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Energy Efficiency Recommendations for Kye Beachfront Resort, Lebanon

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

BUILD_ME

September 2020

Introduction to the BUILD_ME project

Contents

Introduction

Background, Objectives and Methodology

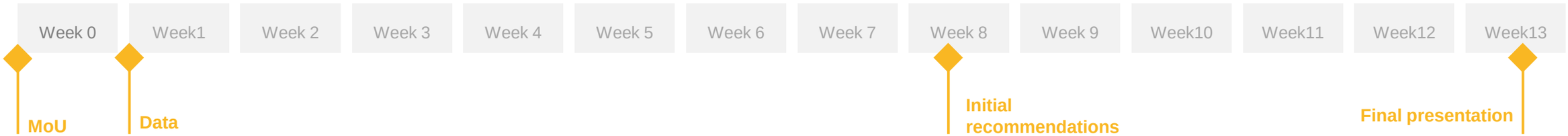
Introduction

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 (Jordan)

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

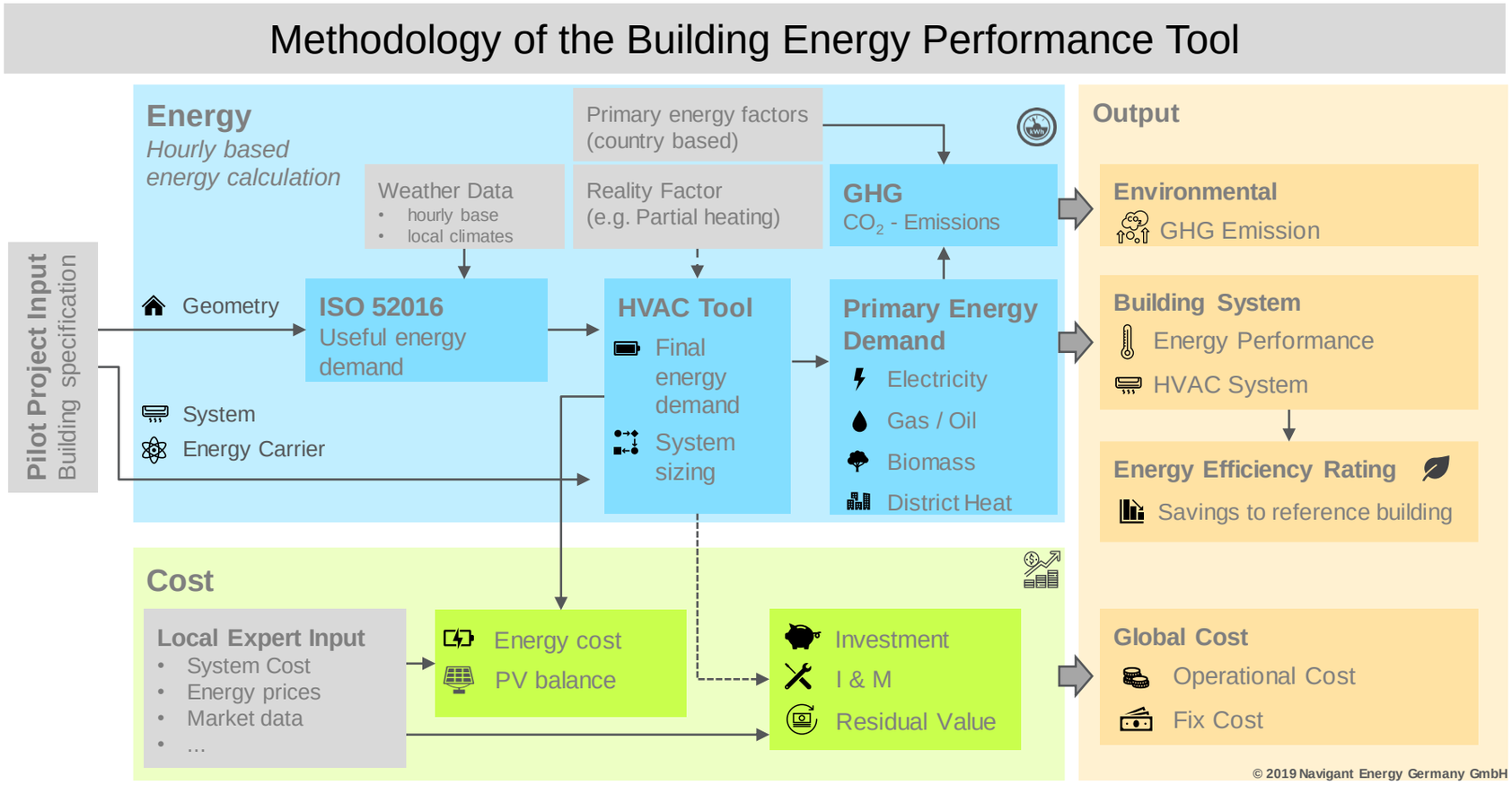
- Calculation of energy cost and investment cost of the systems, based on the HVAC system sized in the energy calculation
- Energy price systematic and PV clearing can be adapted to local situation (here: Jordan)
- Residual values at the end of the calculation period for the systems are considered

Methodology

Cost Benefit Analysis

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 (Jordan)



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Introduction

Kye Beachfront Resort

Boundary conditions

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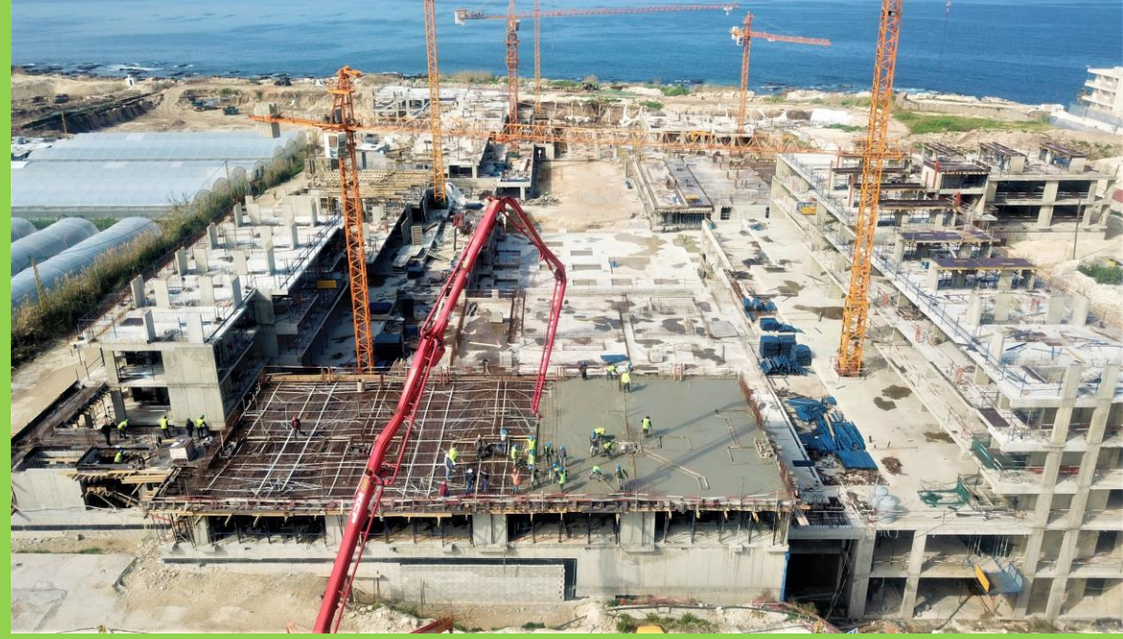

Kye Beachfront Resort

Aims

Creating a private gated community for residential and tourism purposes.

Target Groups

Units for middle and upper middle class.

Function

Multiapartment buildings with several amenities and facilities.
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Size

34 buildings of 4 to 5 floors on 200,000 m2. BUILD_ME will focus on one of the Sector A of the project.

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Boundary conditions

Site : Context matters

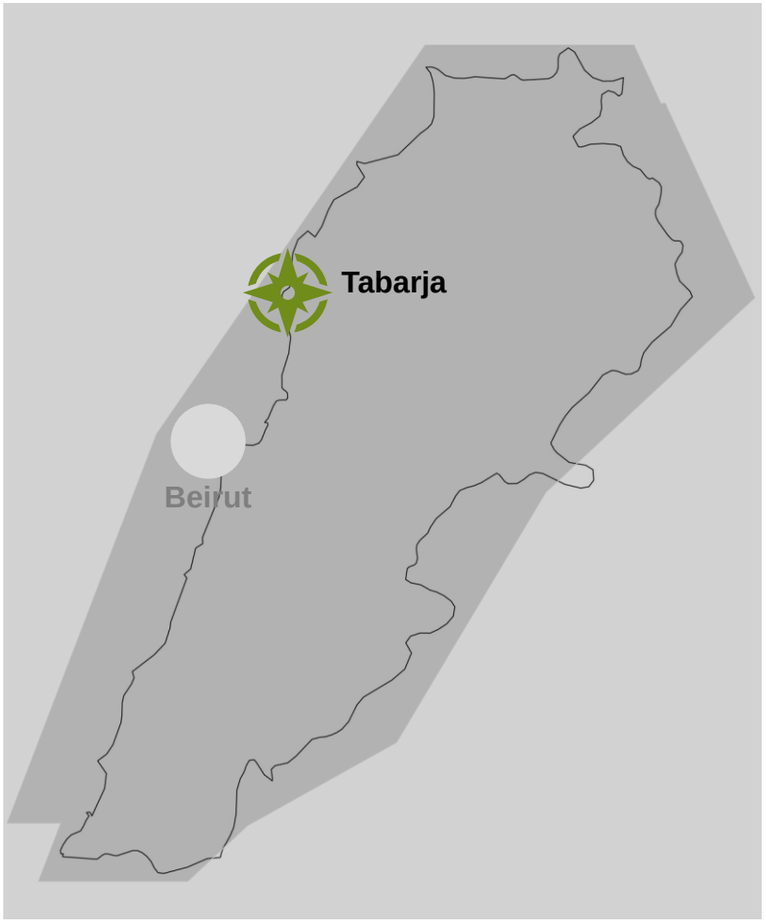
City : **Tabarja**

Location : 27 km north of Beirut

Context

The project located in the heart of the Tabarja directly on the coast. In terms of thermal comfort levels, the location provides potentials of summer sea breeze and high solar radiation but the high summer humidity will be a big challenge.

Source: Google Maps

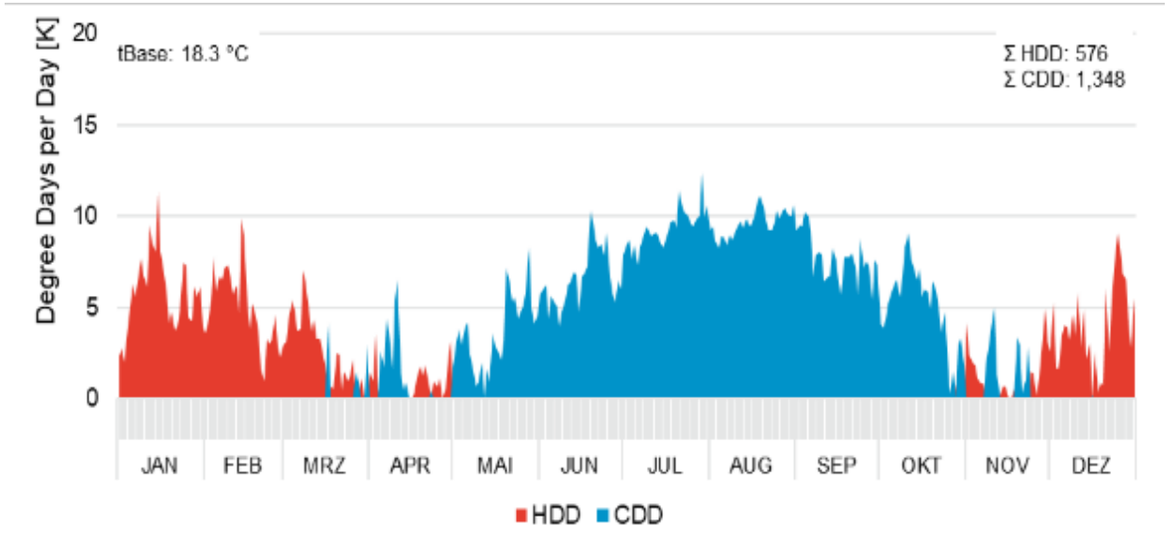


Boundary conditions I Climate Analysis

External temperatures and Relative Humidity *

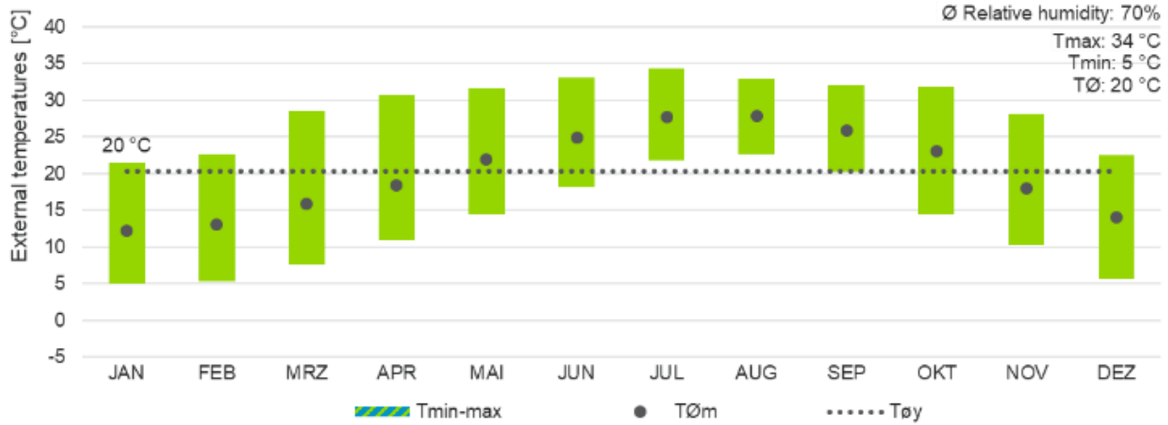
Description

The climate at the project site primarily warm and humid. External temperatures range from 5°C above 0°C to 34°C, with average temperatures around 20°C



Challenges and Potentials

The demand for cooling prevails against heat demand as the high number of >1,300 CDDs. The cooling degree days are 2 times higher than the HDDs. The monthly average relative humidity is above 65% but may also reach >70% in the summer months.



