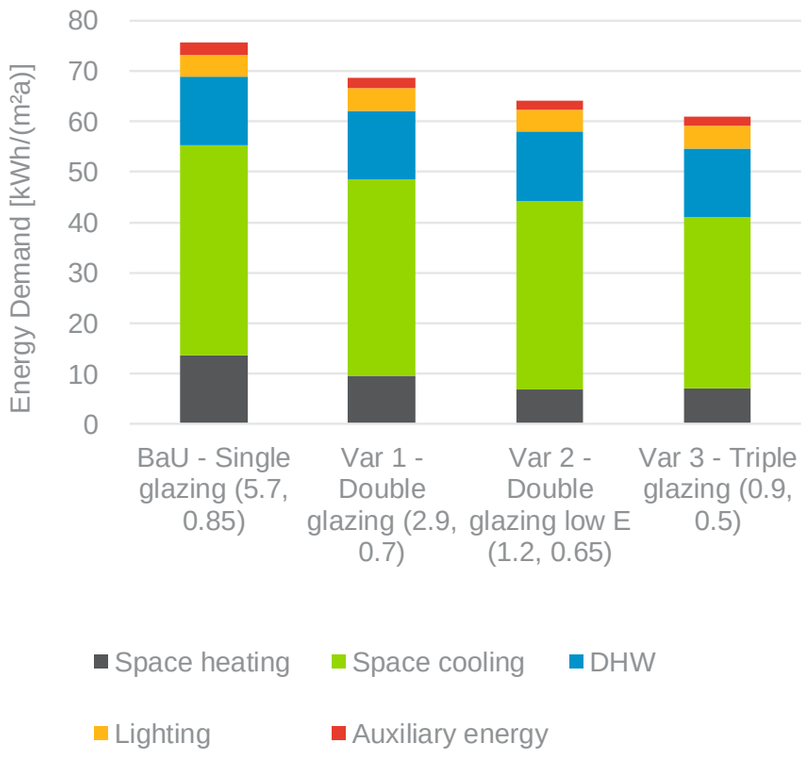
U value 2.8 | 1.2 W/m²K
G-Value 0.7 | 0.65

Triple glazing (Var 2)

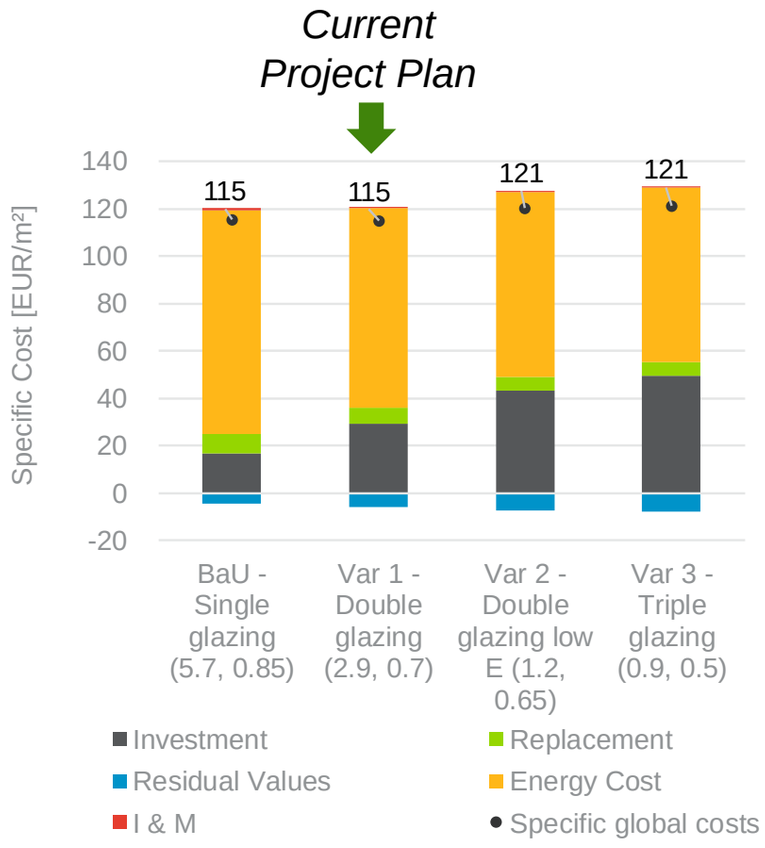
U value 0.9 W/m²K,
G-Value 0.5

Var 2 (current plan) is the more cost-effective case.

