Guidehouse

Energy Efficiency Recommendations for KONN Modular House, Jordan

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

BUILD_ME

May 2020

Introduction to the BUILD_ME project

BUILD_ME

Fund

IKI International Climate Initiative, German Federal Ministry of Environment

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based on a decision of the German Bundestag

MENA Region

EGY JOR LEB ALG MOR TUN

Team

IDG MATRIX Integrated Development Group

الجمعية العلمية الملكية Royal Scientific Society

LCEC Lebanese Center for Energy Conservation

European Bank for Reconstruction and Development

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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

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

Week 0	Week1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week10	Week11	Week12	Week13
MoU	Data							Initial recommendations					Final presentation

- **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

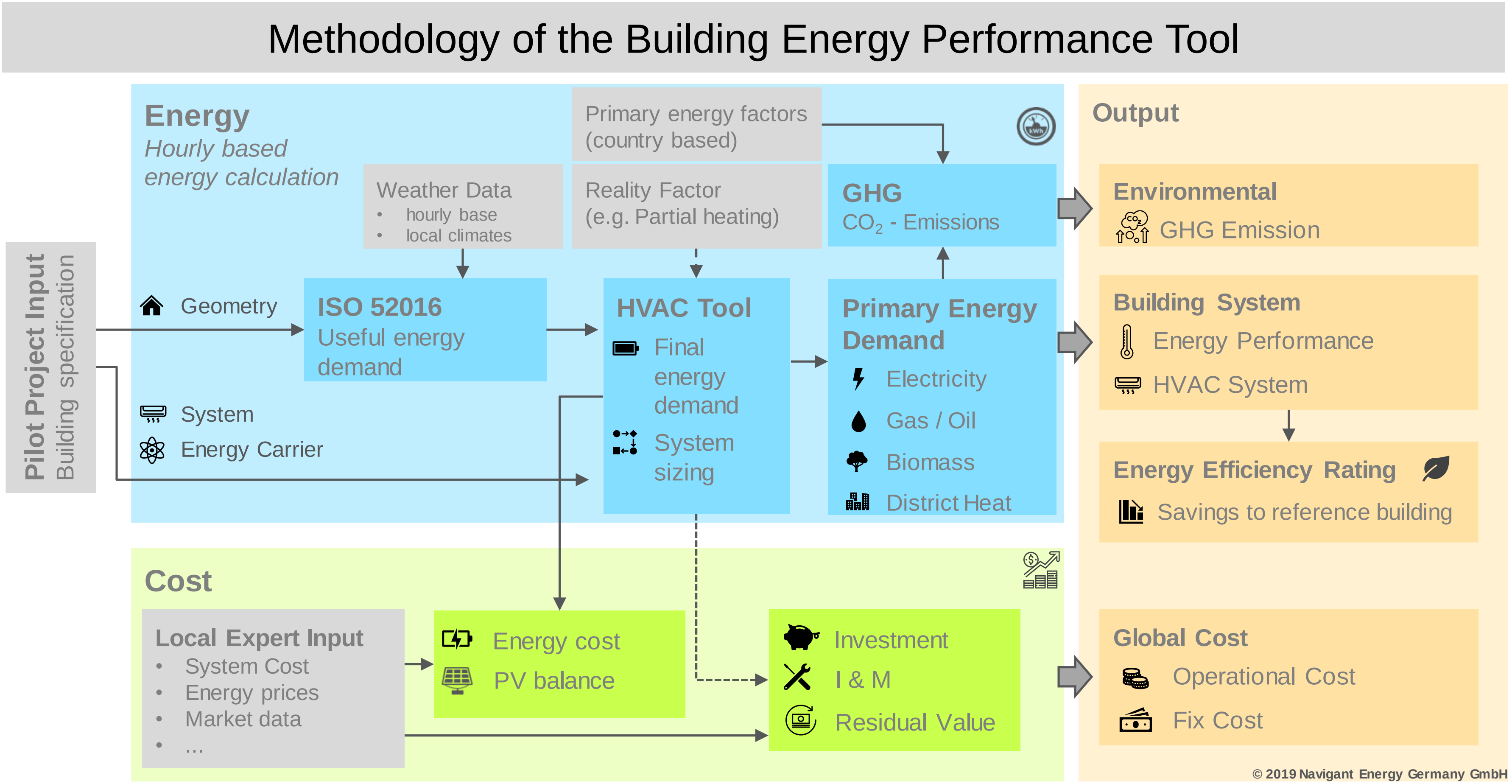
- Calculation of energy cost and investment cost of the systems, based on the HVAC system sized in the energy calculation
- Energy price systematic and PV clearing can be adapted to local situation (here: Jordan)
- Residual values at the end of the calculation period for the systems are considered

Methodology

Cost Benefit Analysis

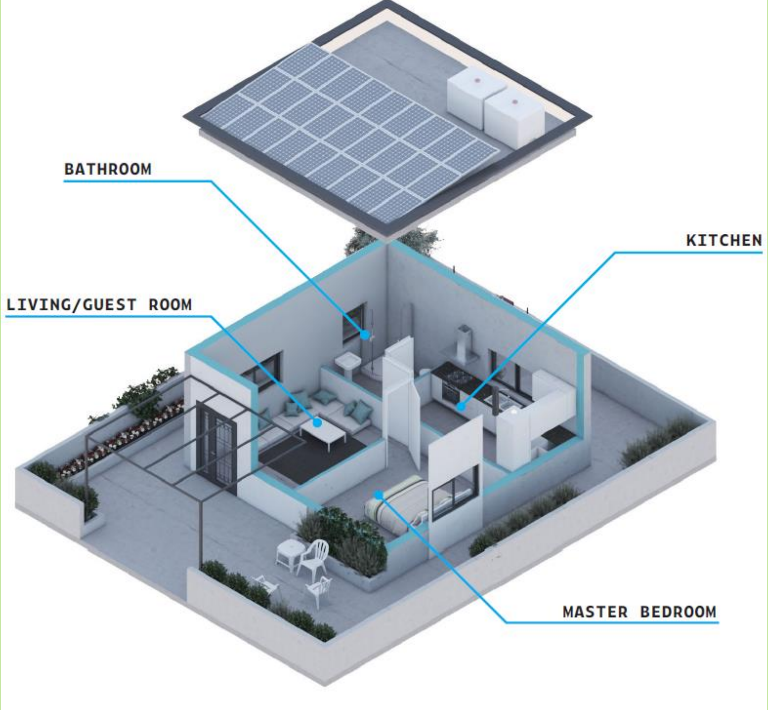
HIGLIGHTS

- 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)



Introduction

The KONN Project
Boundary conditions



KONN Modular Houses

Aims

Creating a community based on Jordanian family values. To Improve quality of life through smart modular construction and technologies empowering community members and encouraging change by simplifying the complex

Target Groups

Affordable housing for the low income groups and families in rural areas and outskirts of urban centers.