* HDD: heating degree days; CDD: cooling degree days; according to ASHREA methodology

Boundary conditions I Climate

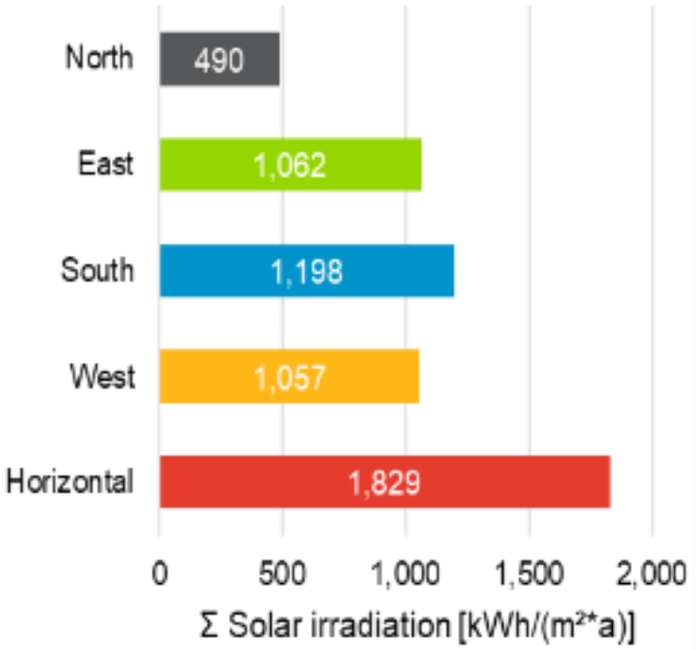
Solar Irradiation in Tabarja (Lebanon)

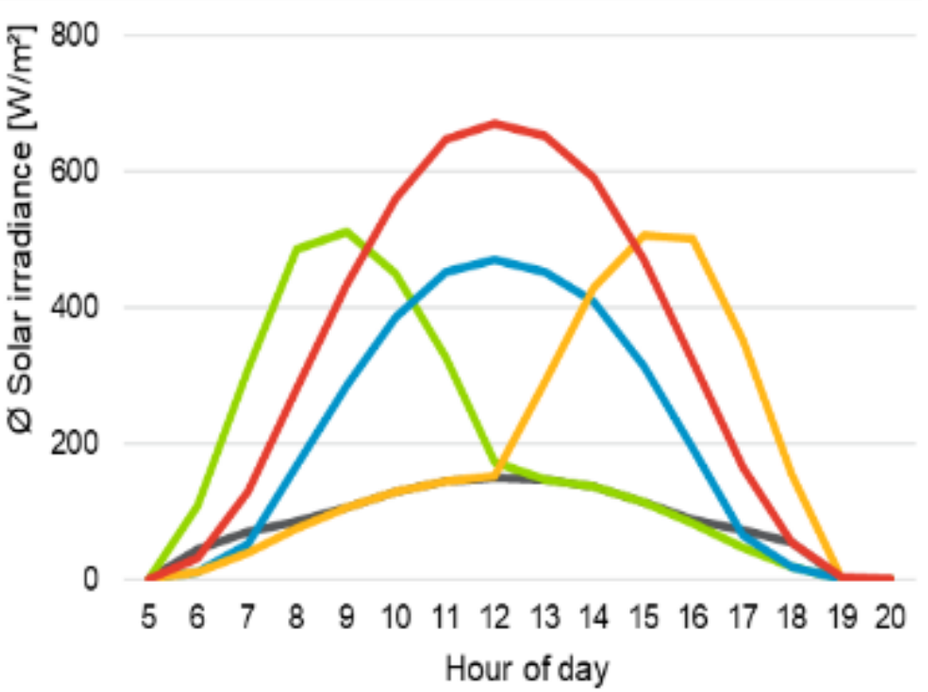
Description

The site experiences a horizontal irradiation of >1,800 kWh/(m²*a) and >1,000 kWh/(m²*a) for each East, South, and West orientations.

Challenges and Potentials

The horizontal solar radiation promises a high potential for the utilization of solar energy.





Boundary conditions I Economic and Emissions Inputs

Cost of Energy and Environmental impact

Energy price increases are assumed in the future and have been considered in the calculation as follows:

- Electricity price 0.175 Eur/kWh (depending on consumption of dwelling, incl. 9h generator)
- Price development of electricity = 10%/a,
- interest rate = 5%.

Energy prices and CO2 emissions		
Parameter	Unit	Electricity
Energy price	LBP/kWh	310
Energy price	EUR/kWh	0.175
Price development	%/year	10
CO2 emission factor	gCO_2/kWh	679
Economic parameters		
Interest rate (real)	%/year	5
Calculation period	years	20

- **Exchange rate: 1 EUR = 1.3 JOD**

Boundary Conditions I Building

Building Data

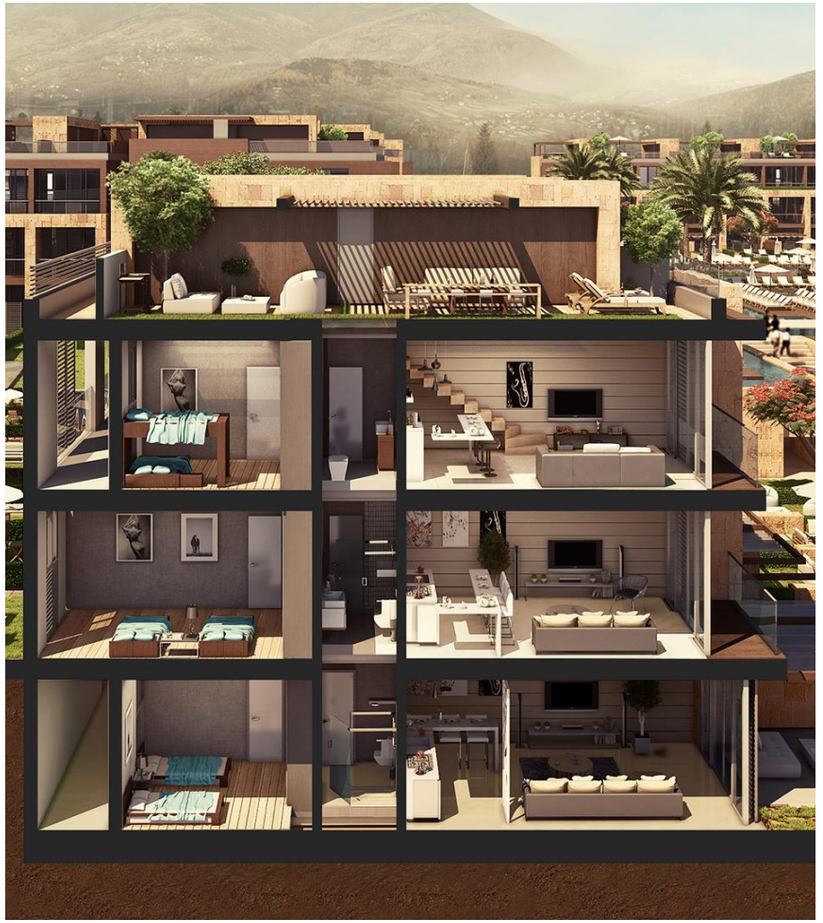
Status

Small Multi-Family houses in a modular construction

Specific Challenge

Located directly on the coast;

Seasonal pattern as it is used as a second home

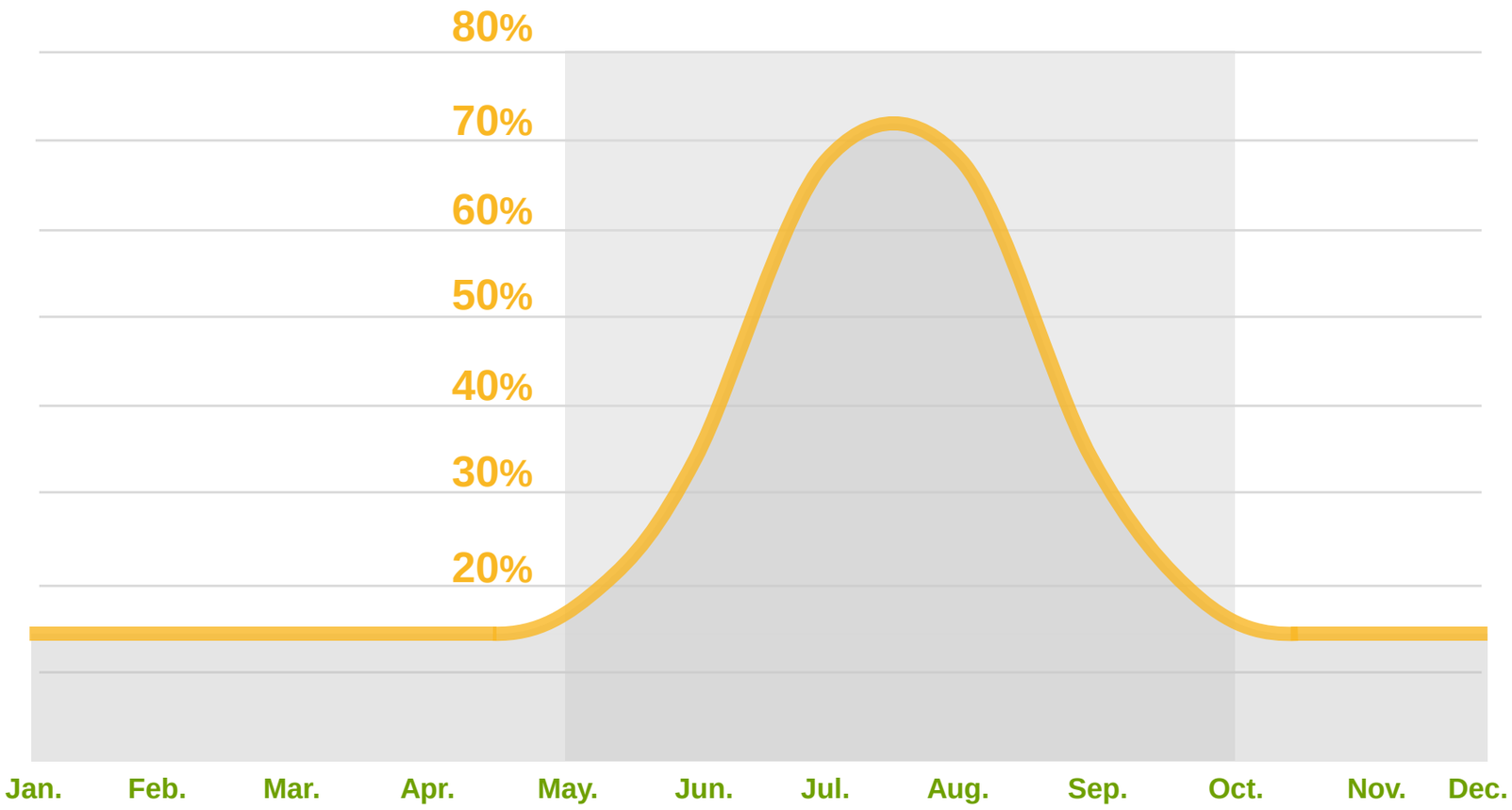


Building Key Information	
Data	Input
Latitude	34.028828
Longitude	35.623939
Elevation [m]	3
Utilization	MFH
Number of floors	4
Number of apartment	192
Conditioned floor area [m²]	11,200
Clear room height [m]	3
Conditioned volume [m³]	33,600
Number of inhabitants [#]	4 per Unit
Year of construction	2020/2021

Boundary Conditions I Buildings Use

Expected Occupancy Percentage

The occupancy percentages changes throughout the year reaching the peak in the summer months.
The building systems and energy efficient measures must be sized for a changing energy demand.



Analysis

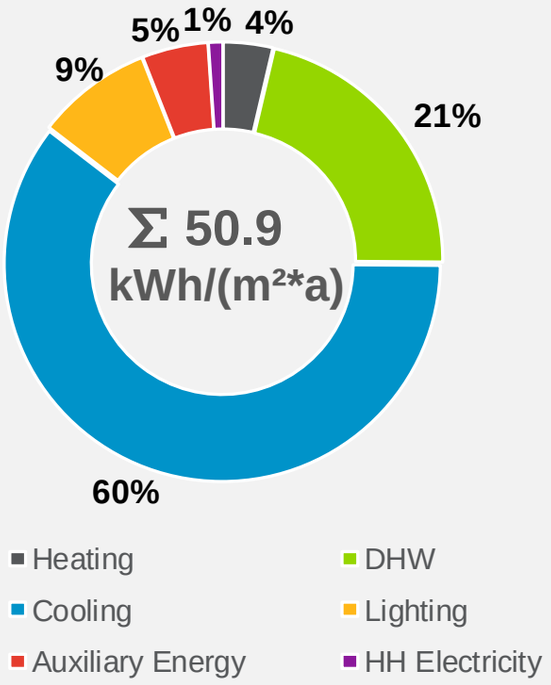
Starting Situation - Baseline and Current planning

Business as Usual

Building Characteristics as 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)	0.60 W/m²K
Wall insulation (U-Value)	0.70 W/m²K
Floor insulation (U-Value)	3.2 W/m²K
Windows (U-Value; G-Value)	5.7 W/m²K; 0.85
Window fraction	Ø 40%
Shading	no
Air infiltration through leakages	0.25 1/h
Heat supply	centralised multi-split unit - COP 4.0
Cold supply	centralised multi-split unit - COP 4.0
Hot water	electric instantaneous
Ventilation system	natural ventilation
Lighting system	LED
Renewable energy	No
Set temperature cooling/heating	23°C / 21°C



Energy Cost
8.9 EUR / (m²*a)

CO2 - Emission
34.5 kg / (m²*a)

Current situation, Kye Beachfront Resort

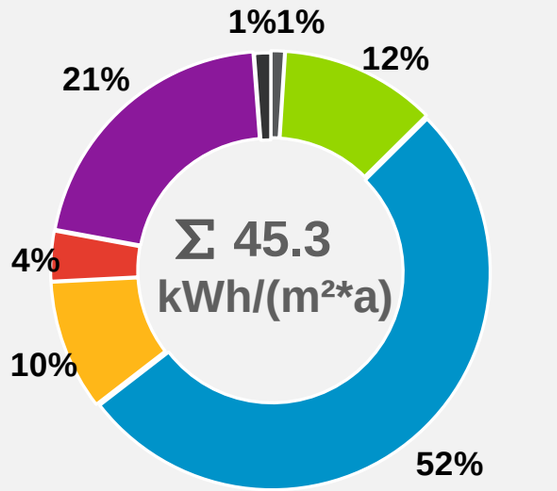
Results

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) and Solar collectors (for hot water).