Final Energy Demand



Global Cost



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Window Fraction
Analysis

Var 1
Window fraction 40 %

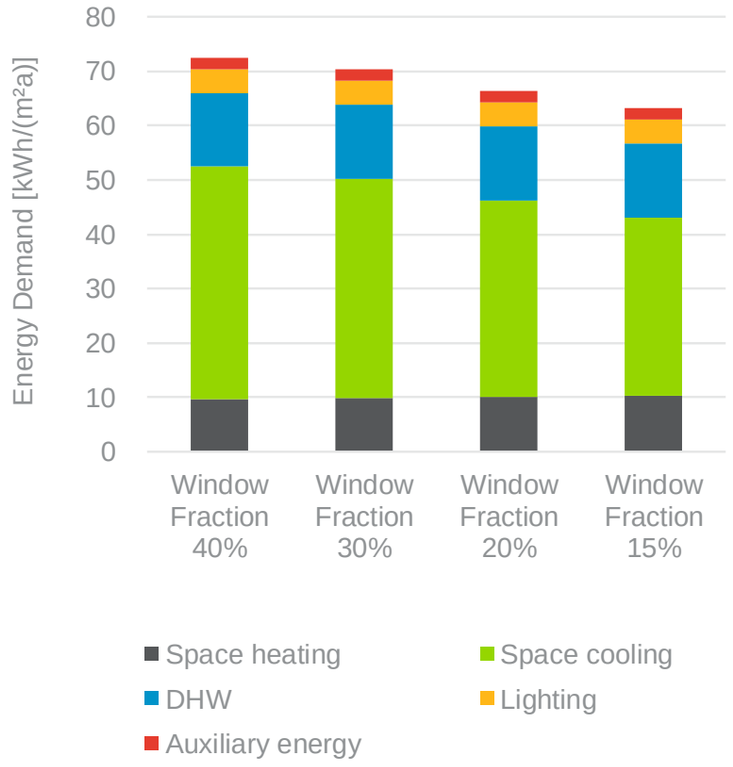
Var 2
Window fraction 30 %

Var 3
Window fraction 20 %

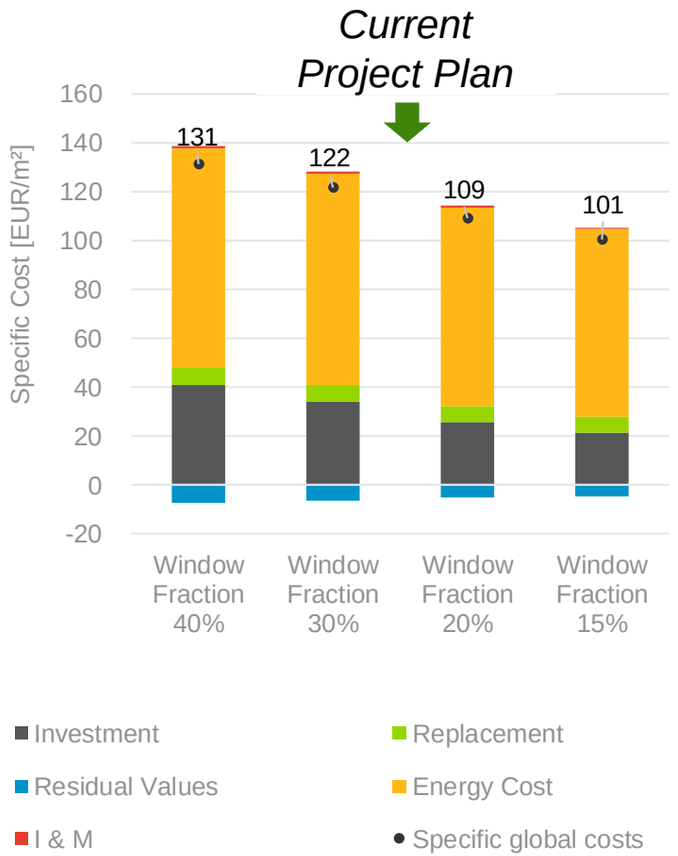
Var 4
Window fraction 15 %

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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Air Tightness

What is the effect of air tightness?

BaU
0.25

Var 1
0.20

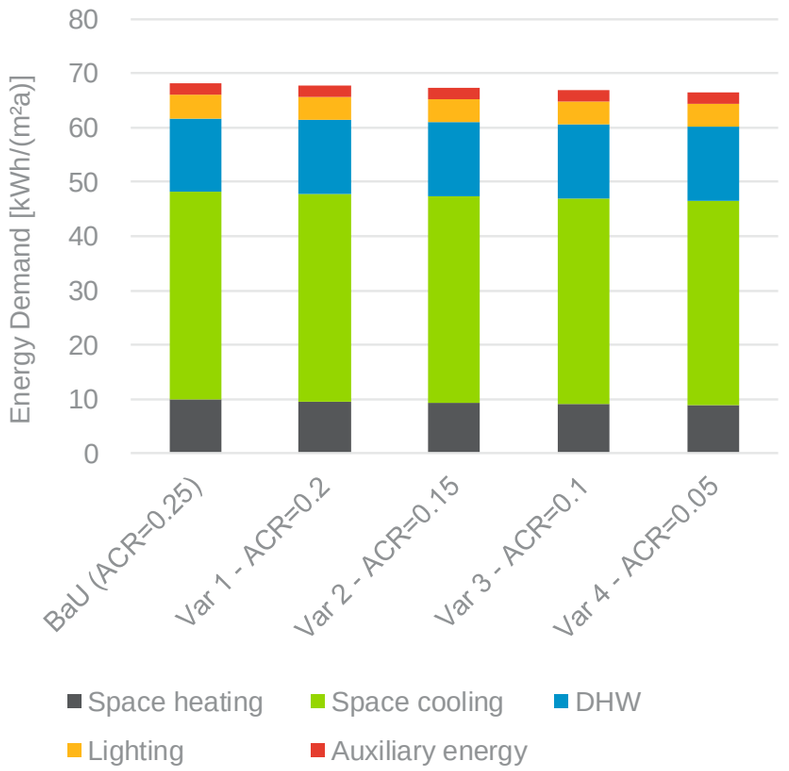
Var 2
0.15

Var 3
0.1

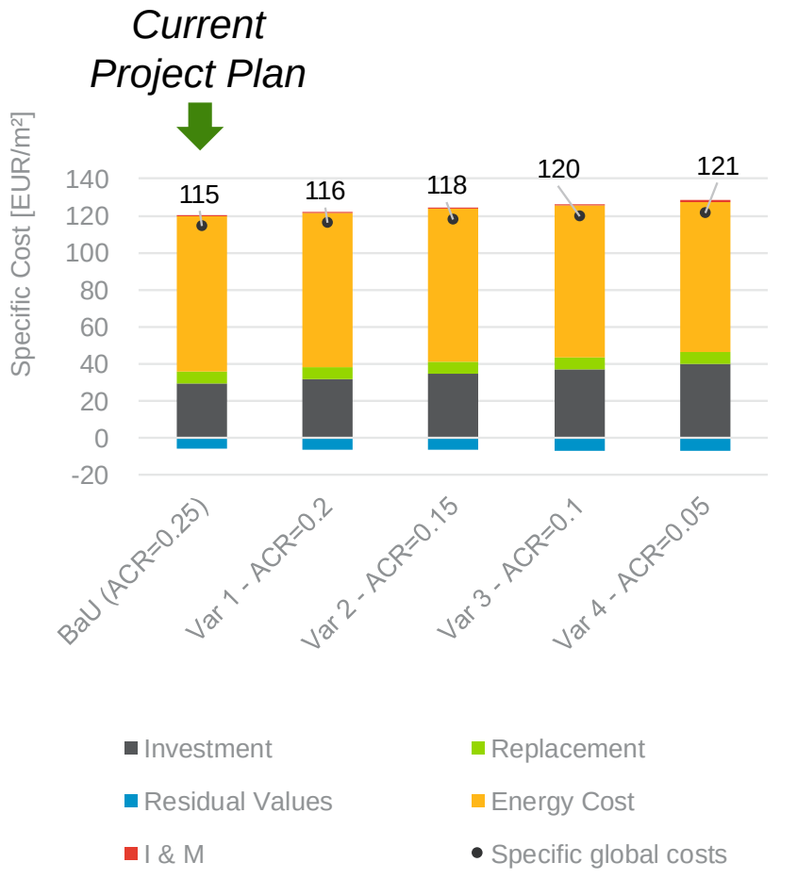
Var 4
0.05

BaU (current) is the most cost effective measure.