Function

Residential single family houses including a small garden.

Size

The project offers diffrent sizes of 50, 85 and 120 square meters.

Boundary conditions

Site : Context matters

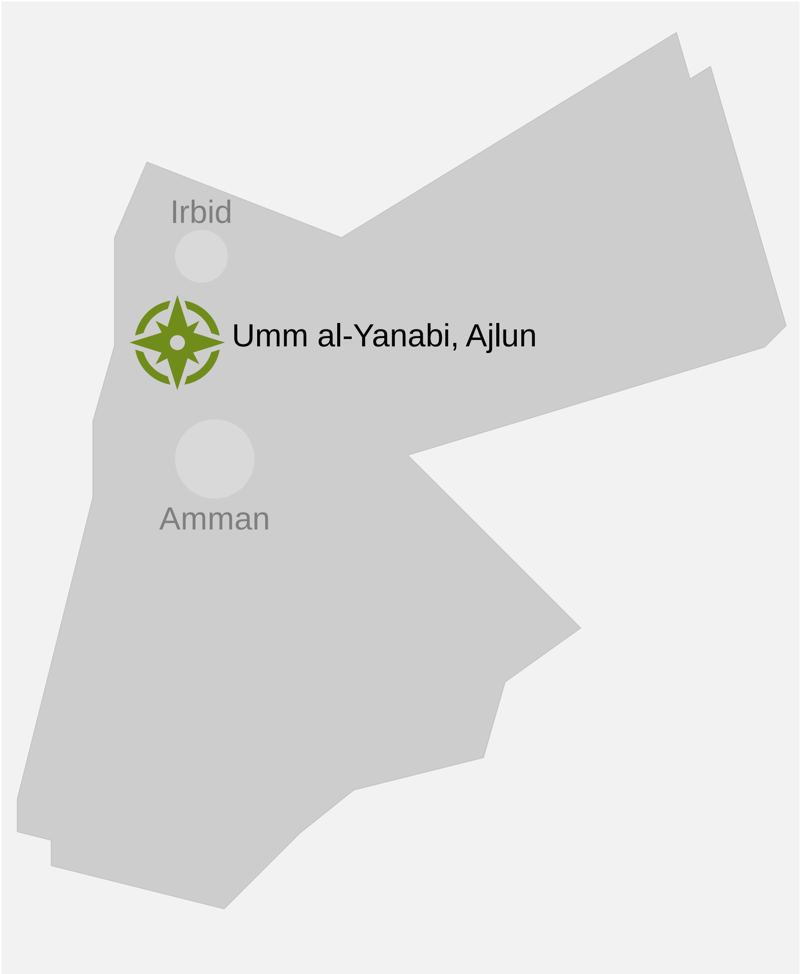
City : Umm al-Yanabi, Ajlun

Location : 40 KM South of Irbid

Context

The northern outskirts of ‘Ajlun, north of Jordan, Umm al-Yanabi’ lies on one of the hills encompassing the ‘Ajlun Natural Reserve. The small village of around one thousand inhabitants sits on the remains of a Byzantine settlement; cross-vaults as well as old walls.