This leads to energy savings and emission reduction.

Parameters	Baseline
Roof insulation (U-Value)	0.60 W/m²K
Wall insulation (U-Value)	0.70 W/m²K
Floor insulation (U-Value)	3.2 W/m²K
Windows (U-Value; G-Value)	**2.8 W/m²K; 0.70**
Window fraction	Ø 40%
Shading	no
Air infiltration through leakages	0.25 1/h
Heat supply	centralised multi-split unit - COP 4.0
Cold supply	centralised multi-split unit - COP 4.0
Hot water	**solar thermal and electric**
Ventilation system	**mechanical ventilation and natural ventilation**
Lighting system	LED
Renewable energy	**Solar thermal**
Set temperature cooling/heating	23°C / 21°C



Energy Cost
7.9 EUR / (m²*a)

CO2 - Emission
30.7 kg / (m²*a)

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Current situation (project developer)

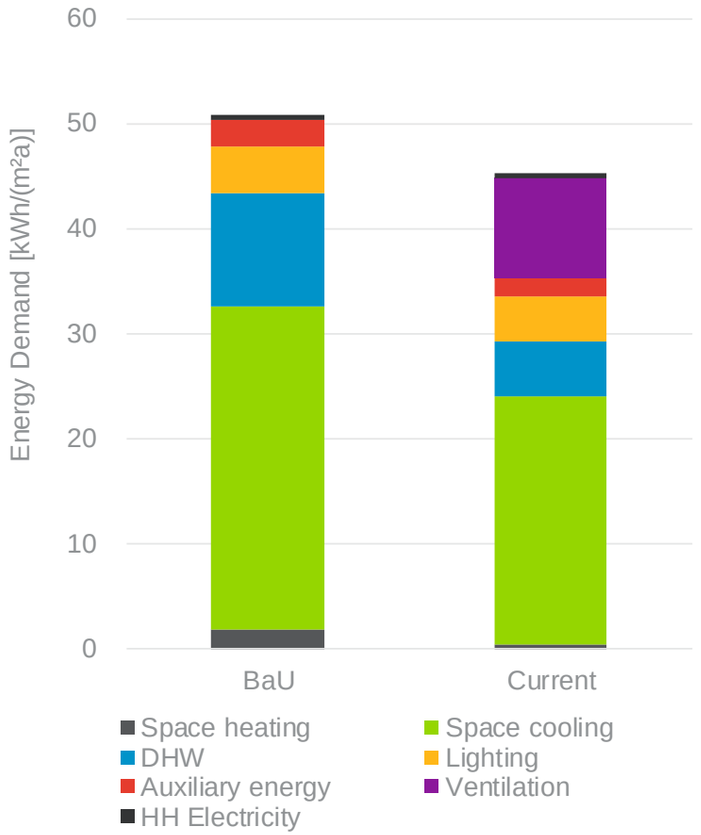
Results VS. BaU

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

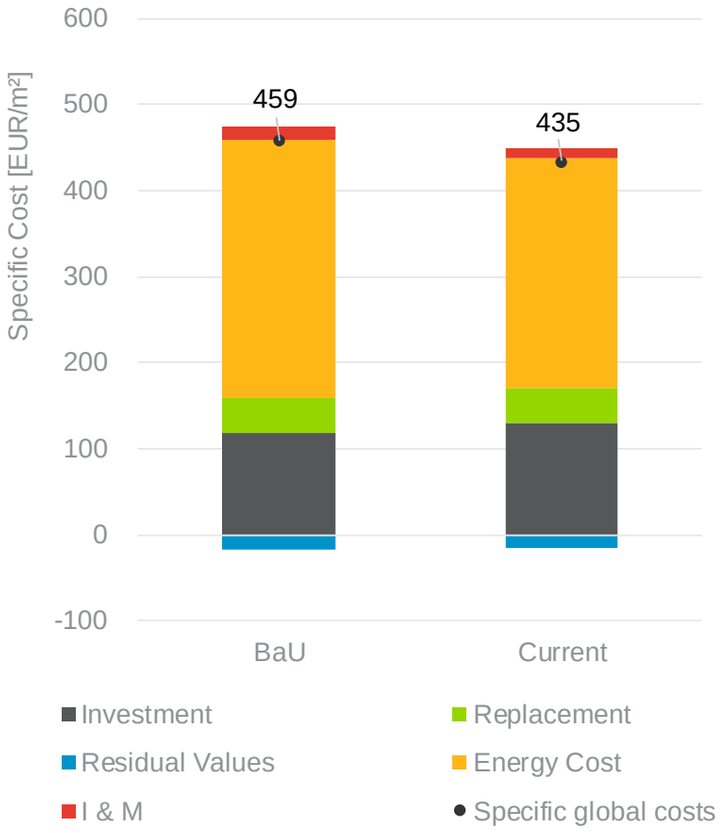
Although the energy cost decrease, the proposed measures will result in a cost increase due to the high investment cost.

The proposed measures seem not to hit the cost optimal point for optimization

Final Energy Demand



Global Cost



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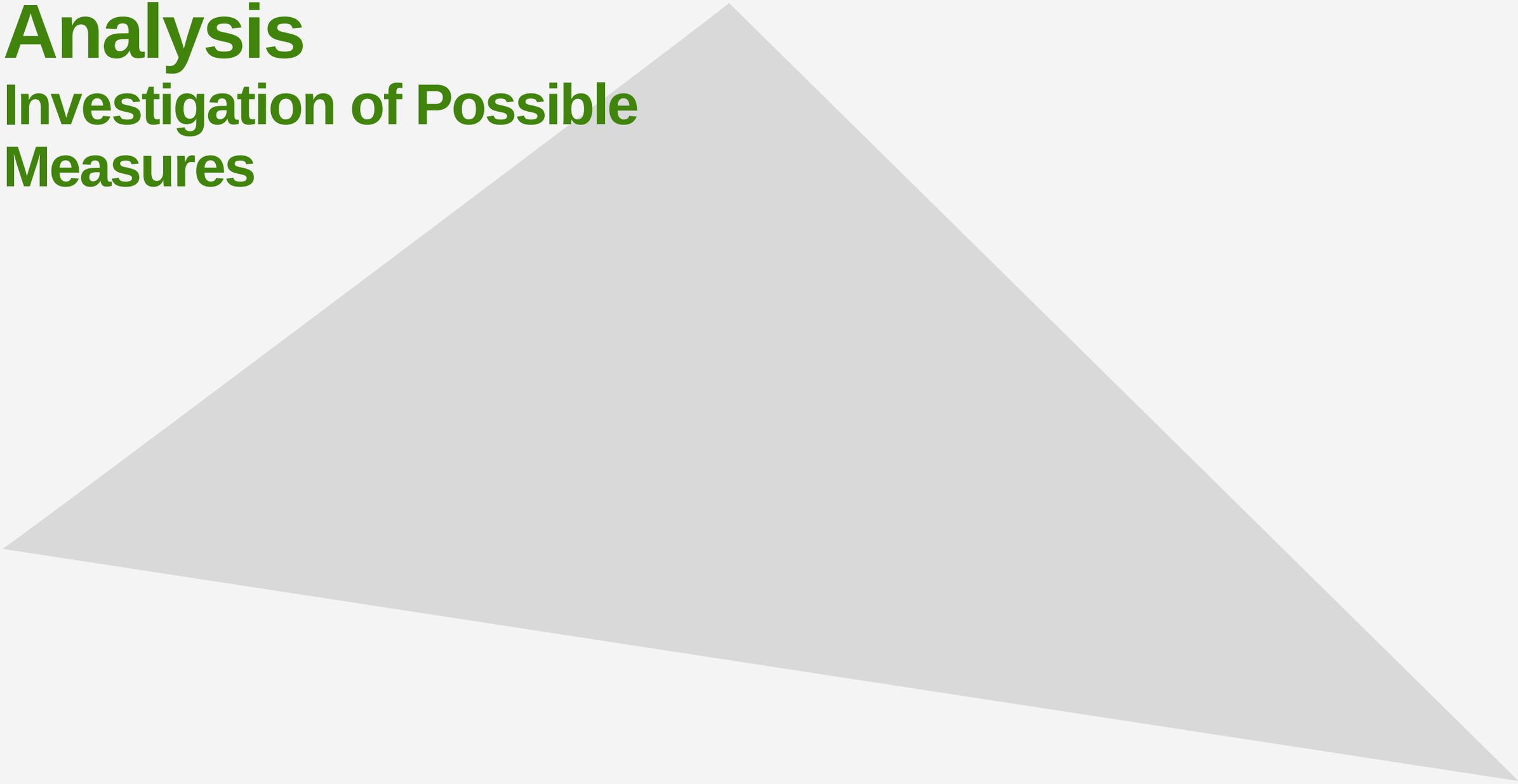
Analysis
Investigation of Possible Measures



Overview of Analyzed Measures

Scope of Measures

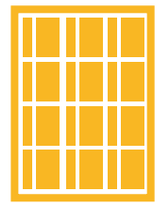
Envelope

- Roof insulation and color
- External wall insulation
- Windows (U, g, window fraction)
- Shading
- Air tightness

Systems

- Heating
- Cooling
- Ventilation systems
- Operational temperatures

Renewable



- PV
- Solar Thermal

Building Envelope I External wall

Thermal insulation

BaU

U-Value = 2.0 W/m²K

Current

U-Value = 0.7 W/m²K (no insulation)

Var 1

U-Value = 0.5 W/m²K (4 cm insulation)

Var 2

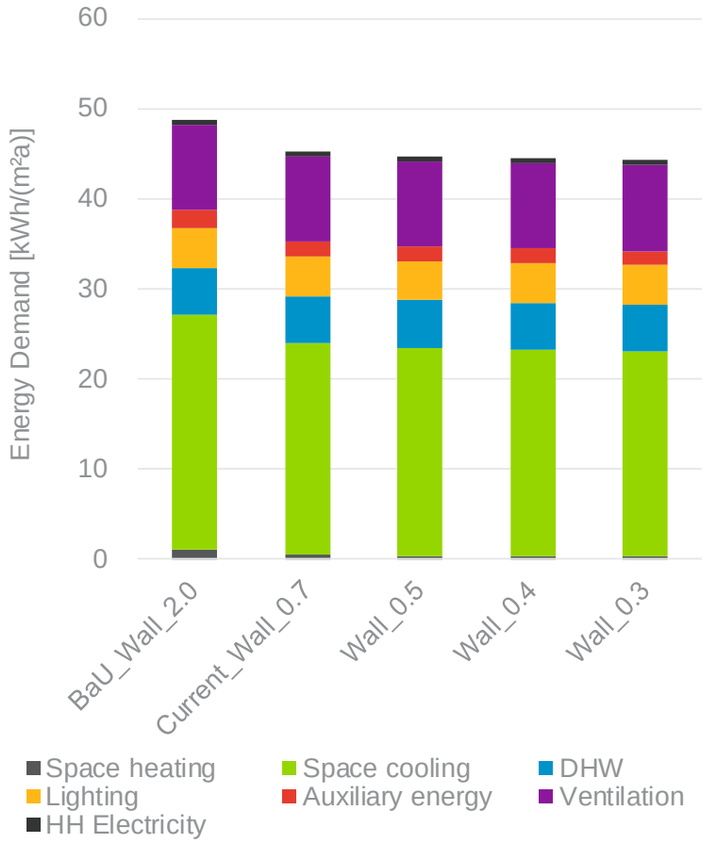
U-Value = 0.4 W/m²K (6 cm insulation)