Final Energy Demand



Global Cost



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Shading concept

Analysis

BaU
No shading

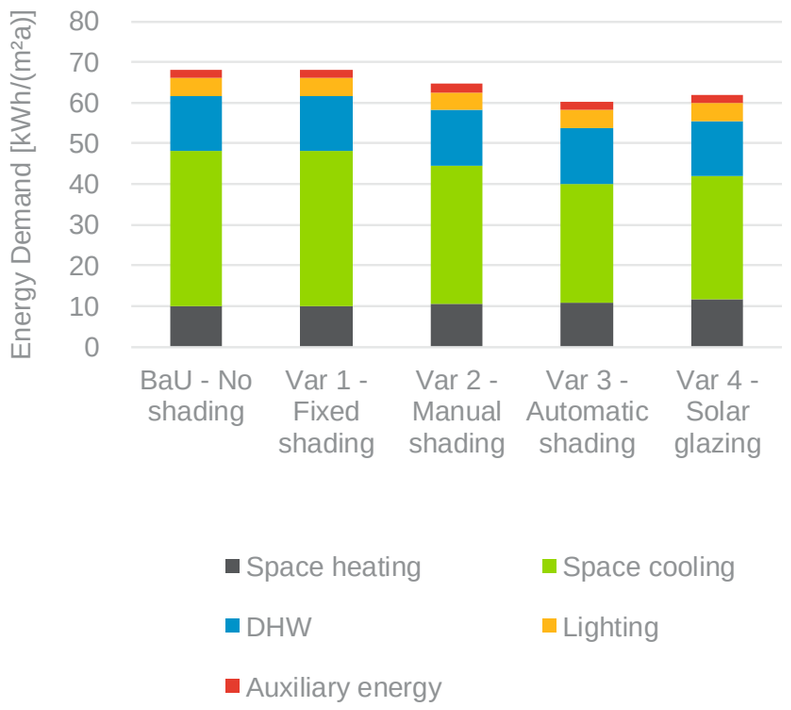
Var 1
Fixed Overhangs

Var 2
Manual Shading

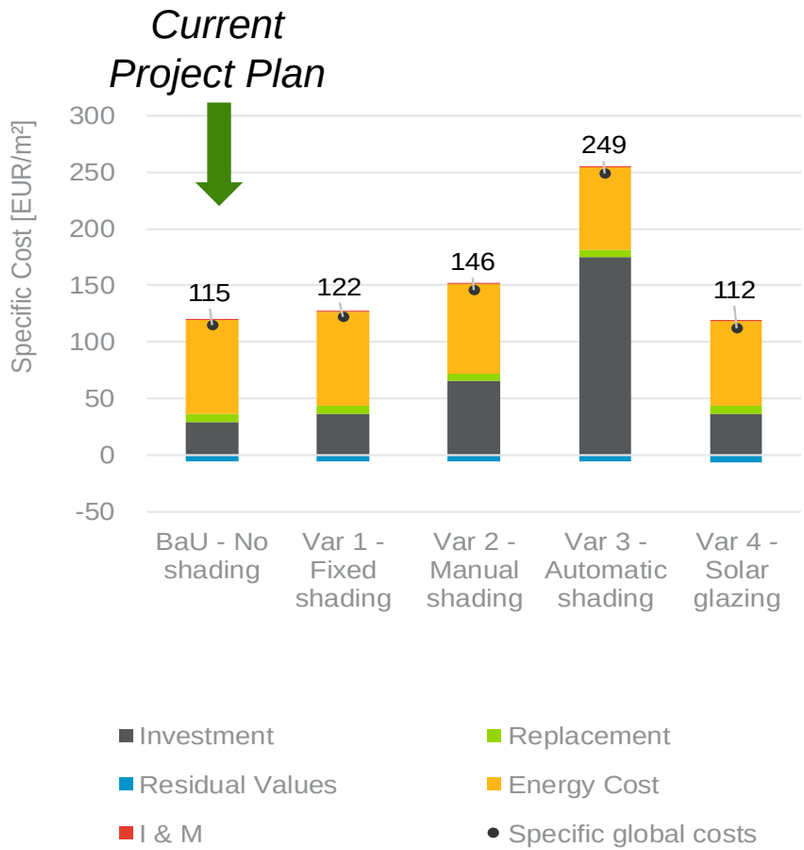
Var 3
Automatic Shading

Var 4
Solar Glazing

Final Energy Demand



Global Cost



Var 4 is the most cost effective measure.