Source: Google Maps



Boundary conditions I Climate Analysis

External temperatures (left) and degree days (right) in Amman (Jordan)*

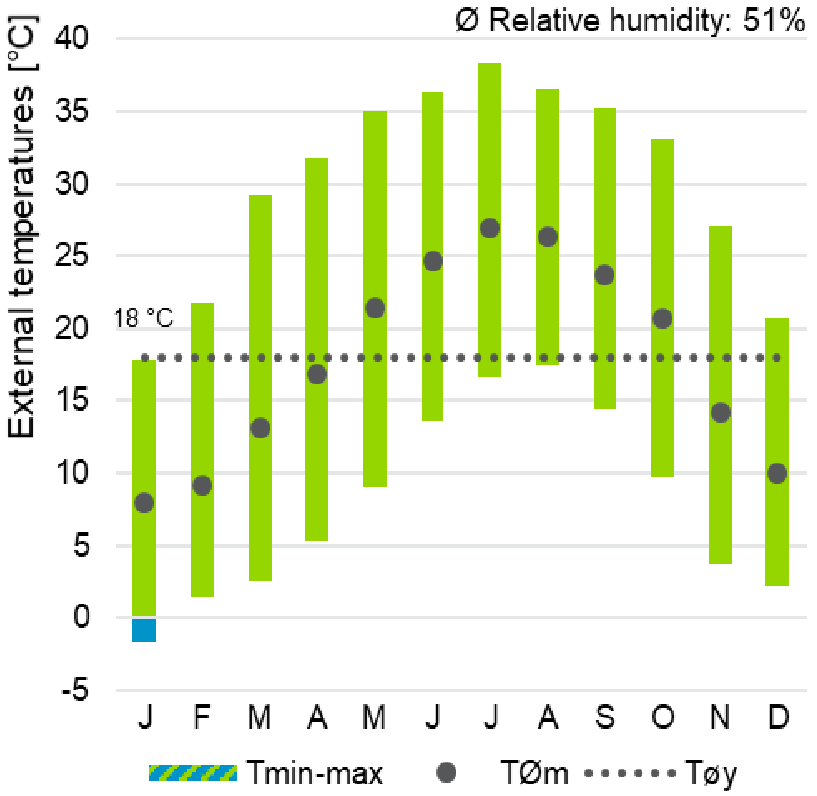
Description

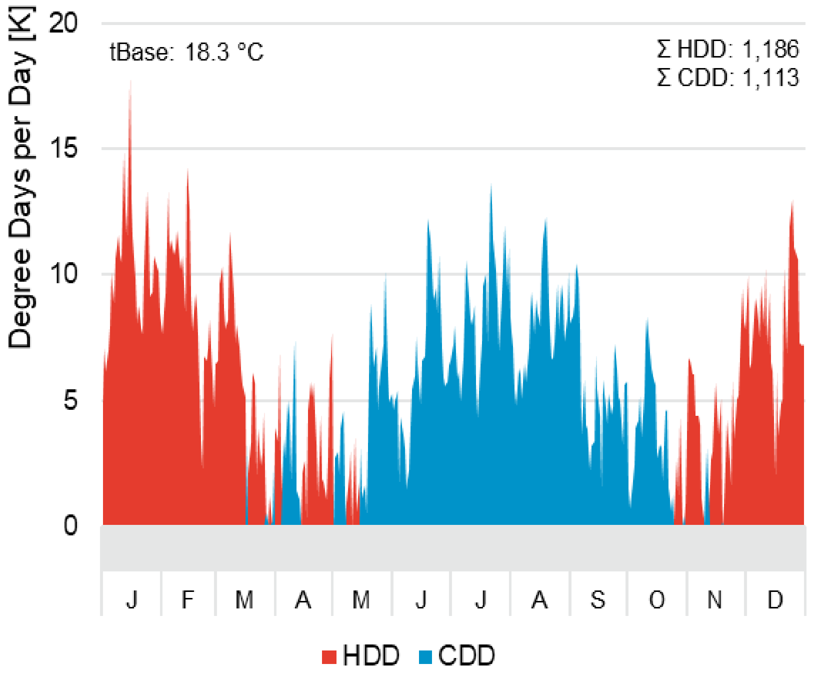
The climate in Amman is moderate. The annual average temperatures are about 18°C

Challenges and Potentials

A few hours per year undercut the freezing point.

Similar heating and cooling degree days of around 1,150 Kd indicate a balanced and moderate need for heating and cooling.





* The following paragraphs refer to Amman due to data availibility
* HDD: heating degree days; CDD: cooling degree days; according to ASHREA methodology

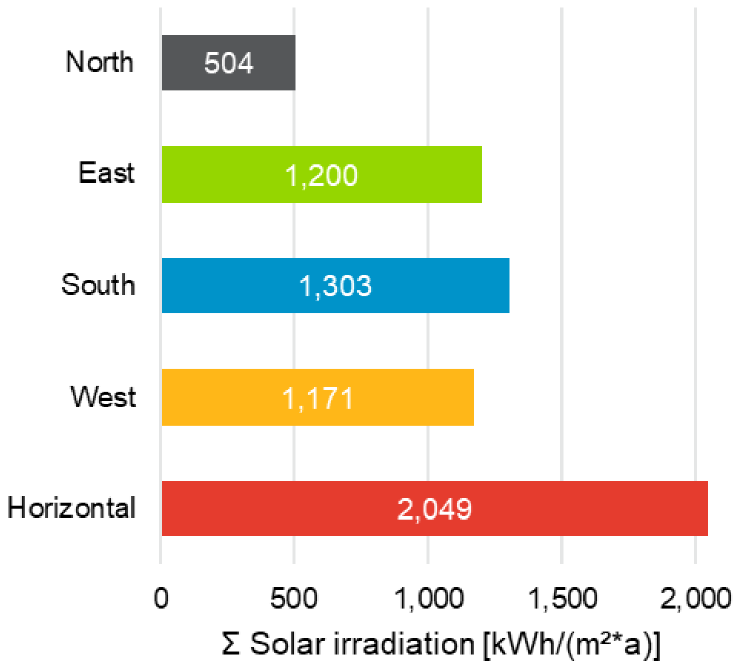
Boundary conditions I Climate
Solar Irradiation in Amman (Jordan)

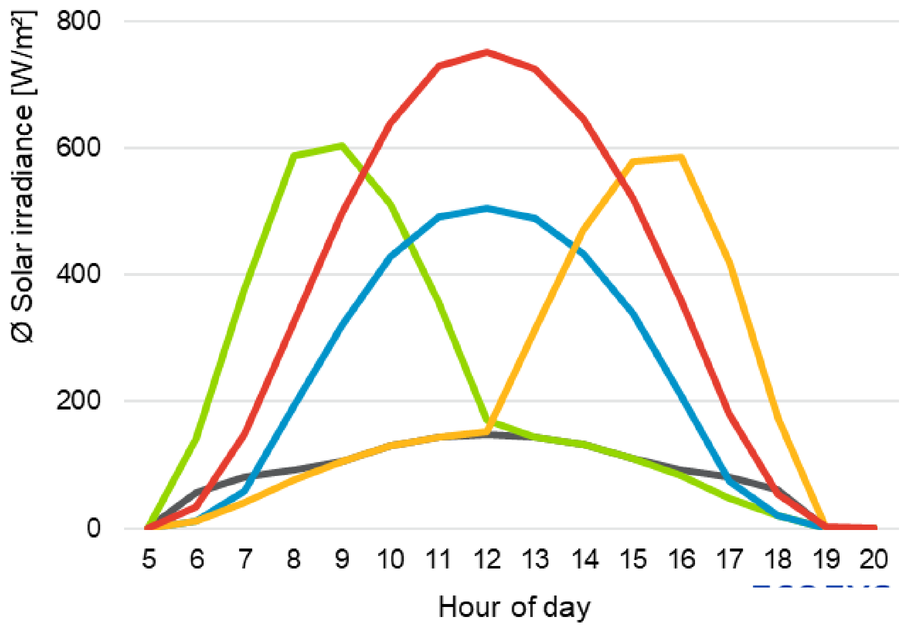
Description

High horizontal irradiation of > 2,000 kWh/(m²*a)

Challenges and Potentials

and > 1,100 kWh/(m²*a) for East, South and West orientation bring opportunities for solar based energy generation.





Boundary conditions I Economic and Emissions Inputs

Cost of Energy and Environmental impact

Status

In Jordan, natural gas is only used for power generation plants, while the LPG, diesel fuel and electricity are used in space heating.