Var 3

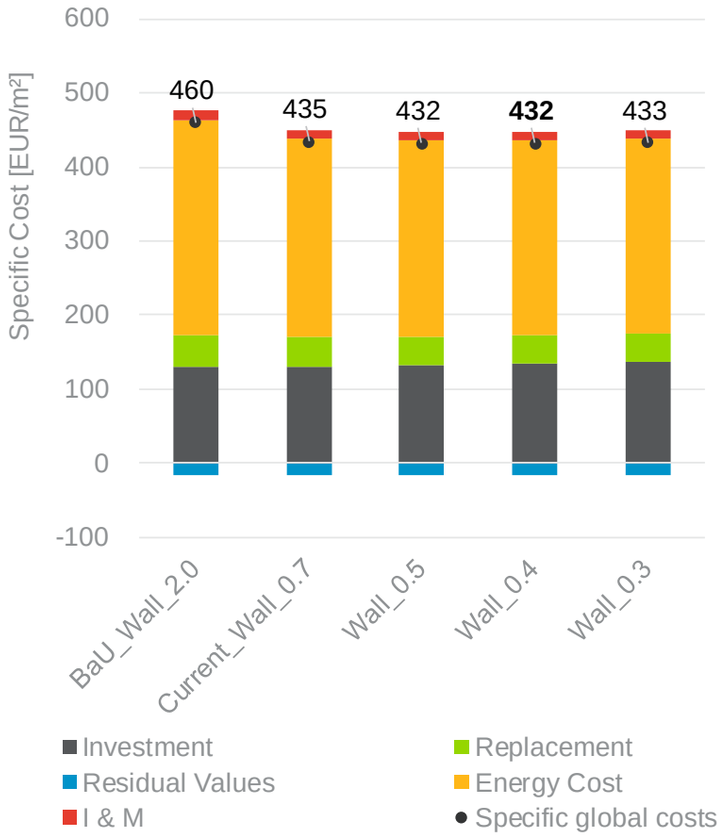
U-Value = 0.3 W/m²K (10 cm insulation)

Result: Var 2 is the most cost effective measure

Final Energy Demand



Global Cost



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Building Envelope I Roof

Thermal insulation

BaU / Current

U-Value = 0.6 W/m²K (5 cm insulation)

Var 1

U-Value = 0.5 W/m²K (6 cm insulation)

Var 2

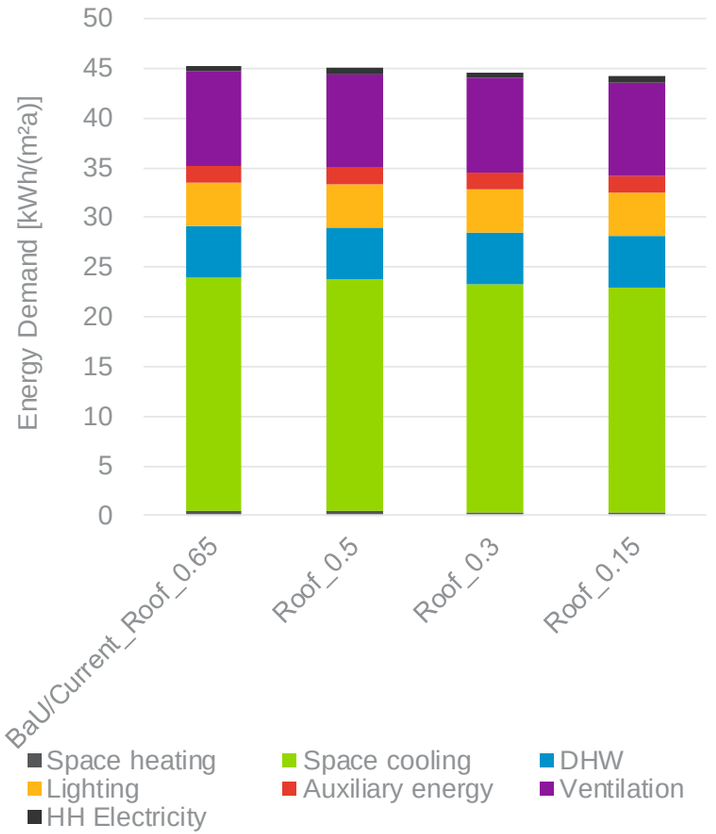
U-Value = 0.3 W/m²K (12 cm insulation)

Var 3

U-Value = 0.15 W/m²K (25 cm insulation)

Result: Var 2 is the most cost effective measure

Final Energy Demand



Global Cost

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Building Envelope I Roof

Appropriate Color - Absorption factor

BaU / Current

Dark color (0.9)

Var 1

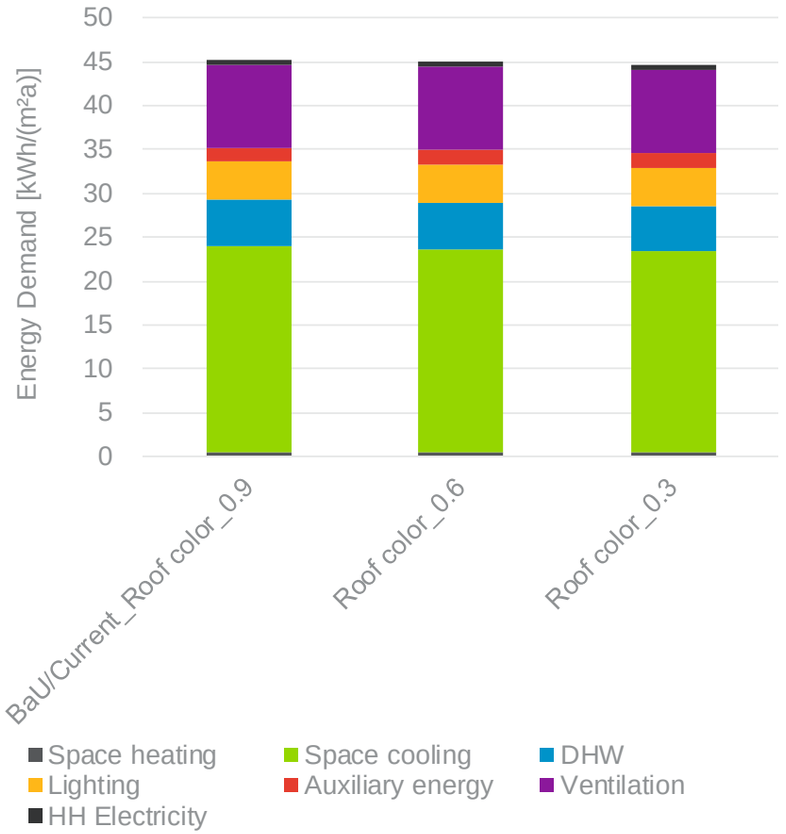
Intermediate (0.6)

Var 2

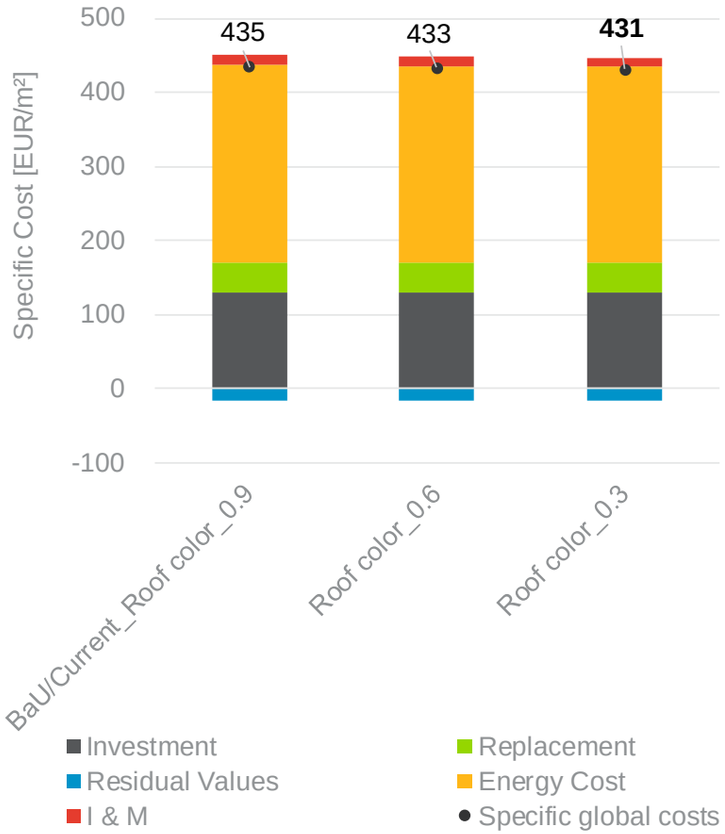
Light color (0.3)

Result: Var 2 is the most cost effective measure

Final Energy Demand



Global Cost



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Building Envelope I Windows

U-Value

Single glazing (BaU)

U value 5.7 W/m²K, G-Value 0,85

Double glazing (Current)

U value 2.8 W/m²K, G-Value 0,54

Double glazing – low E (Var 1)

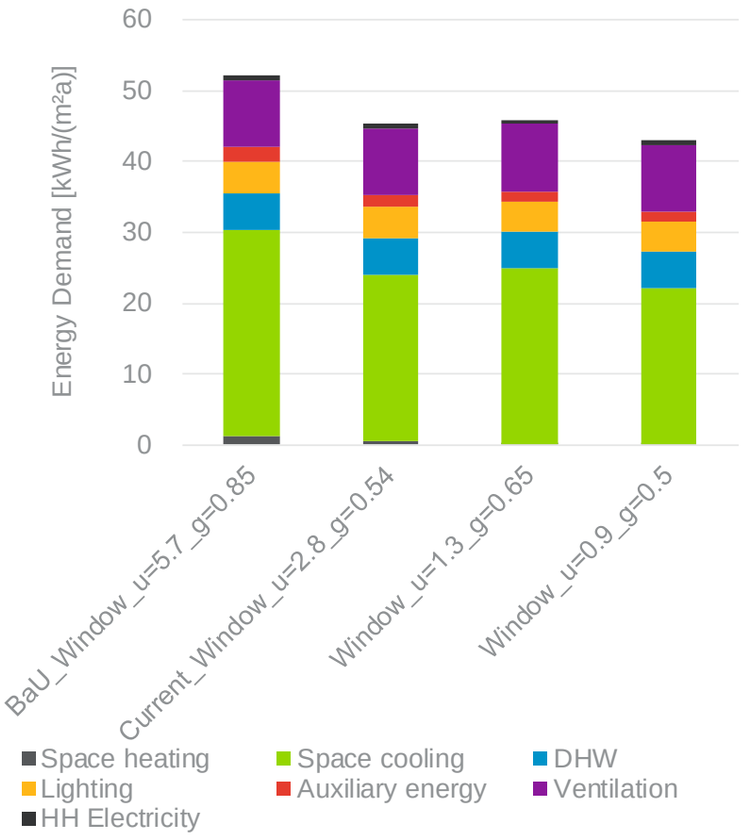
U value 1.3 W/m²K, G-Value 0,65

Triple Glazing (Var 2)