HVAC | Efficiencies

Analysis

BaU

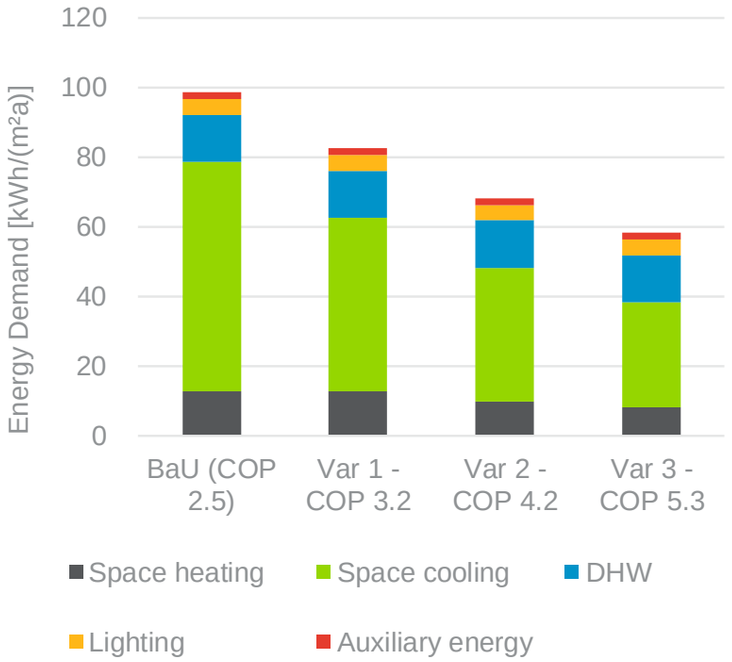
Cooling/Heating: 2.5 COP

Var 1 | 2 | 3

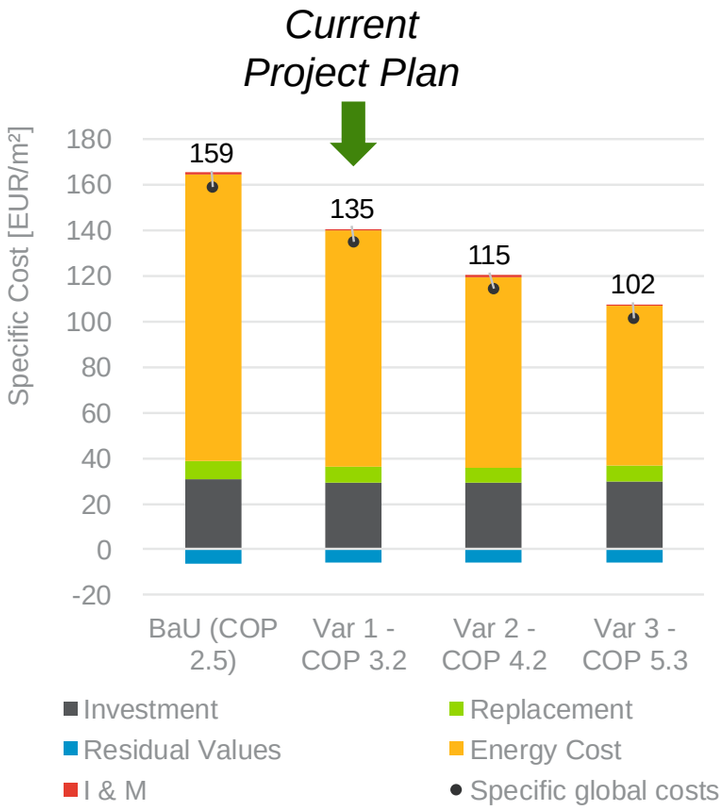
Reversible Split Unit with increased efficiency (COP: 3.2 | 4.2 | 5.3)

Var 3 (System with best COP) has the highest effect 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

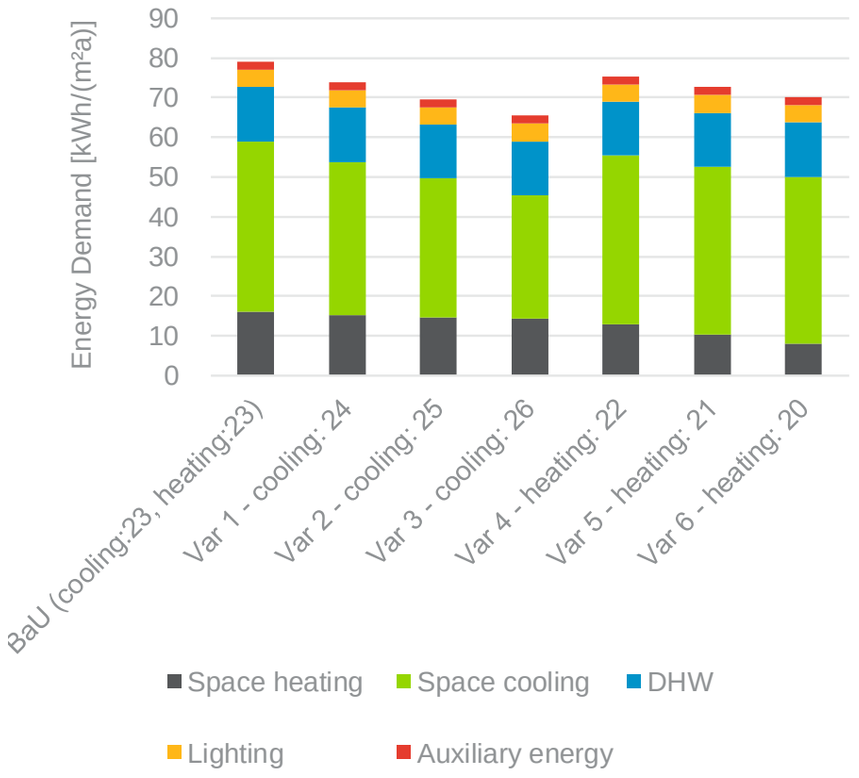
Cooling Temperature adapted (24°C - 26°C)

Var 4 - 6

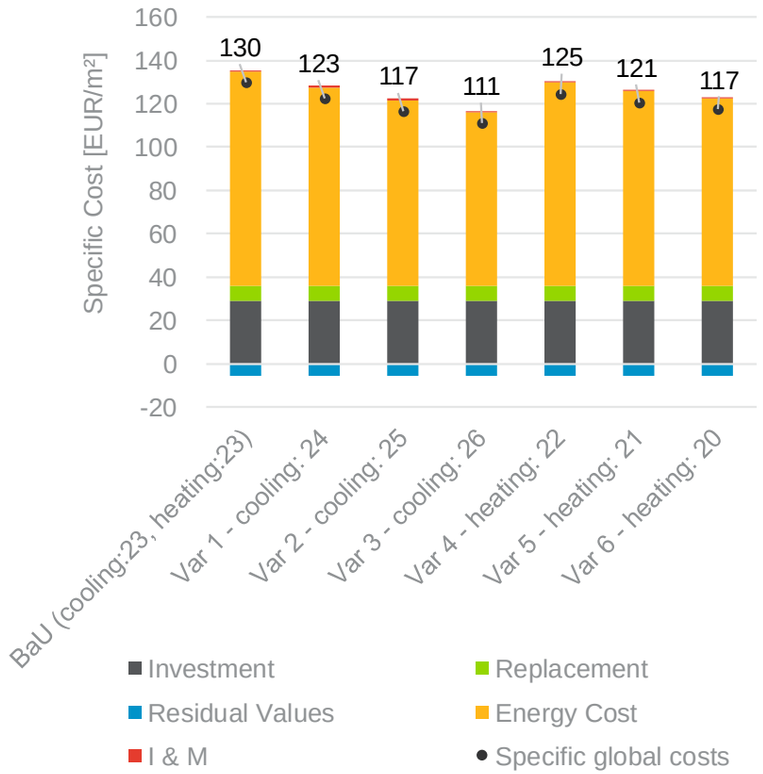
Heating Temperature adapted (22°C - 20°C)