Objectives

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

Energy prices and CO_2 emissions			
Parameter	Unit	Electricity	Diesel
Energy price	JOD/kWh	Mean 0.04	0.048
Energy price	EUR/kWh†	0.055	0.06
Price development	%/year	3	6
CO_2 emission factor	gCO_2/kWh	635	300
Economic parameters			
Interest rate (real)	%/year	5	
Calculation period	years	20	

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

Boundary Conditions I Building

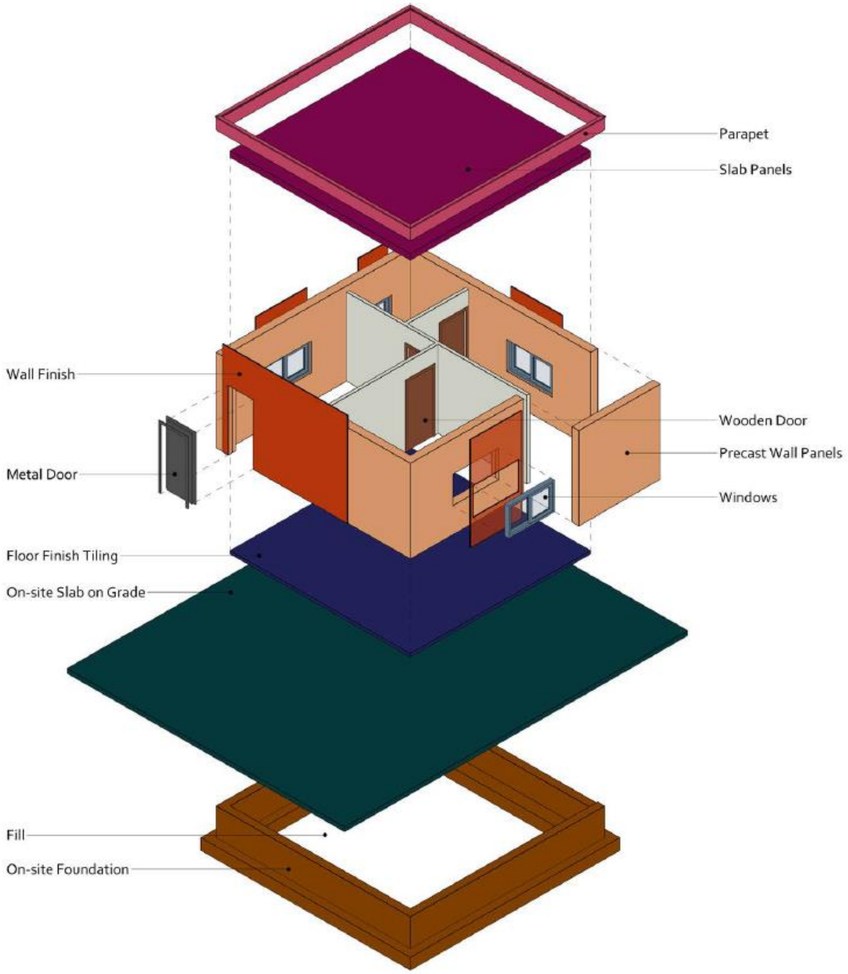
Building Data

Status

Small Single Family houses in a modular construction

Specific Challenge

Located in remote areas. It is significant to reduce on-site workmanship to the minimum aiming to industrialize building components.



Building Key Information	
Data	Input
Latitude	opt
Longitude	opt
Elevation [m]	opt
Utilization	SFH
Number of floors	1
Number of apartment	1
Conditioned floor area [m²]	47
Clear room height [m]	2.5 m
Conditioned volume [m³]	127
Number of inhabitants [#]	4
Year of construction	2020

Analysis

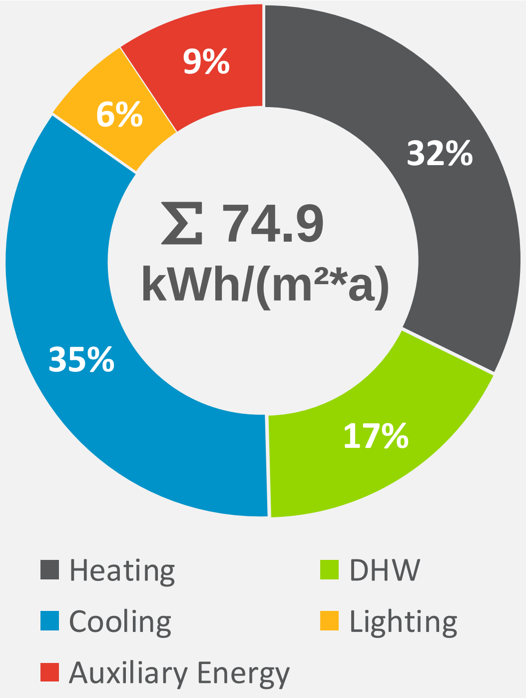
Starting Situation - Baseline and Current planning

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)	0.55 W/m²K
Wall insulation (U-Value)	0.57 W/m²K
Floor insulation (U-Value)	3.6 W/m²K
Windows (U-Value; G-Value)	5.7 W/m²K; 0.85
Window fraction	Ø 5%
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	electric instantaneous
Ventilation systems	Natural ventilation
Lighting systems	LED
Renewable energy	No
Set temperature cooling/heating	23°C / 21°C



Energy Cost
7,4 EUR / (m²*a)

CO_2 - Emission
2.5 kg / (m²*a)

Current situation (KONN)

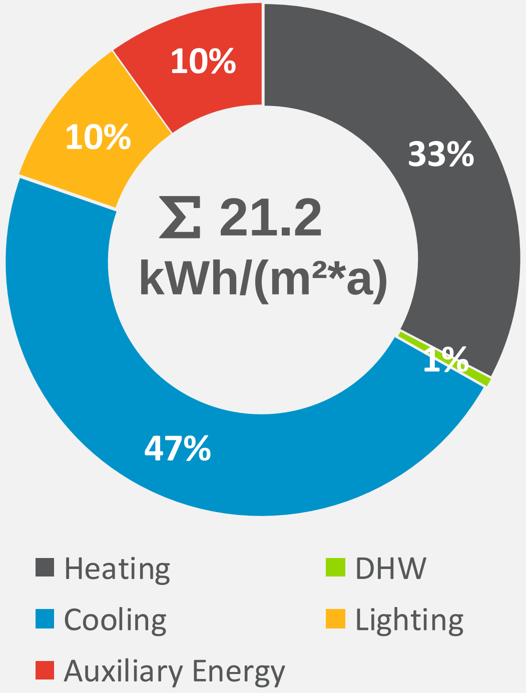
Results

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)	0.41 W/m²K
Wall insulation (U-Value)	0.46 W/m²K
Floor insulation (U-Value)	0.68 W/m²K
Windows (U-Value; G-Value)	1.8 W/m²K; 0.75
Window fraction	Ø 5%
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	electric instantaneous | Solar
Ventilation systems	Natural ventilation
Lighting systems	LED
Renewable energy	3.8 kWp (PV) | 5m² (Solar)
Set temperature cooling/heating	23°C / 21°C



Energy Cost
4.4 EUR / (m²*a)

CO2 - Emission
0.7 kg / (m²*a)

Current situation (project developer)