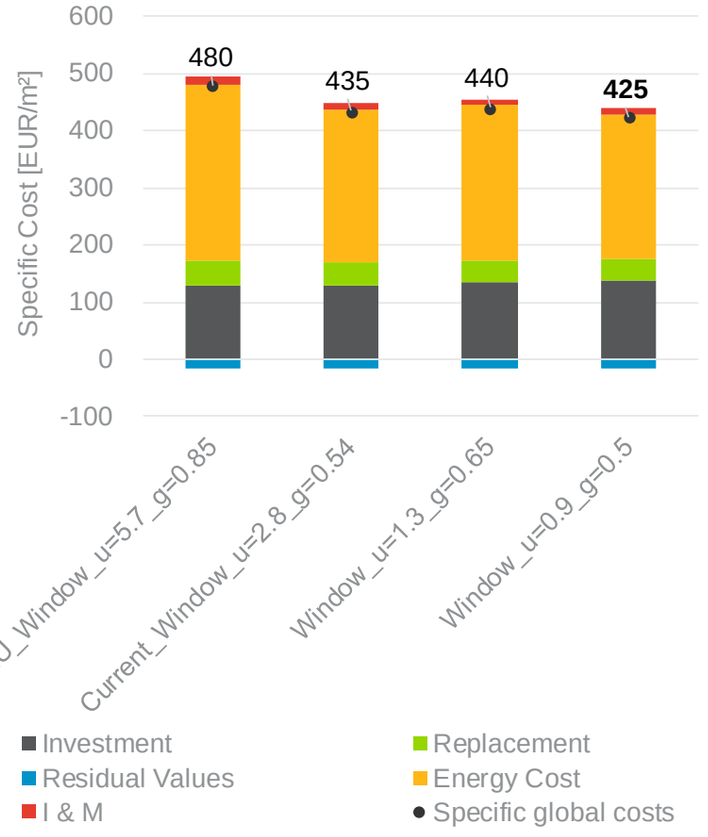
U value 0.9 W/m²K, G-Value 0,5

Result: Var 2 is the most cost effective measure

Final Energy Demand



Global Cost



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Building Envelope I Window

Window fraction

BaU / Current

40 %

Var 1

30 %

Var 2

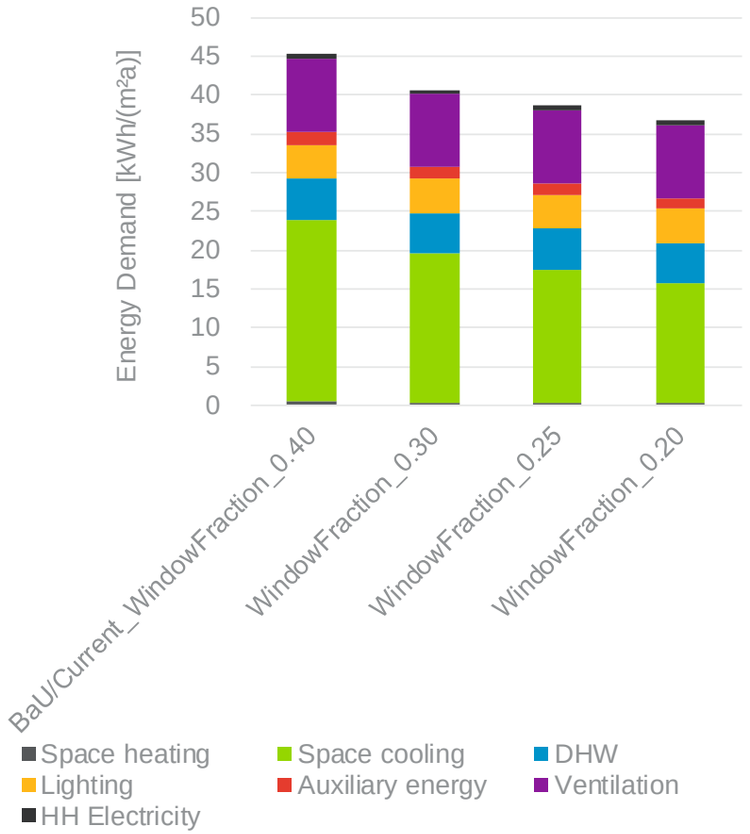
25 %

Var 3

20 %

Result: Var 3 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 / Current

0.25

Var 1

0.20

Var 2

0.15

Var 3

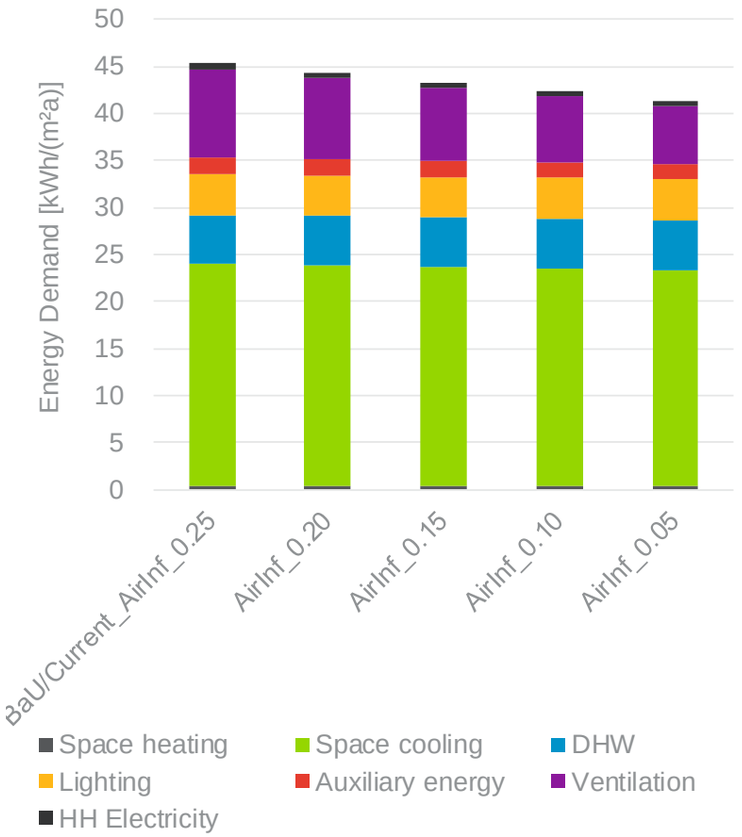
0.1

Var 4

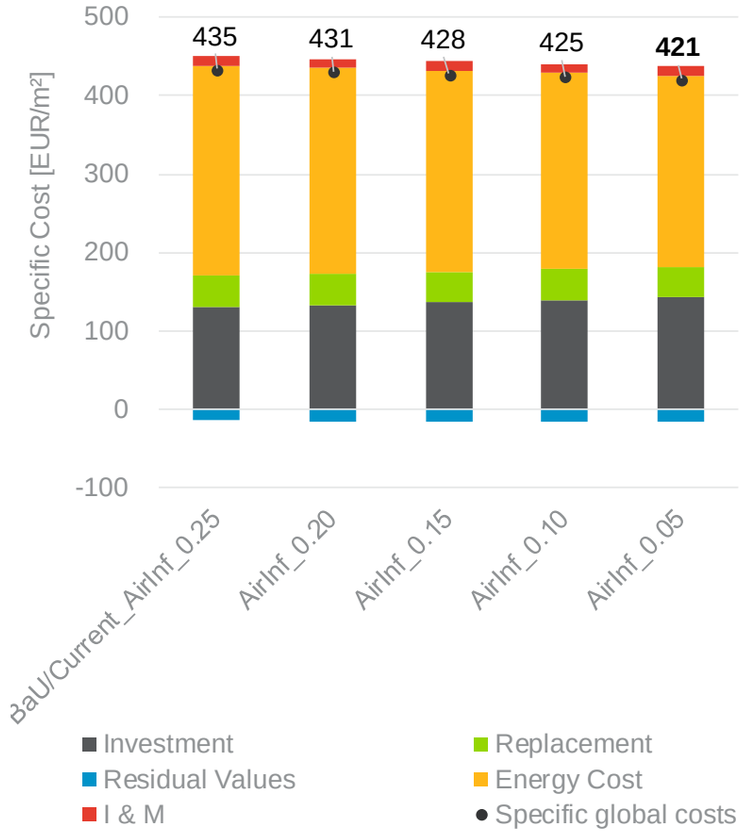
0.05

Result: Var 4 is the most cost effective measure

Final Energy Demand



Global Cost



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Shading concept

Analysis

BaU / Current

No shading

Var 1

Fixed Overhangs

Var 2

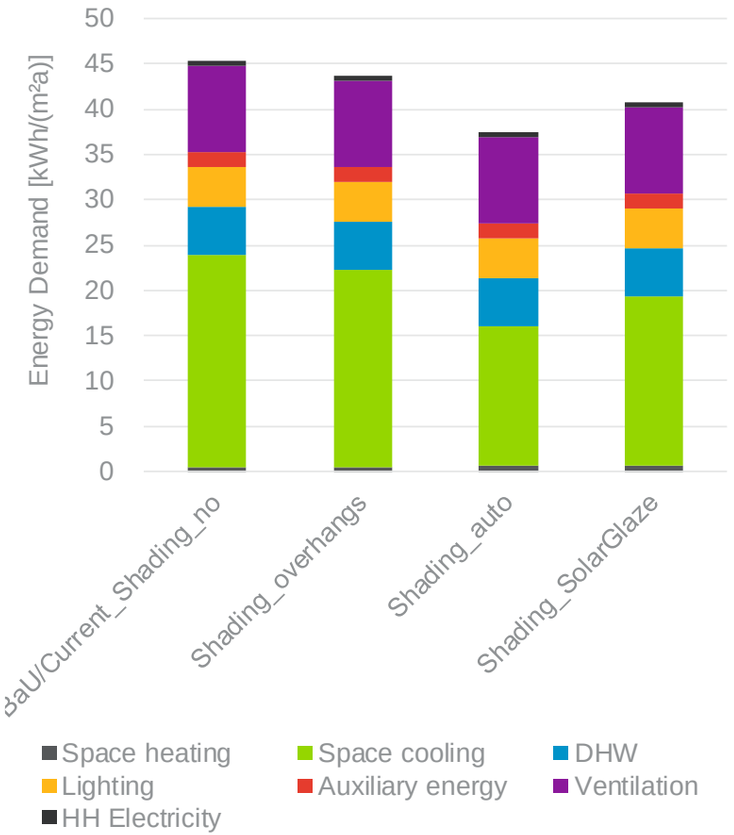
Automatic Shading

Var 3

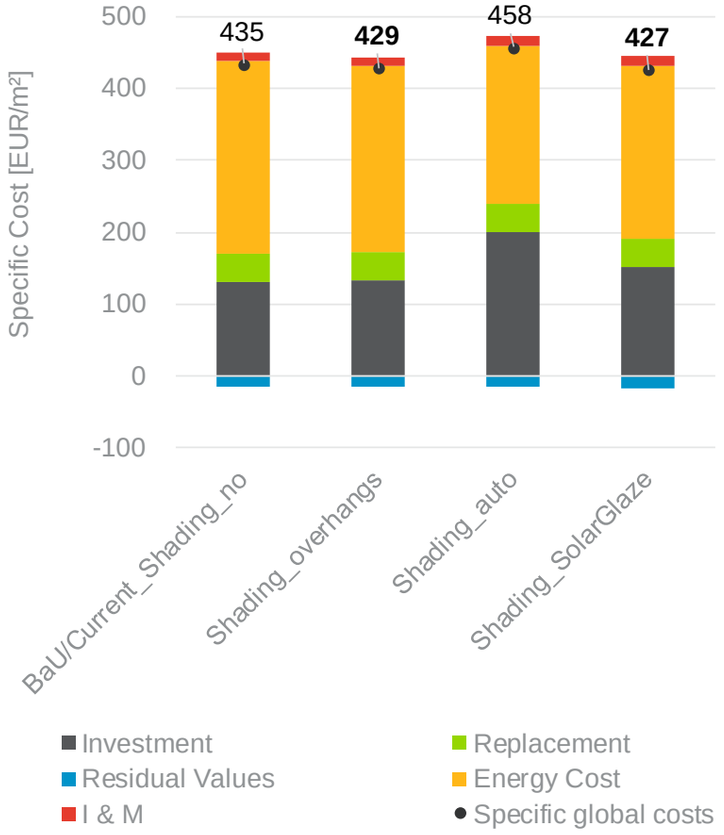
Solar Glazing

Result: Var 1 and 3 are the most cost effective measures

Final Energy Demand



Global Cost



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HVAC I Cooling

Analysis

BaU / Current

Centralised multi-split system (Heating COP 4 I Cooling COP 4)

Var 1

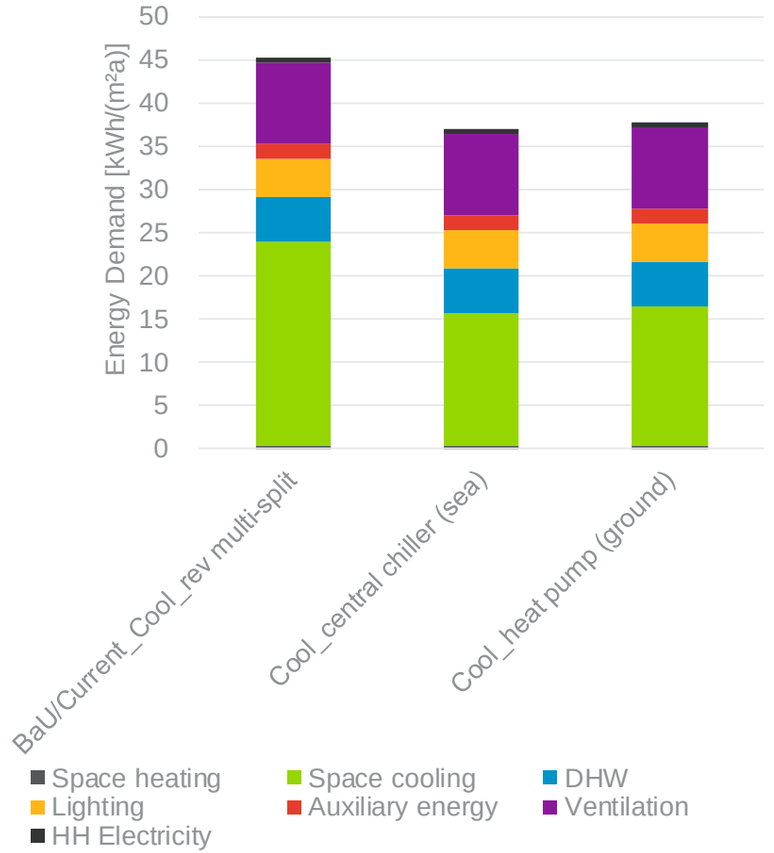
Central chiller (Sea Water)

Var 2

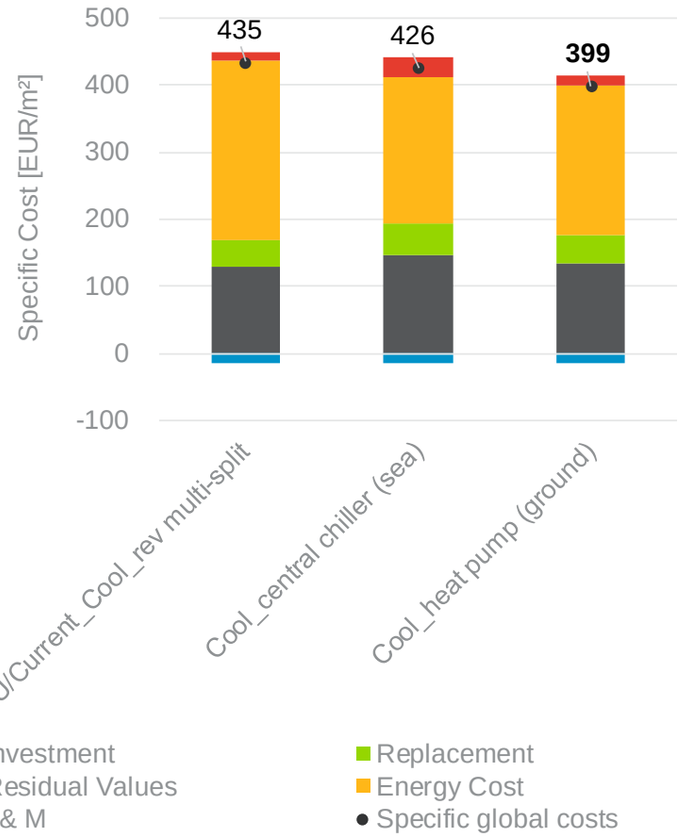
Heat pump (Ground Source)