This measure is very effective and not related to any cost

Final Energy Demand



Global Cost



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Renewables | Solar Thermal

Analysis

Current

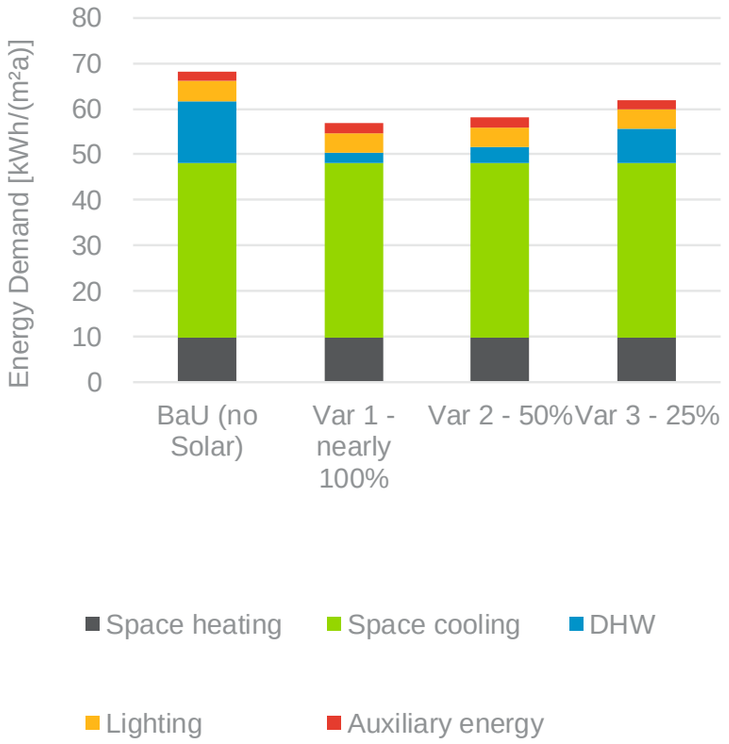
No solar hot water generation

Var 1 | 2 | 3

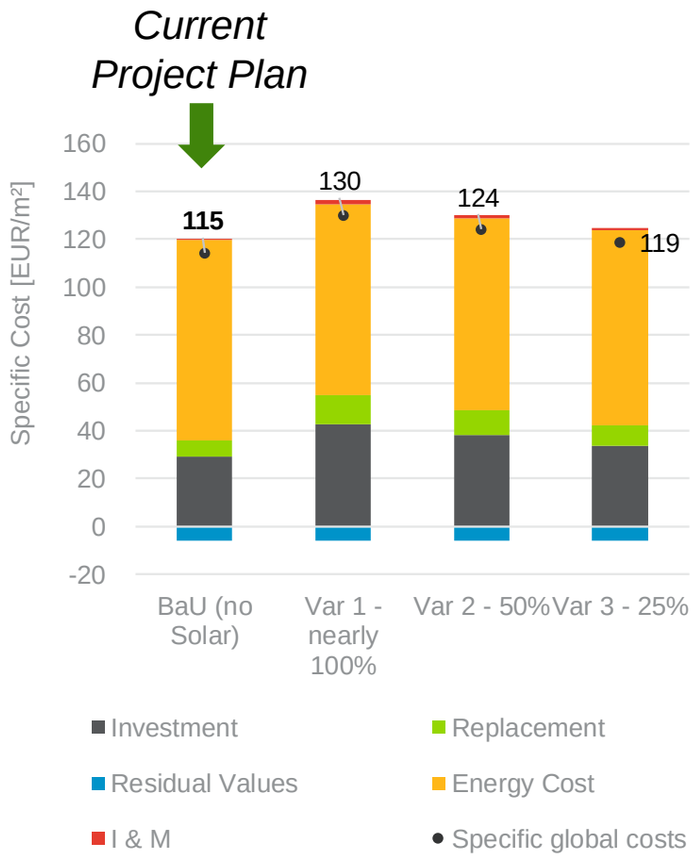
60 | 30 | 20 m² solar collector area installed, which is about 100% | 50% | 25% of the DHW demand covered by solar.

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

Final Energy Demand



Global Cost



Renewables | PV

Analysis

Sizing (net metering as assumption)