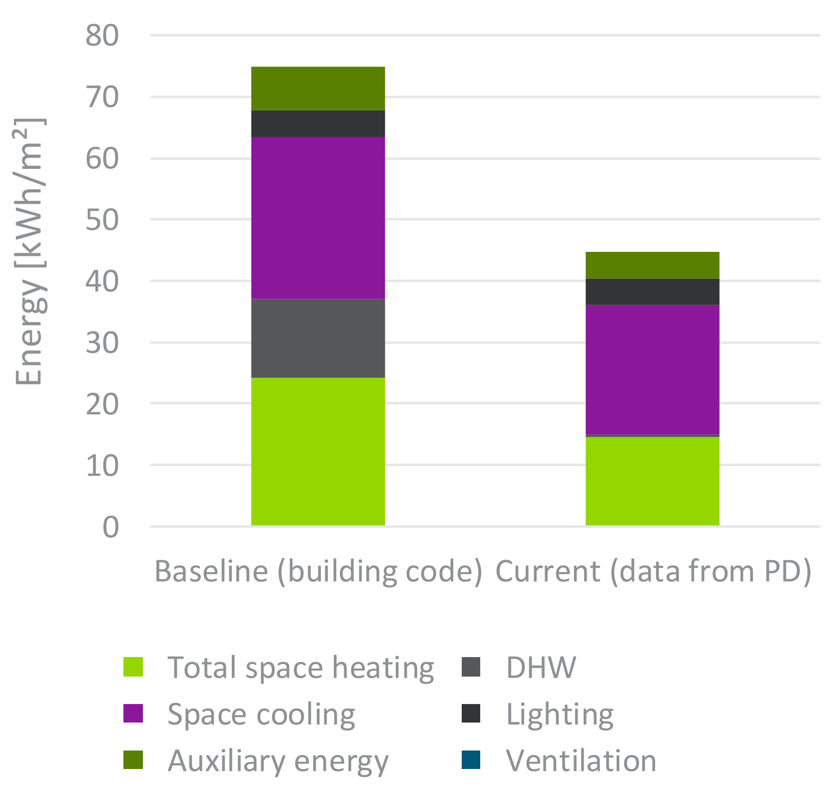
Results VS. BaU

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

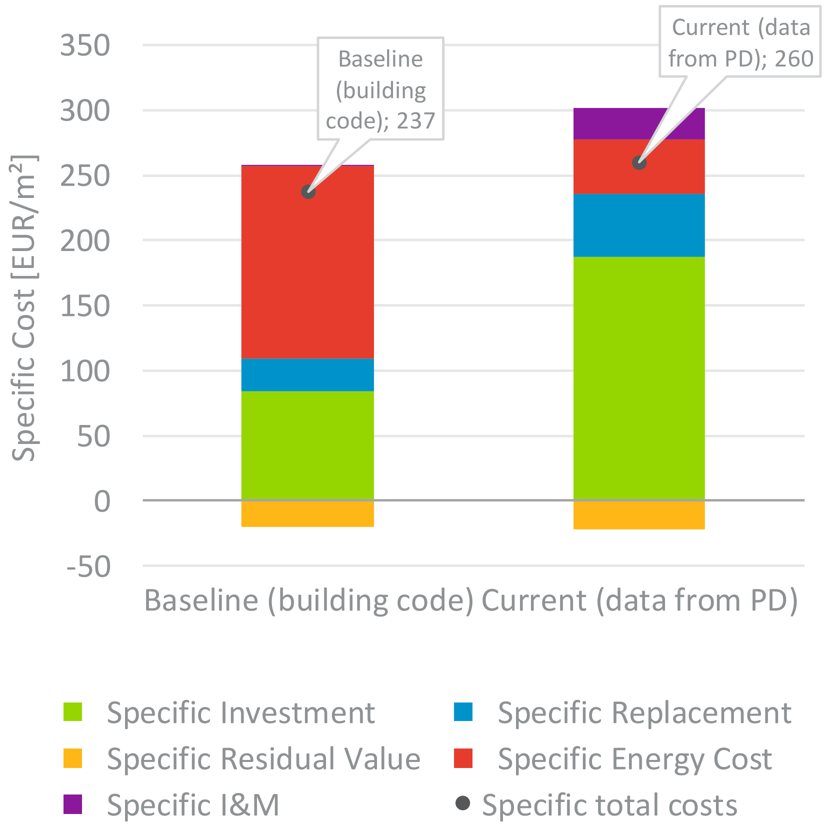
Although the energy cost decrease, the proposed measures will result in a cost increase due to the high investment cost.

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

Final Energy Demand



Global Cost



Analysis

Investigation of Possible Measures

Overview of Analyzed Measures

Building Envelope

External Wall	• Insulation thickness variants • Introducing ETICS solution
Roof	• Insulation thickness variants • Reduction of layers
Windows	• Verifying different Window U- and G-Values
Air tightness	• Checking the effect of air tightness
Shading	• What is the effect of shading?

HVAC and Systems

Cooling	• What is the cost optimal efficiency? [COP] • What is the saving of an adjusted temperature?
Heating	• What is the saving of an adjusted temperature?
Lighting	• Optimal type of lighting?

Renewable Energy

- Renewable energy sources
- Solar water heaters
- Small size wind turbines

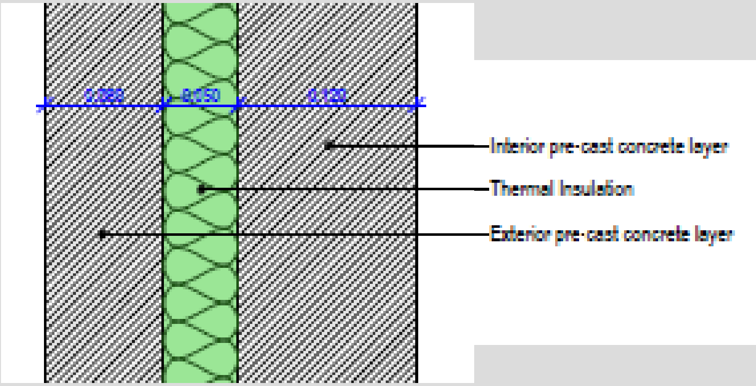
Building Envelope

External wall

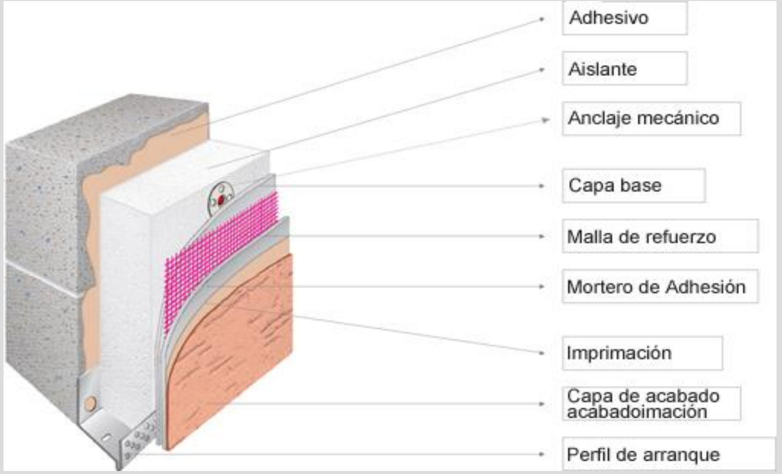
ETICS providers and suppliers are available in Jordan. We will further investigate that.