Result: Var 2 is the most cost effective measure

Final Energy Demand



Global Cost



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HVAC I Ventilation

Analysis

BaU

Natural ventilation

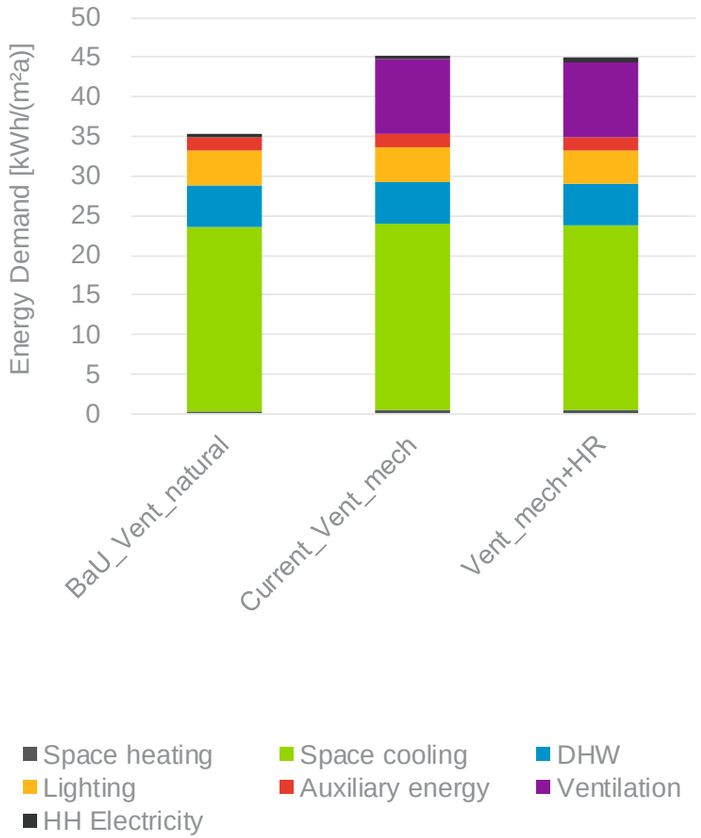
Current

Mech. Ventilation (1 floor)

Var 1

Mech. Ventilation with heat recovery (1 floor)

Final Energy Demand



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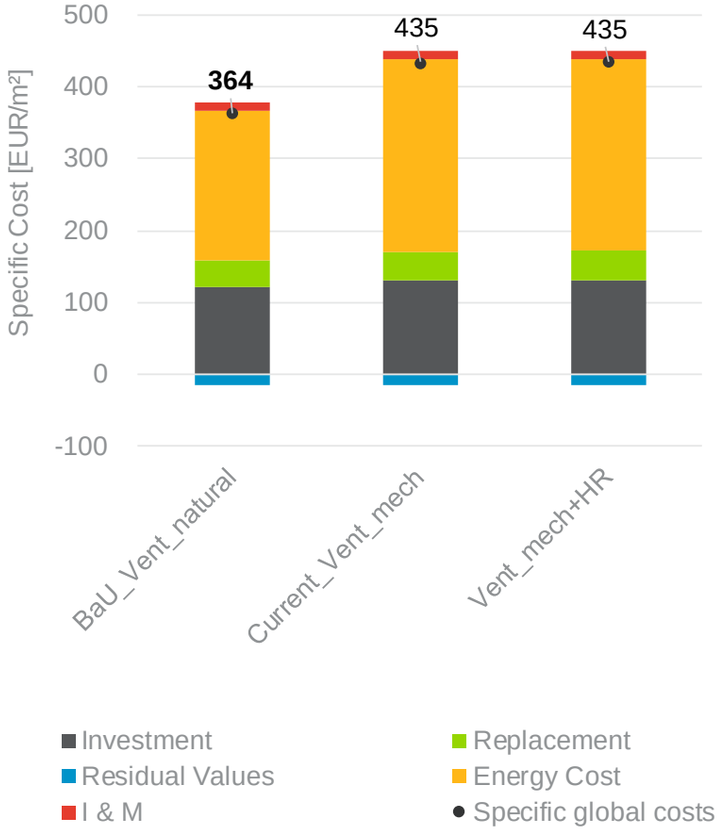

Result: BaU has the most cost effective measure

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Operational Temperatures

Analysis

BaU / Current

Cooling Temperature: 23°C
Heating Temperature: 21°C

Var 1

Cooling Temperature: 26°C

Var 2

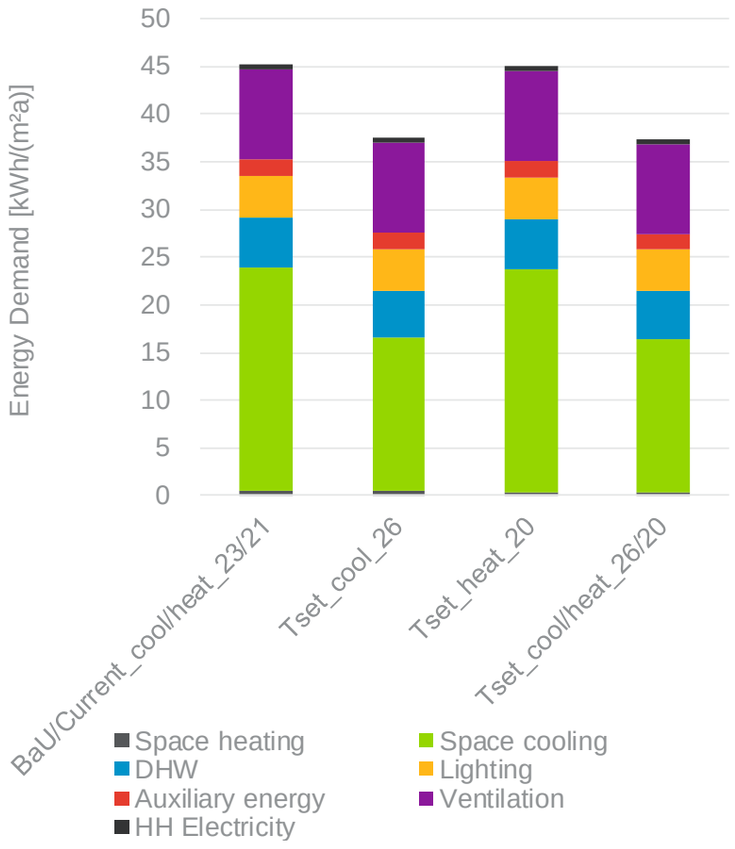
Heating Temperature: 20°C

Var 3

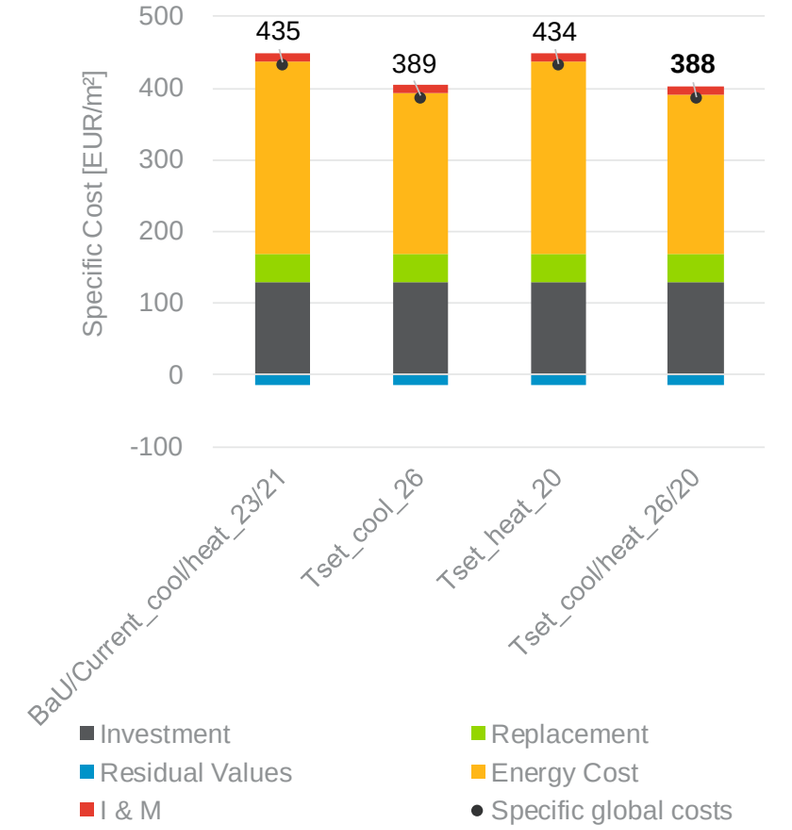
Cooling Temperature: 26°C
Heating Temperature: 20°C

Result: This measure is very effective and not related to any cost. **Variant 3** is the most cost effective variant.

Final Energy Demand



Global Cost



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Renewables I Solar Thermal

Analysis

BaU

no ST = electrical inst. heater

Current

ST – max roof exploitation (10% of total roof area)