Current

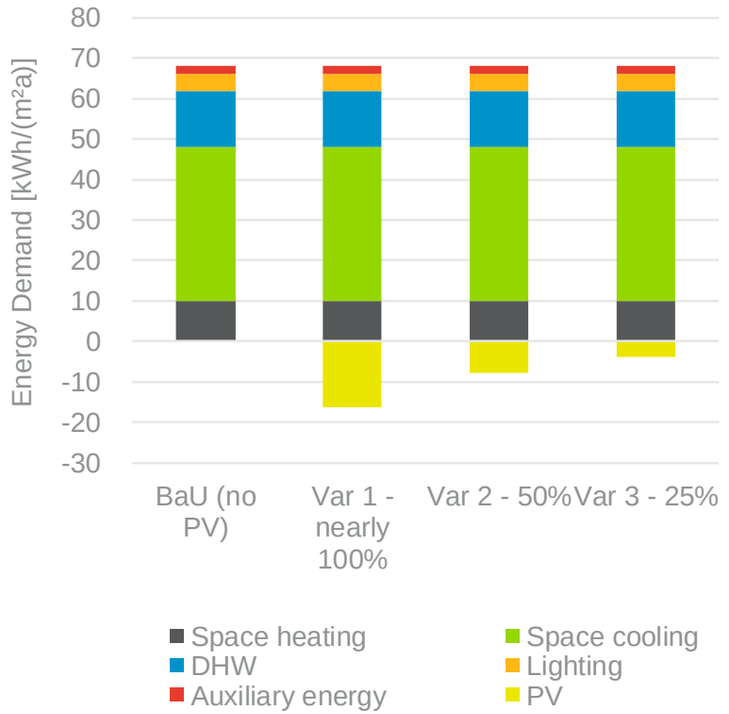
no PV

Var 1 | 2 | 3

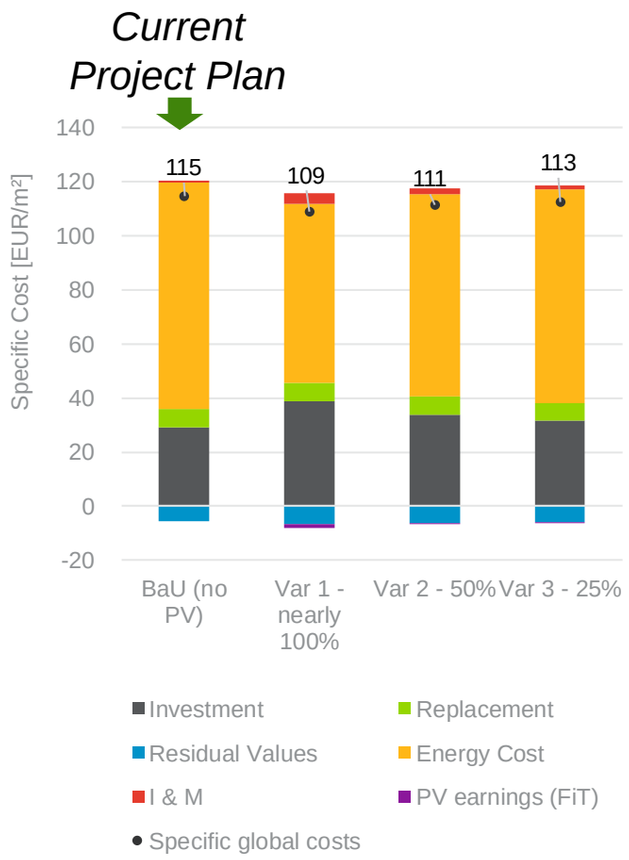
PV 25 | 12 | 6 kWp
(Roof area 175 | 84 | 42 m²)

Var 1 with **25 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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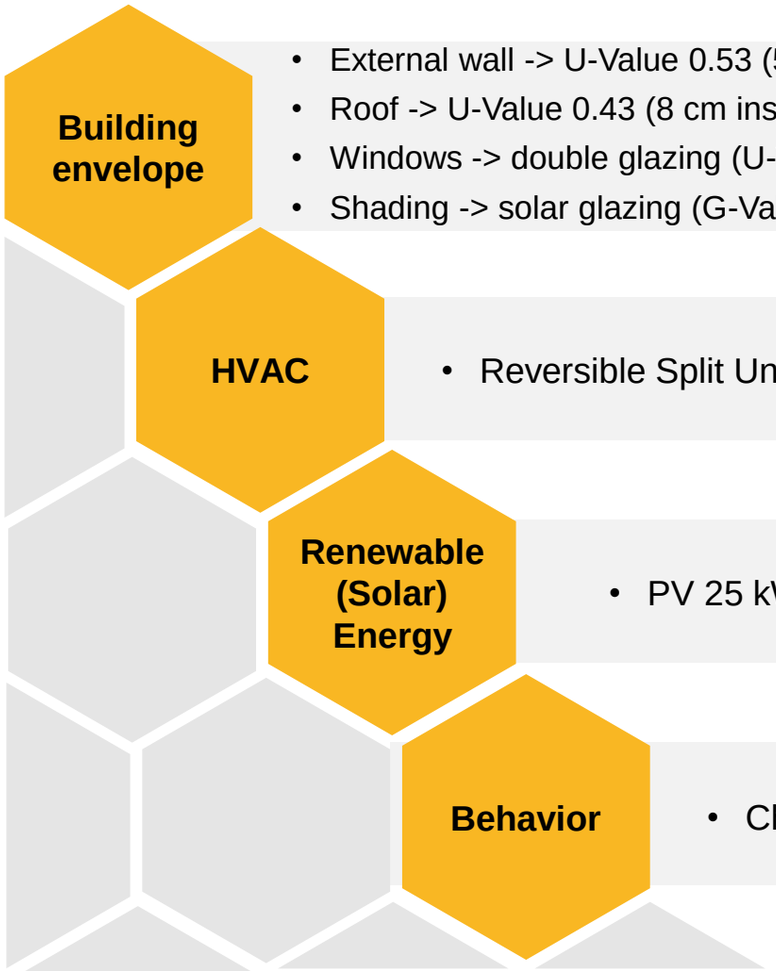
Overview of recommended measures

Four steps to reduce energy demand significantly



Building envelope

- External wall -> U-Value 0.53 (5 cm insulation)
- Roof -> U-Value 0.43 (8 cm insulation)
- Windows -> double glazing (U-Value 2.9 W/m²K, G-Value 0.66)
- Shading -> solar glazing (G-Value 0.3)

HVAC

- Reversible Split Unit heating / cooling with high efficiency (COP ~5)

Renewable (Solar) Energy

- PV 25 kWp (with maximised use of available roof area of 360 m²)

Behavior

- Change set temperature from Cooling 23°C/ Heating 23°C to Cooling 26°C/ Heating 20°C