- Thermal heat bridges may appear. For example: screws of sandwich panel may lead thermal leakage.
- To increase the insulation of the sandwich panel. Different variation to be considered.

Existing external wall solution



Possible ETICS solution



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Building Envelope I External wall
Results

Modified insulation thickness with given sandwich panel

Current -> 5cm = 0.59 W/m²K

0.46 mentioned by KONN?

(attention 0.57 W/m²K asked by Building Code!)

6 cm -> 0.51 W/m²K

ETICS solution

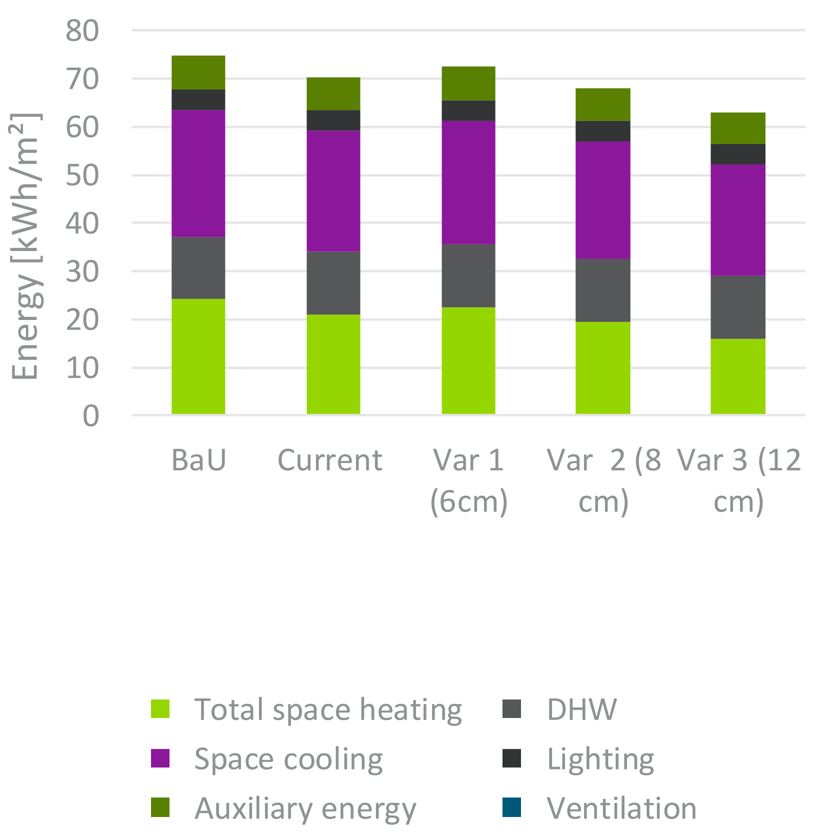
6 cm ETICS + 12 cm concrete -> 0.51 W/m²K

8 cm ETICS + 12 cm concrete -> 0.40 W/m²

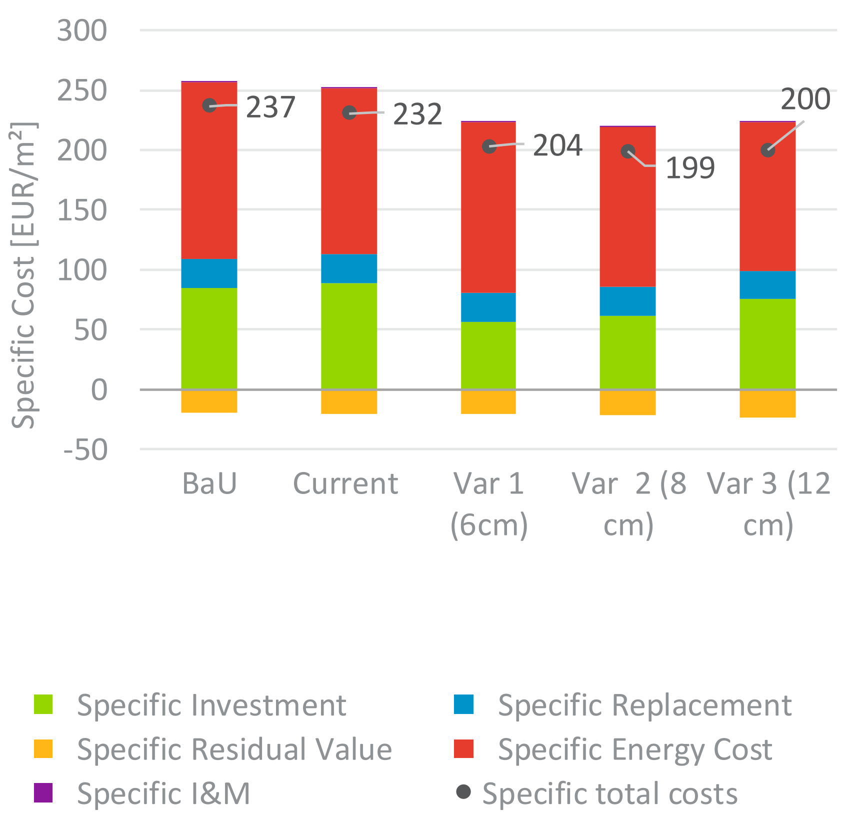
12 cm ETICS + 12 cm concrete -> 0.27 W/m²K