Var 1

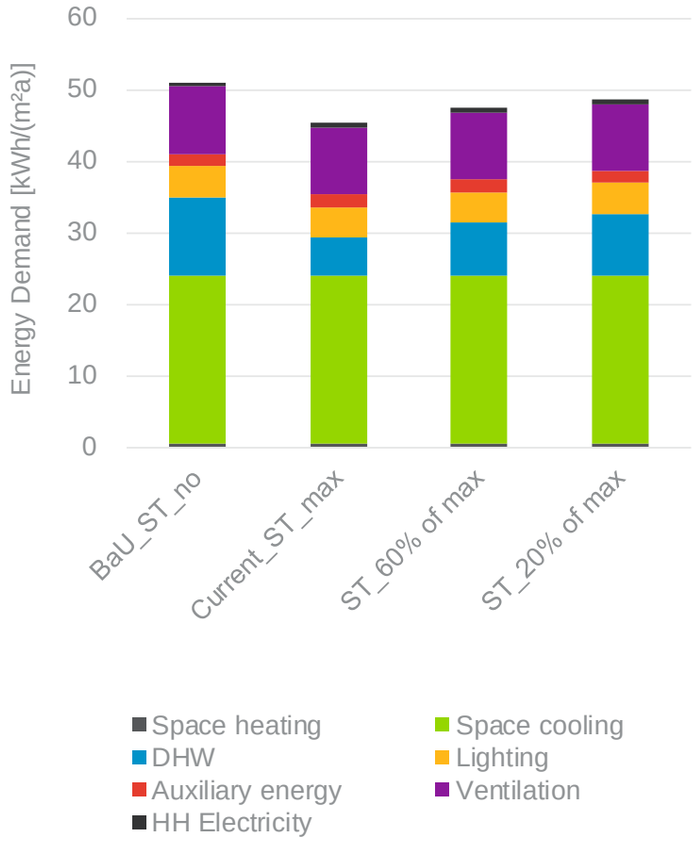
ST – 60% of max

Var 2

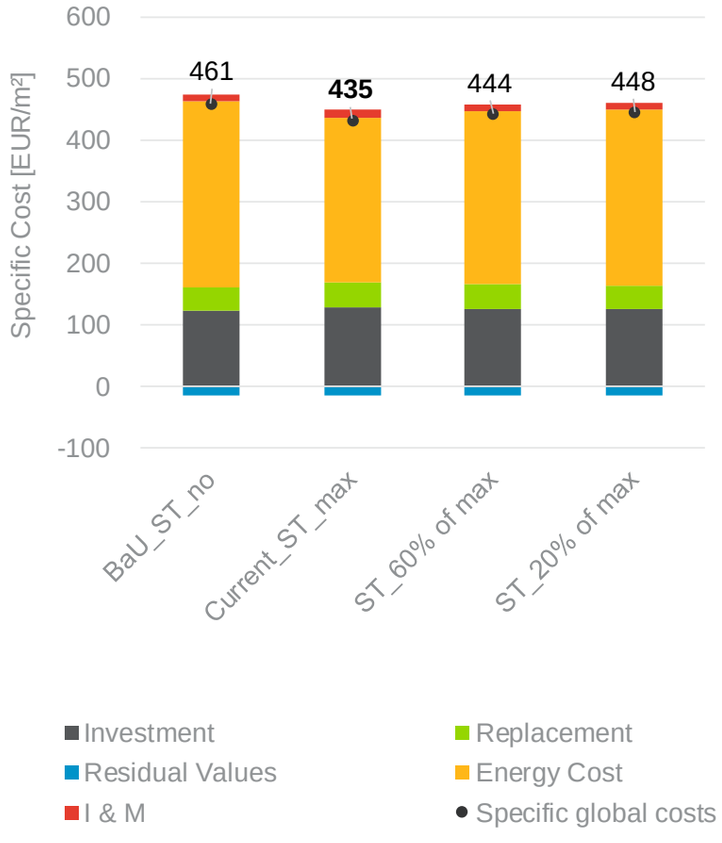
ST – 20% of max

Result: Var 2 is the most cost effective measure

Final Energy Demand



Global Cost



Renewables I PV

Analysis

BaU/Current

no PV

Var 1

PV – max. exploitation of roof surface

Var 2

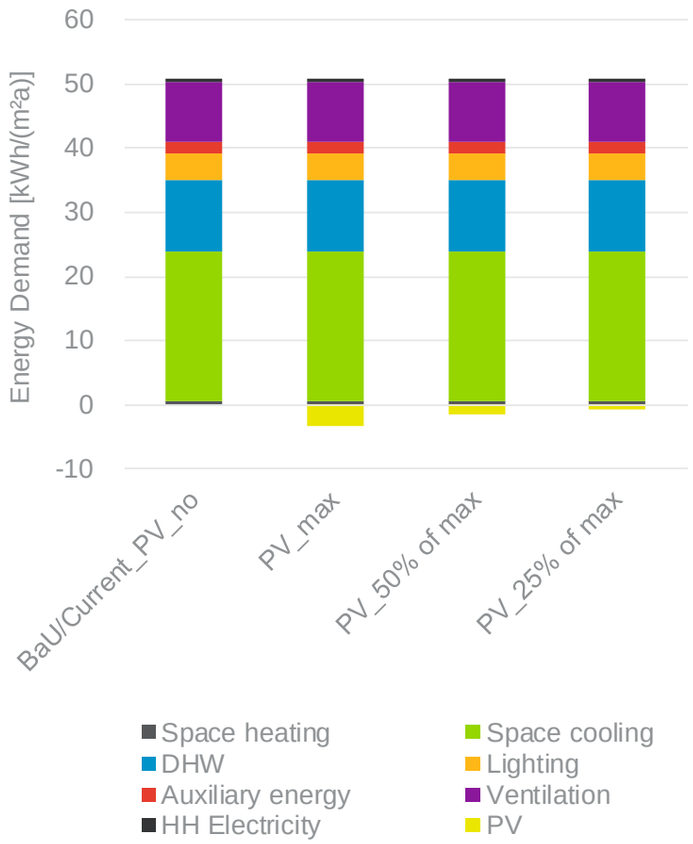
PV – 50% of max

Var 3

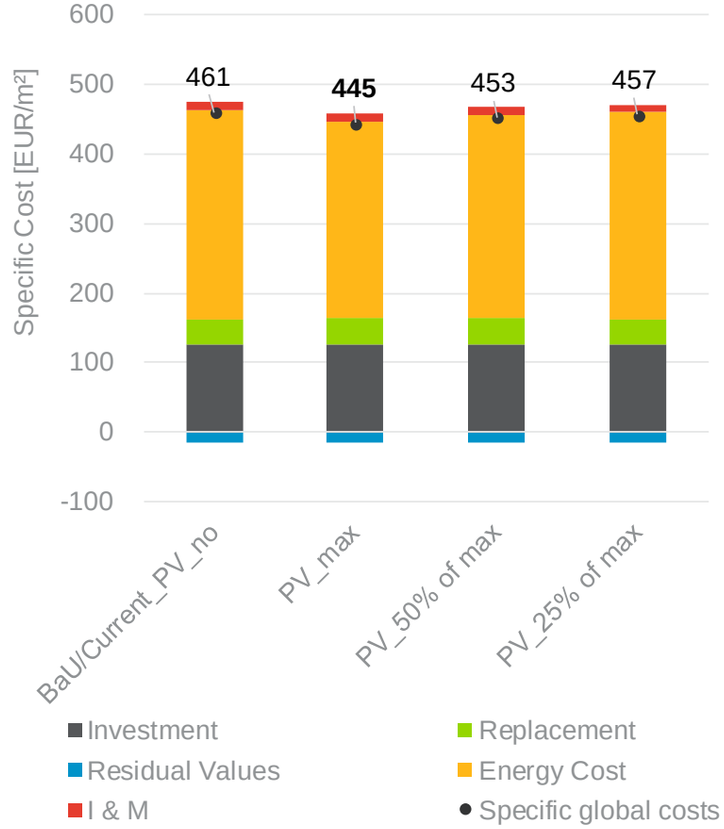
PV – 25% of max

Result: Var 1 is the most cost effective measure

Final Energy Demand



Global Cost



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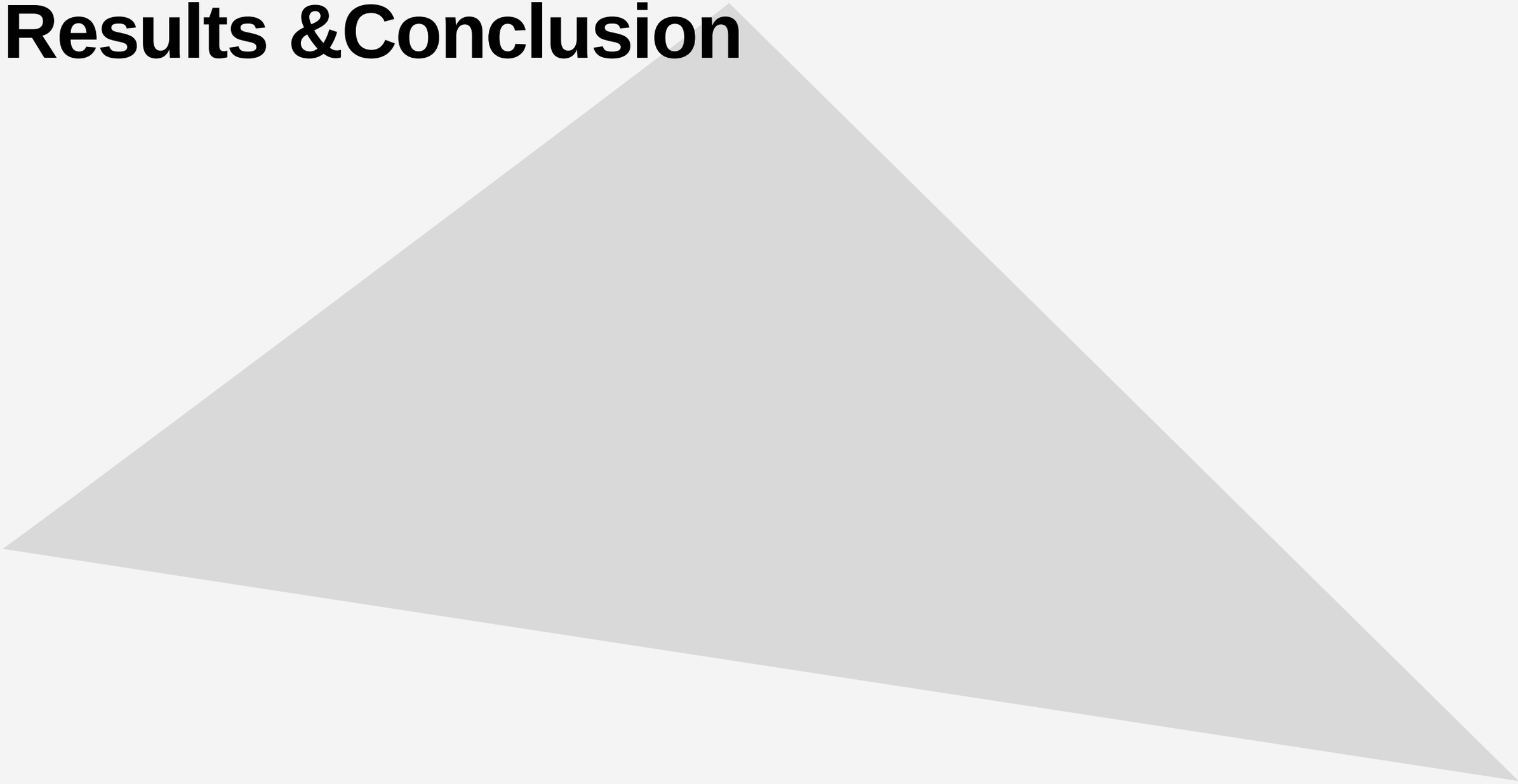
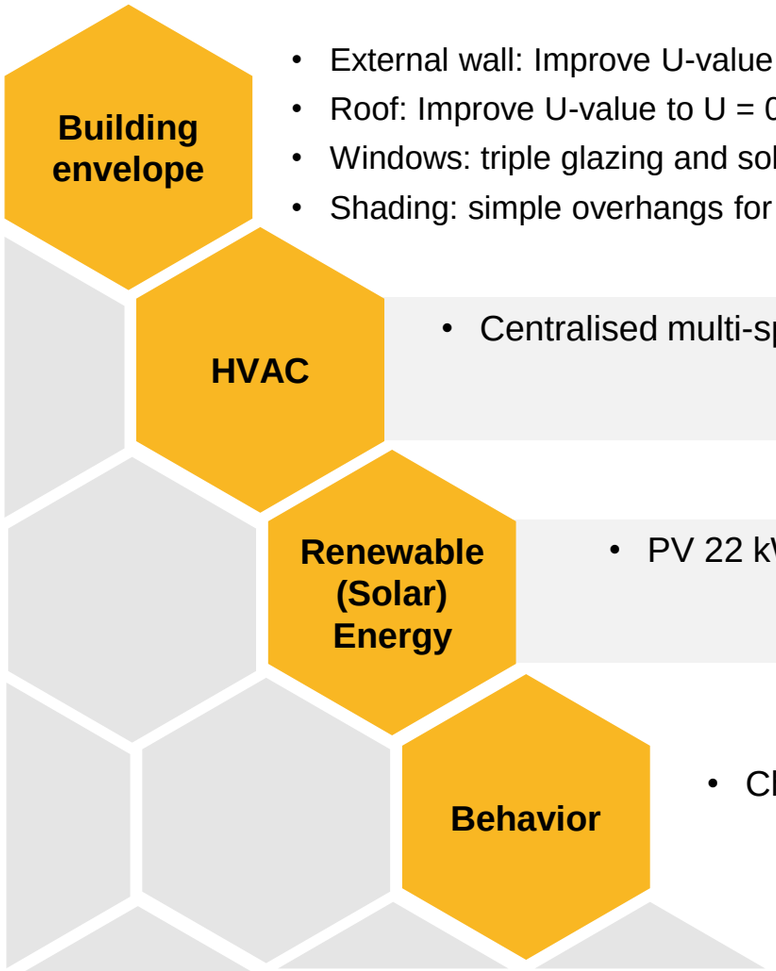
Results &Conclusion



Overview of recommended measures (for ongoing sectors)

Four steps to reduce energy demand significantly



Building envelope

- External wall: Improve U-value to U = 0.4 W/m²K
- Roof: Improve U-value to U = 0.3 W/m²K, choose light roof color
- Windows: triple glazing and solar protection glazing (U-Value 0.9 W/m²K, G-Value 0.3), improve air tightness (aim: n_{inf} = 0.05 1/h)
- Shading: simple overhangs for south orientation

HVAC

- Centralised multi-split system heating / cooling with high efficiency (COP ~ 5)

Renewable (Solar) Energy

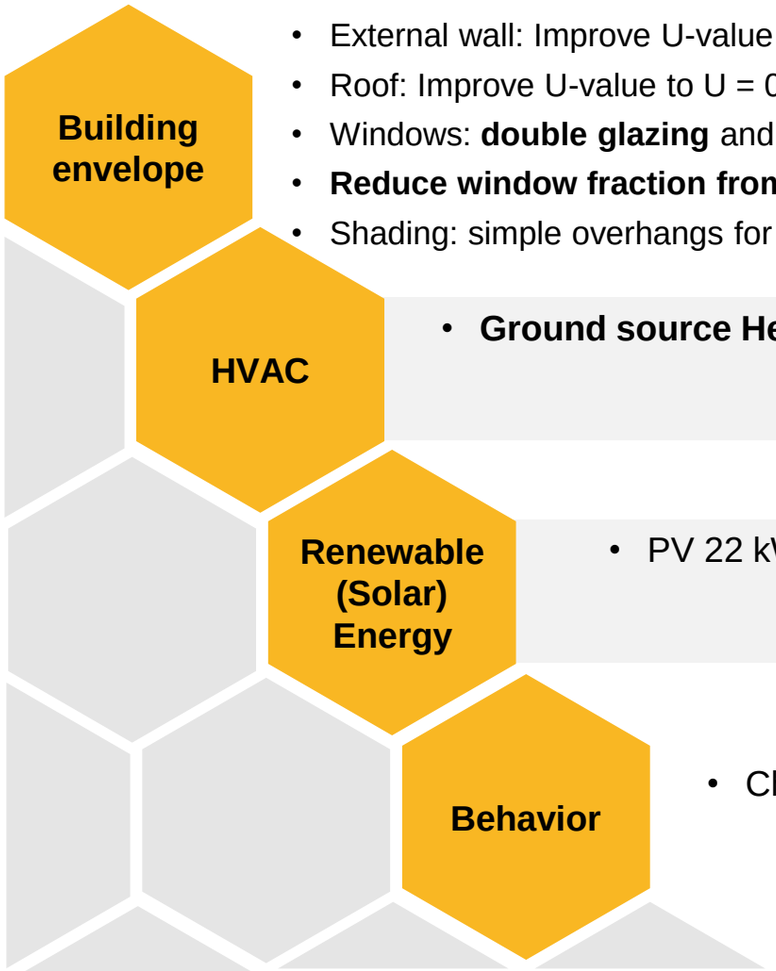
- PV 22 kWp

Behavior

- Change set temperature from Cooling 23°C/ Heating 21°C to Cooling 26°C/ Heating 20°C

Overview of recommended measures (for planned sectors)

Four steps to reduce energy demand significantly



Building envelope

- External wall: Improve U-value to U = 0.4 W/m²K
- Roof: Improve U-value to U = 0.3 W/m²K, choose light roof color
- Windows: **double glazing** and solar protection glazing (U-Value **2.8 W/m²K**, G-Value 0.3), improve air tightness (aim: n_{inf} = 0.05 1/h)
- **Reduce window fraction from 40 to 20%**
- Shading: simple overhangs for south orientation

HVAC

- **Ground source Heat Pump for heating and cooling (COP ~ 6)**

Renewable (Solar) Energy

- PV 22 kWp

Behavior

- Change set temperature from Cooling 23°C/ Heating 21°C to Cooling 26°C/ Heating 20°C

Optimized Solution (ongoing sectors)

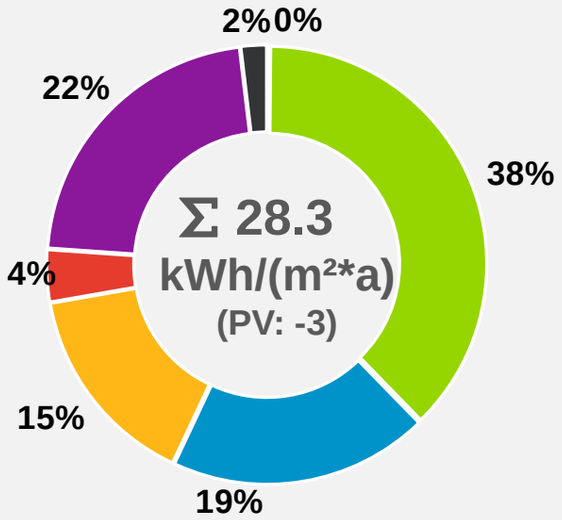
Results

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) and Solar collectors (for hot water).

This leads to energy savings and emission reduction.