Optimized Solution

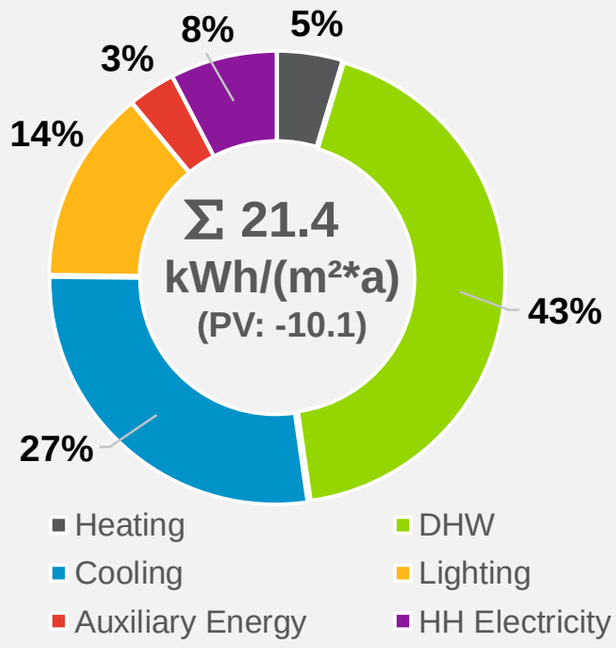
Results

The key components of the energy concept are illustrated in this table, it shows that the building envelope is significantly enhanced 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)	**0.43 W/m²K**
Wall insulation (U-Value)	**0.53 W/m²K**
Floor insulation (U-Value)	3.6 W/m²K
Windows (U-Value; G-Value)	2.88 W/m²K; **0.3**
Window fraction	Ø 15%
Shading	**Solar Glazing**
Air tightness	0.25 1/h
Heat supply	Reversible split unit - **COP 5.3**
Cold supply	Reversible split unit - **COP 5.3**
Hot water	Gas instantaneous
Ventilation systems	Natural ventilation
Lighting systems	LED
Renewable energy	**25 kWp (PV)**
Set temperature cooling/heating	**26°C / 20°C**



Energy Cost
0.8 EUR / (m²*a)

CO2 - Emission
0.4 kg / (m²*a)

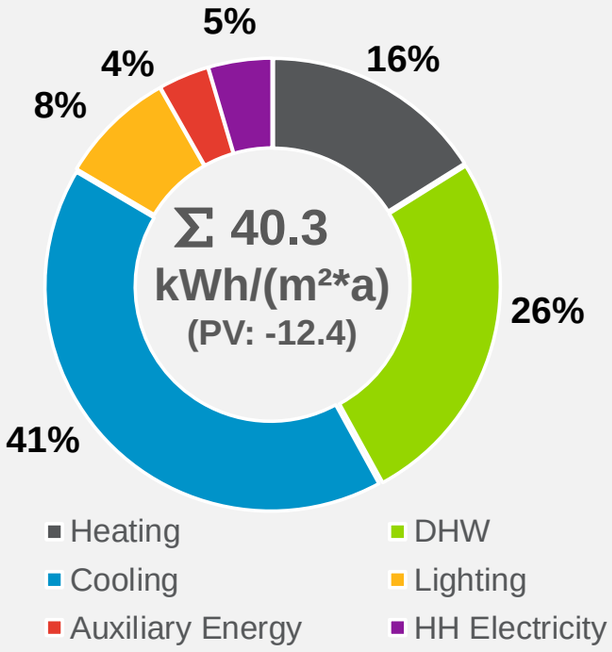
Selected Measures

Results

The table shows the selected measures (out of the recommended measures in the “optimized solution”) that were chosen.

Special attention is given to the use of renewable energy sources in terms of **PV**, increased **envelope quality** and higher heating and cooling **efficiencies**.

Parameters	Optimized Building
Roof insulation (U-Value)	**0.43 W/m²K**
Wall insulation (U-Value)	2.0 W/m²K
Floor insulation (U-Value)	3.6 W/m²K
Windows (U-Value; G-Value)	2.88 W/m²K; **0.3**
Window fraction	Ø 15%
Shading	**Solar Glazing**
Air tightness	0.25 1/h
Heat supply	Reversible split unit - **COP 5.3**
Cold supply	Reversible split unit - **COP 5.3**
Hot water	Gas instantaneous
Ventilation systems	Natural ventilation
Lighting systems	LED / Sensors
Renewable energy	**25 kWp (PV)**
Set temperature cooling/heating	21°C / 24°C



Energy Cost
2.1 EUR / (m²*a)

CO2 - Emission
1.1 kg / (m²*a)

Comparative overview

BaU vs. Current vs. Optimized vs. Selected measures

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 (current vs.Optimized)

Energy: - 70 %

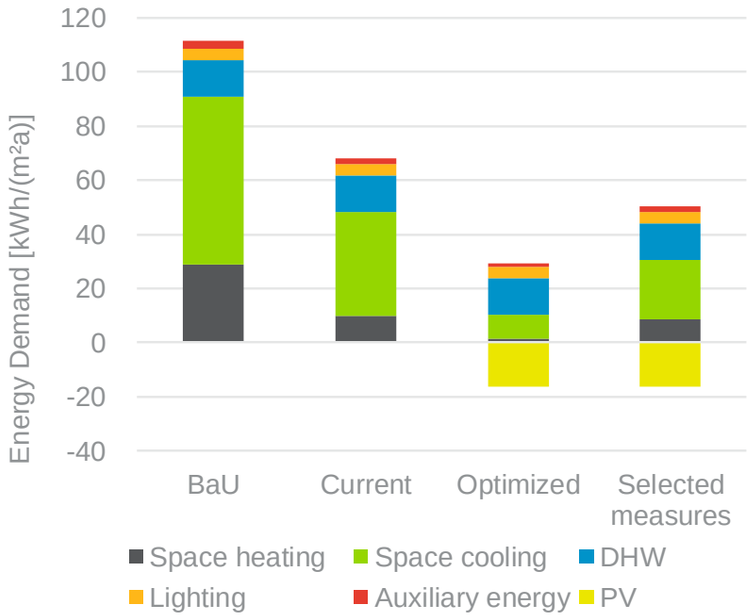
Cost: - 55%

Savings (current vs. selected)