Var 2 (ETICS with 8 cm) is the most cost effective measure

Final Energy Demand



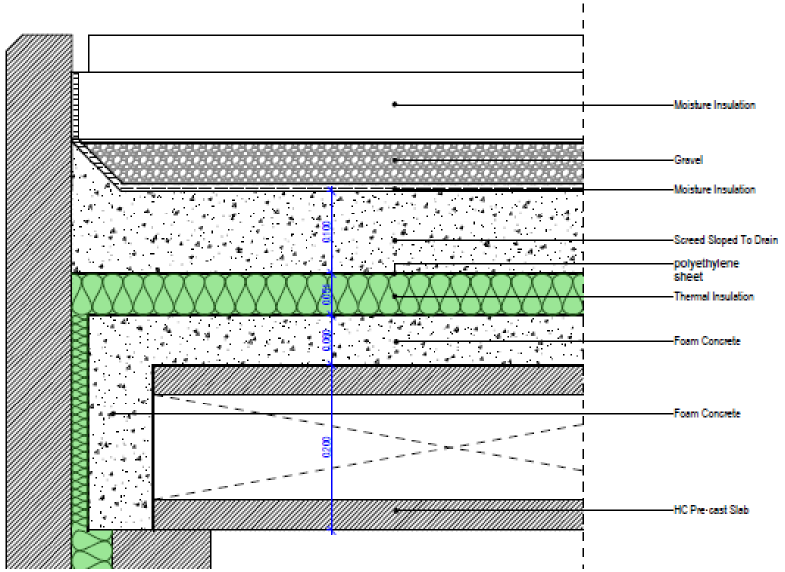
Global Cost



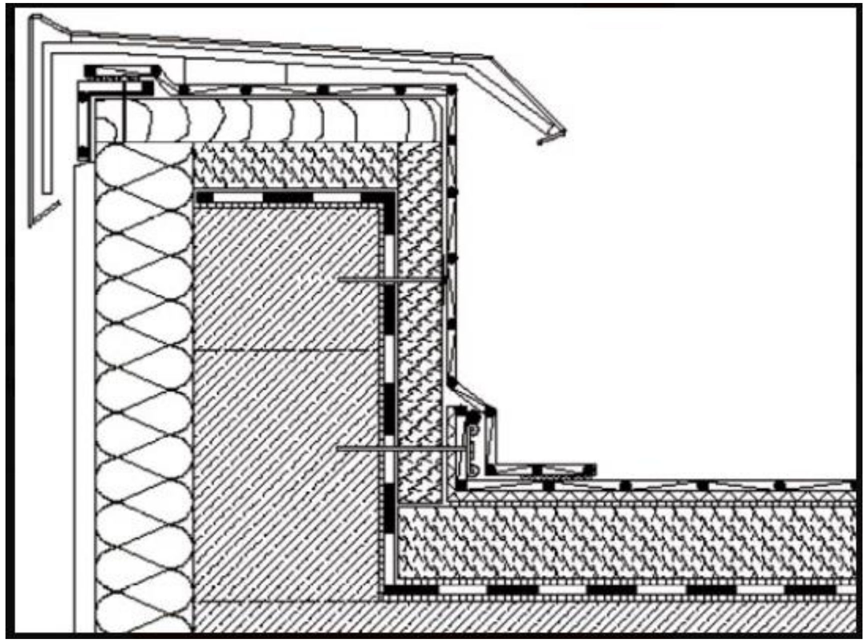
Building Envelope : Roof

- Layers of roof construction may be reduced. This will make the roof lighter, simple and cheaper
- Not sufficient thermal insulation in the corners may lead to Thermal heat bridges
- A metal cop to cover the Attica (surrounding parapet) may be useful to protect the roof and reduce maintenance as well.

Existing roof solution



Possible reduced solution



Building Envelope I Roof
Results

Current

0.56 W/m²K from the plans

0.41 was mentioned by KONN

Eliminate (gravel + screed)

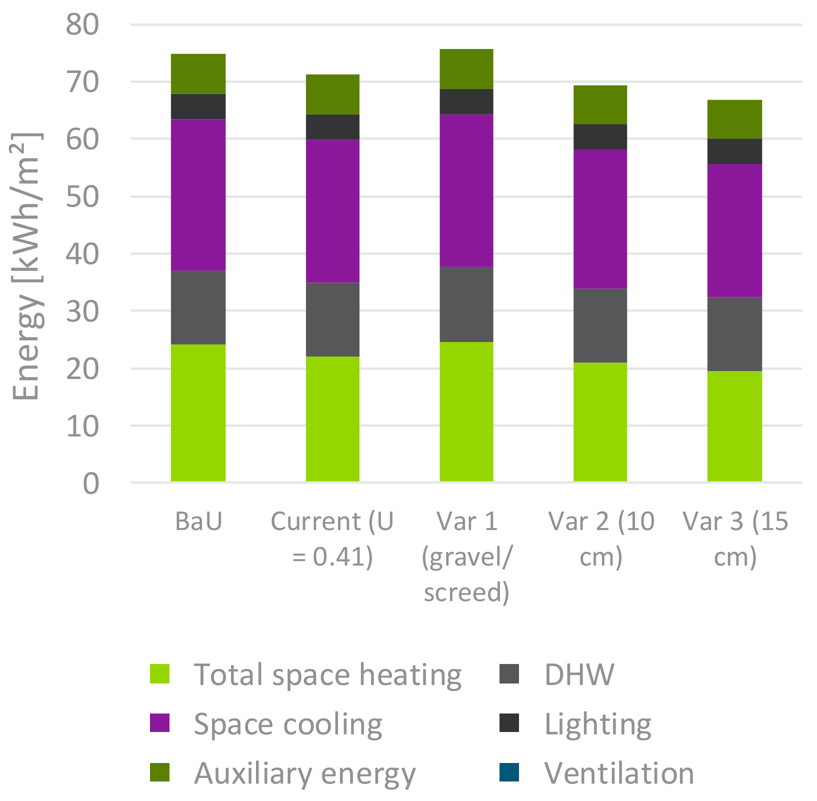
0.58 W/m²K

Increase roof insulation (without gravel + screed)