Parameters	Baseline
Roof insulation (U-Value)	**0.30 W/m²K (light color)**
Wall insulation (U-Value)	**0.40 W/m²K**
Floor insulation (U-Value)	3.2 W/m²K
Windows (U-Value; G-Value)	**0.9 W/m²K; 0.3 (solar glazing)**
Window fraction	Ø 40%
Shading	**overhang South**
Air infiltration through leakages	**0.05 1/h**
Heat supply	**centralised multi-split unit - COP 5**
Cold supply	**centralised multi-split unit - COP 5**
Hot water	**electric instantaneous**
Ventilation systems	mechanical ventilation
Lighting systems	LED
Renewable energy	**22 kWp (PV)**
Set temperature cooling/heating	**26°C / 20°C**



Energy Cost (- PV)
4.4 EUR / (m²*a)

CO2 - Emission
17.1 kg / (m²*a)

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Optimized Solution (planned sectors)

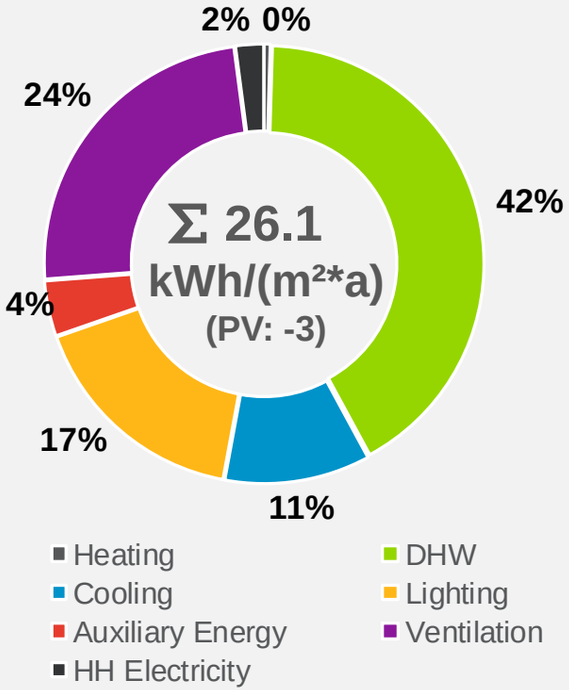
Results

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) and Solar collectors (for hot water).

This leads to energy savings and emission reduction.

Parameters	Baseline
Roof insulation (U-Value)	0.30 W/m²K (light color)
Wall insulation (U-Value)	0.40 W/m²K
Floor insulation (U-Value)	3.2 W/m²K
Windows (U-Value; G-Value)	**2.8 W/m²K;** 0.3 (solar glazing)
Window fraction	**Ø 20%**
Shading	overhang South
Air infiltration through leakages	0.05 1/h
Heat supply	**ground source HP - COP 6**
Cold supply	**ground source HP - COP 6**
Hot water	electric instantaneous
Ventilation systems	mechanical ventilation
Lighting systems	LED
Renewable energy	22 kWp (PV)
Set temperature cooling/heating	26°C / 20°C



Energy Cost (- PV)
4.0 EUR / (m²*a)

CO2 - Emission
15.6 kg / (m²*a)

Comparative overview

Baseline vs. Current vs. Optimized (ongoing and planned sectors)

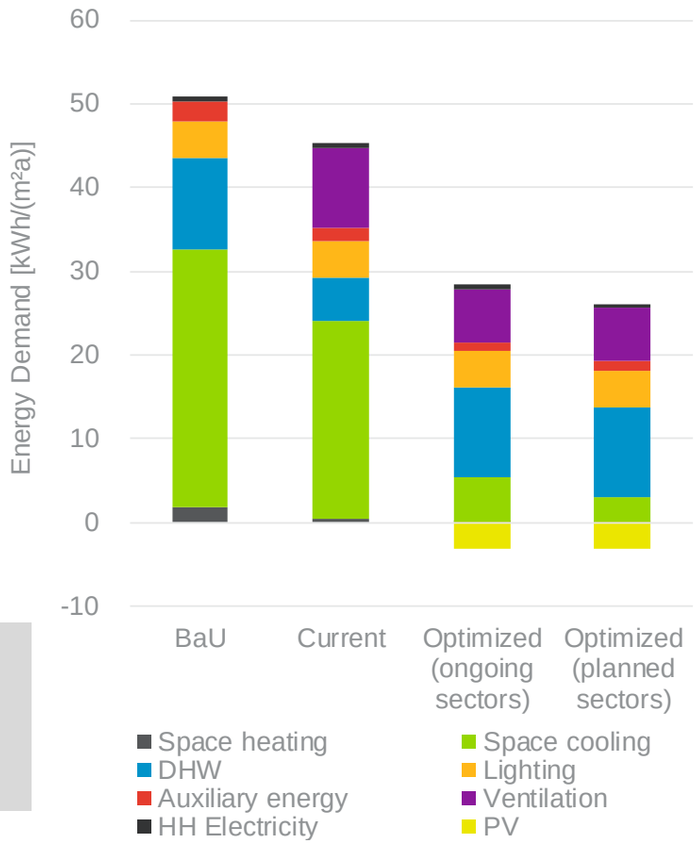
Conclusion

- 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**

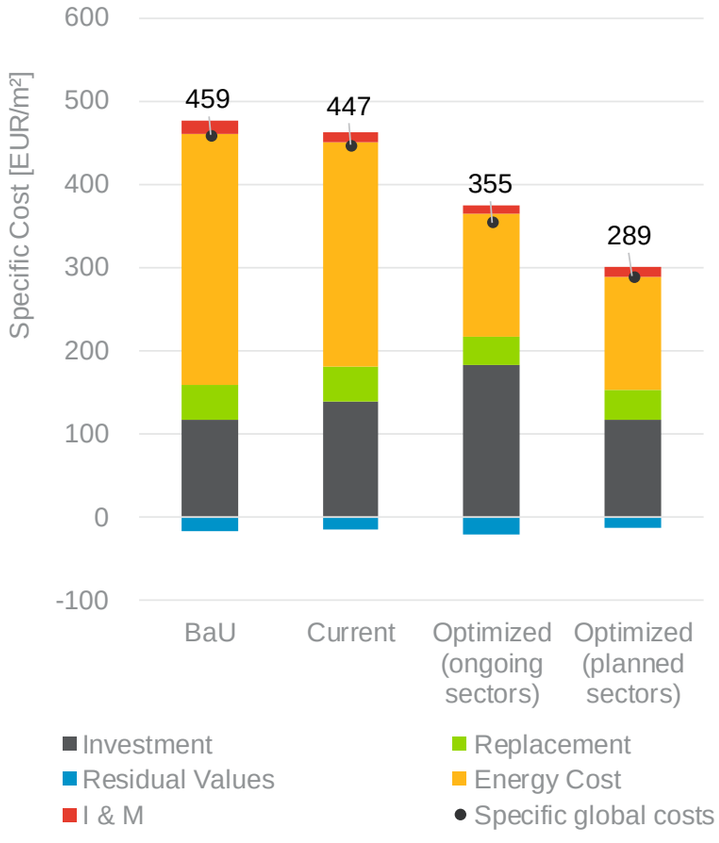
Savings BaU to Optimized (incl. PV)

- Energy: **51** => **23** kWh/m²a
- Energy Cost: **8.9** => **4.0** EUR/m²a

Final Energy Demand



Global Cost



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Key conclusion

Main take aways for the Kye Project (ongoing sectors)

- Compared with the baseline you will save with the current approach approx. 10 % energy and energy costs when paying comparable invest cost
- The recommended package is able to save 50% energy compared to the baseline and 45% energy related to the current planning
- Simplify the cooling concept to ensure manageable operation, at the same seek for a high COP/efficiency
- Maximise the use of PV

Key conclusion

Main take aways for the Kye Project (planned sectors)

- Compared with the baseline you will save with the current approach approx. 10 % energy and energy costs when paying comparable invest cost
- The recommended package is able to save **55%** energy compared to the baseline and **50%** energy related to the current planning
- Seek for a high COP/efficiency of your cooling system, e.g. with the **ground source heat pump**
- Reduce the window fraction from **40 to 20%.** Then you might also choose moderate window qualities instead of triple glazing (2.8 vs. 0.9 W/m²K)

Optimized vs. current

Payback of single measures and whole package (**bold** = planned sectors)

Parameters	Optimized	Investment (optimized-current) [EUR]	Energy cost savings* [EUR / year]	Payback [years]	Lifetime [year]
Roof insulation (U-Value)	0.3 W/m²K	51,000	-1,400	35	40
Wall insulation (U-Value)	0.4 W/m²K	54,600	-1,600	35	40
Windows (U-Value; G-Value)	Ongoing: 0.9 W/m²K; 0.50 **(Planned: 2.8 W/m²K; 0.55)**	148,300	-4,600	33	30
Window fraction	**Planned: 20%** (Ongoing: 40%)	-331,700	-16,800	immediately	30
Shading	Solar glazing	248,100	-15,400	28	30
Air infiltration through leakages	0.05 1/h	155,100	-7,700	20	-
Heat/Cold supply	(Ongoing: centralised multi-split - COP 5) **Planned: Ground source HP - COP 6**	28,100	-15,200	2	20
Renewable energy	PV: 22 kWp (maximum) (ST: 157 m² (maximum))	18,200 (59,200)	-6,300 (-11,000)	3 (5)	20
Set temperature cooling/heating	26°C / 20°C	0	-15,300	immediately	-
Total (current to optimized)**		**Ongoing: 588,425 (+5 to +10%)*** **Planned: -139,465 (-1 to -2%)********	**-33,200 (-37%)** **-37,500 (-42%)**	**18 immediately**	

* Remark: The energy cost savings have been calculated conservatively based on the current electricity starting price (appr. 17.5 Cent/kWh, incl. 9h of diesel generator outage time).

** 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).

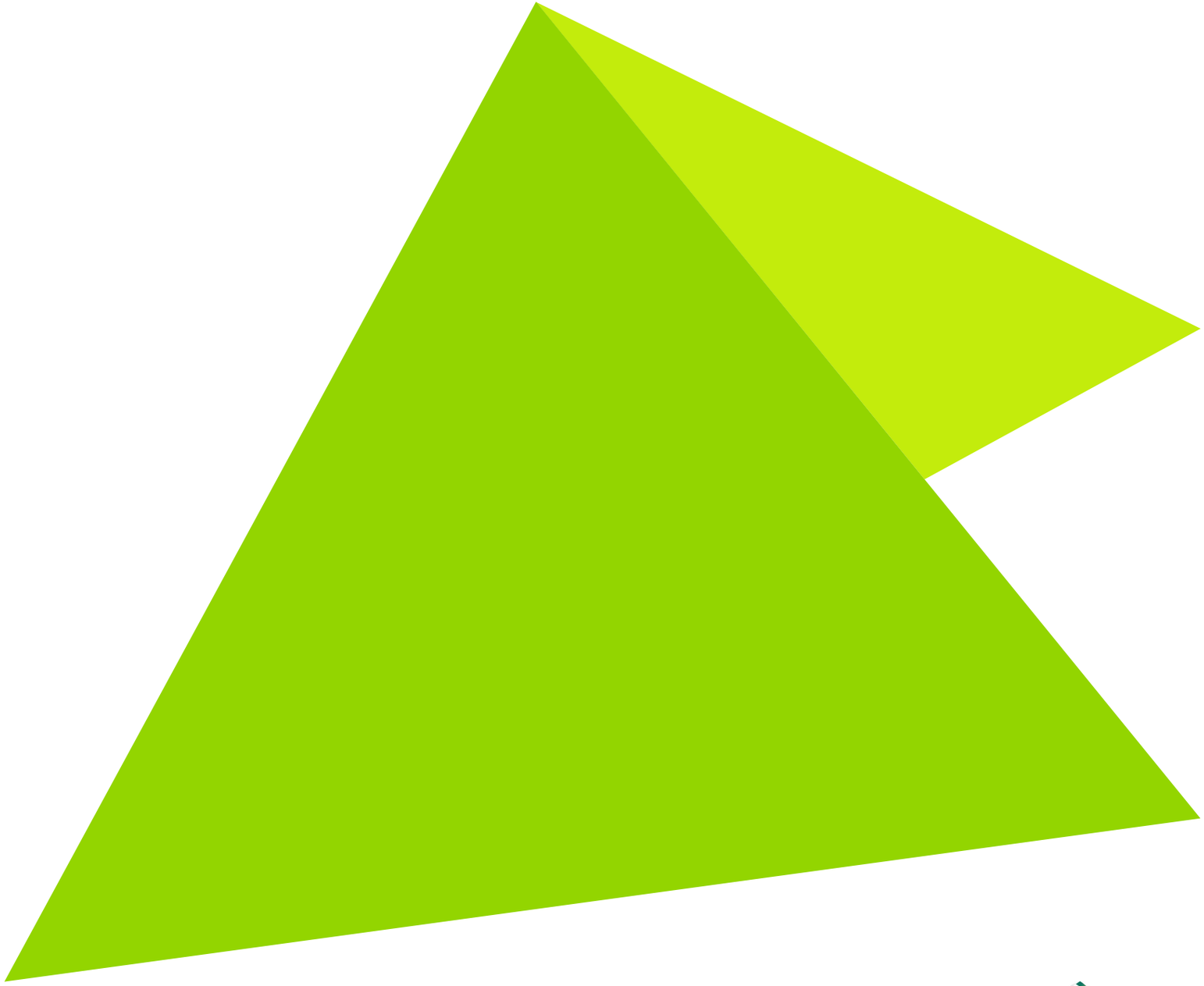
*** Remark: Compared to costs of current case and overall construction costs assumptions of 500 or 1000 Euro/m² (10 or 5 % additional costs).

**** Remark: Compared to costs of current case and overall construction costs assumptions of 500 or 1000 Euro/m² (2 or 1 % **less** costs) due to the lower window fraction.

Contact

Riadh Bhar
Managing Consultant
riadh.bhar@guidehouse.com

Eslam Mahdy
Senior Consultant
eslam.mahdy@guidehouse.com



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