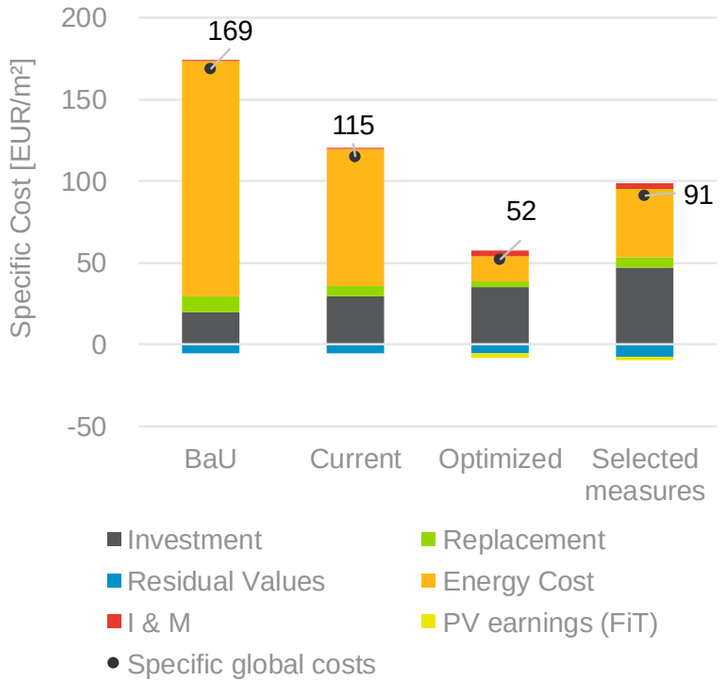
Energy: - 40%

Cost: - 20%

Final Energy Demand



Global Cost



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Selected vs. current
Payback of single measures and whole package

Parameters	Optimized	Investment (selected-current) [EUR]	Energy cost savings* [EUR / year]	Payback [years]	Lifetime [year]
Roof insulation (U-Value)	0.43 W/m²K	9,297	-3,803	4	40
Windows (U-Value; G-Value)	2.9 W/m²K; 0.3	18,300	-1,365	14	30
Heat/Cold supply	reversible split unit - COP 5.3	3,000	-5,328	2	20
Renewable energy	25 kWp (PV, maximum)	34,920	-3,553	10	20
Set temperature cooling/heating	26°C / 20°C	0	-1,819	immediately	-
Total (current to selected)**		**65,000 (5%)*****	**-15,868**	**5**	

* 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 500 Euro/m² (5 % additional costs).

Conclusion of Selected Measures

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

Size renewable (Solar) to demand

- The use of a PV system on the maximum available roof area is cost effective.
- Enable one clearly defined area for PV 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

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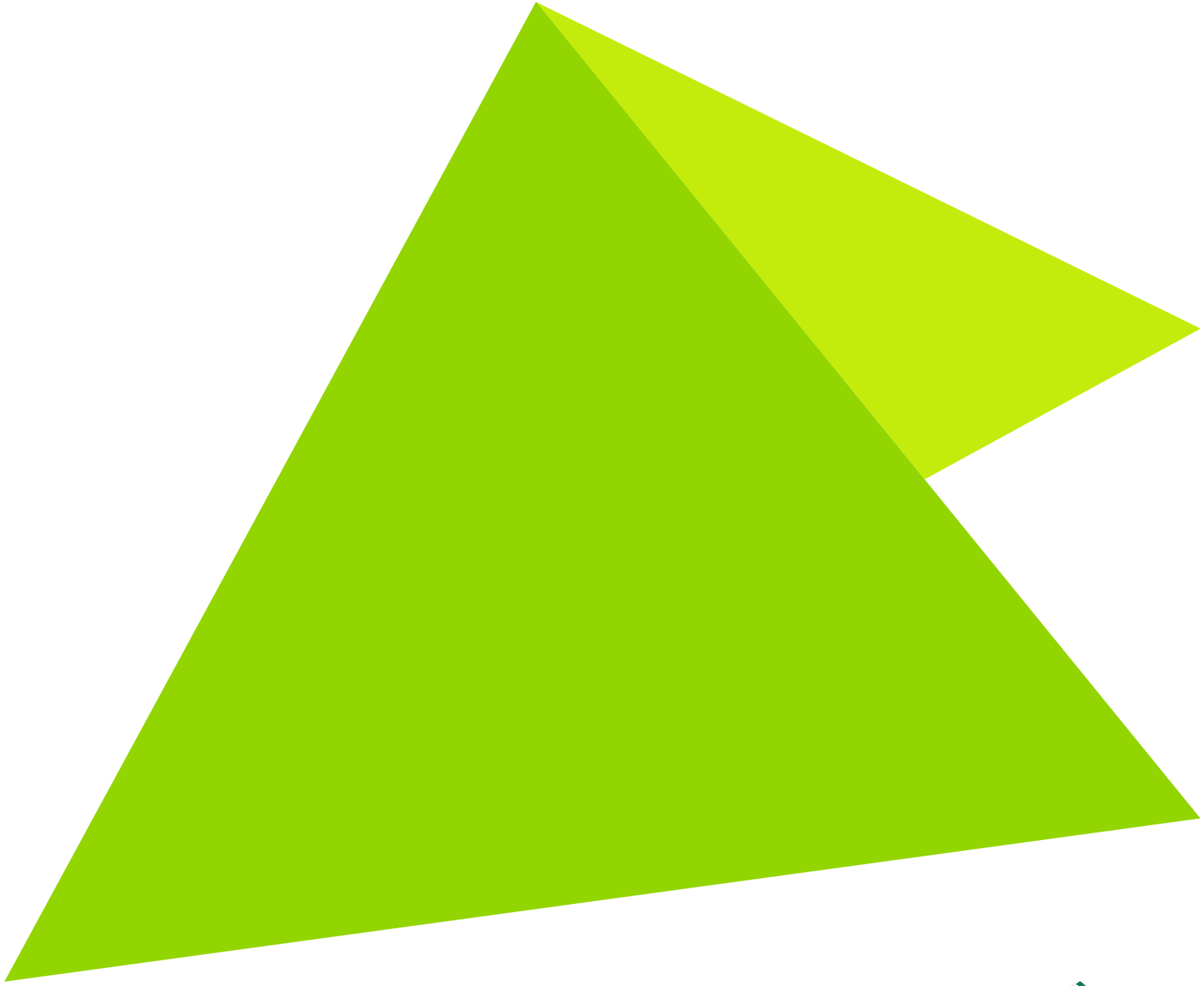

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