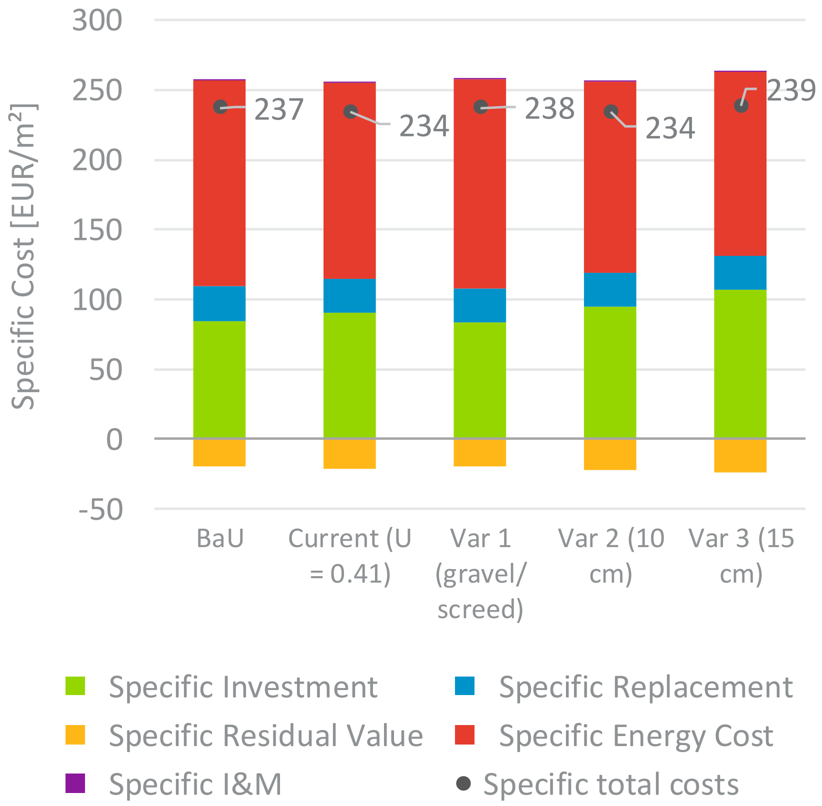
- 10 cm -> 0.34 W/m²K
- 15 cm -> 0.24 W/m²K

Var 2 (insulation thickness 10 cm) is the most cost effective measure

Final Energy Demand



Global Cost



Building Envelope I Windows

Results

Single glazing (baseline)

U value 5.7 W/m²K, G-Value 0,85

Double glazing

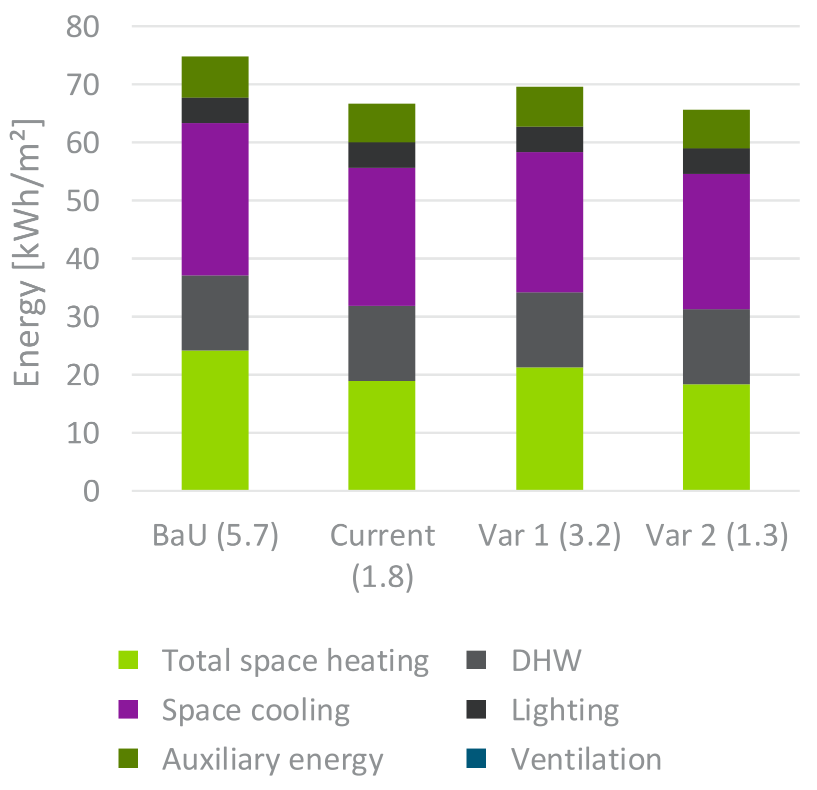
U value 3.2 W/m²K, G-Value 0,7

Double glazing – low E

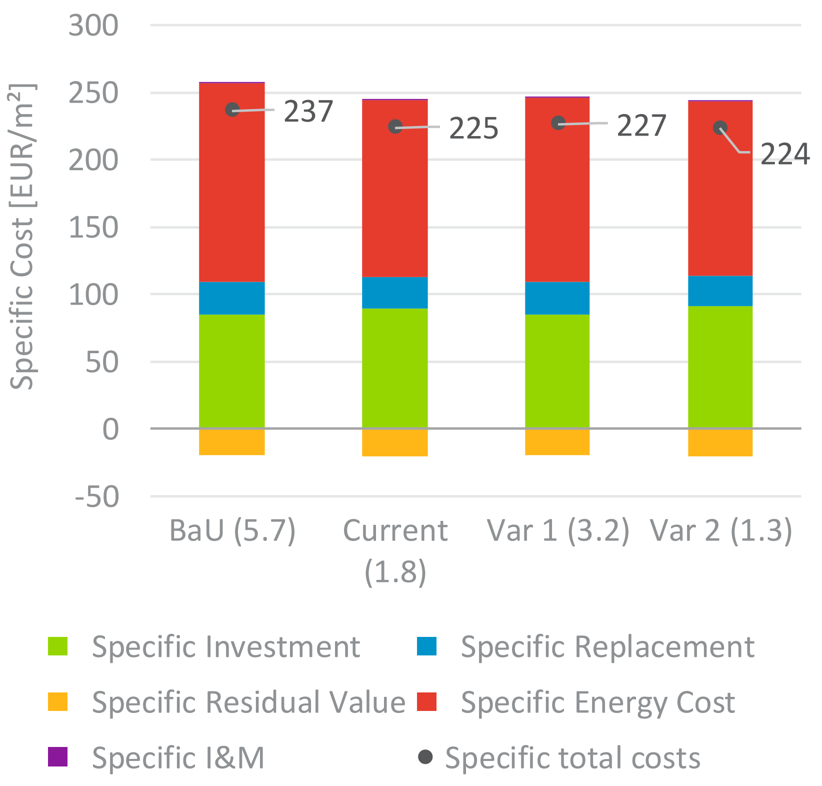
U value 1.3 W/m²K, G-Value 0,65

Var 2 (U-Value of 1.3 W/m²/K) is the most cost effective measure

Final Energy Demand



Global Cost



HVAC I Efficiencies

Analysis

Baseline / Current Situation

Reversible Unit Heating 2.5 COP I Cooling 2.5 COP

Var 1

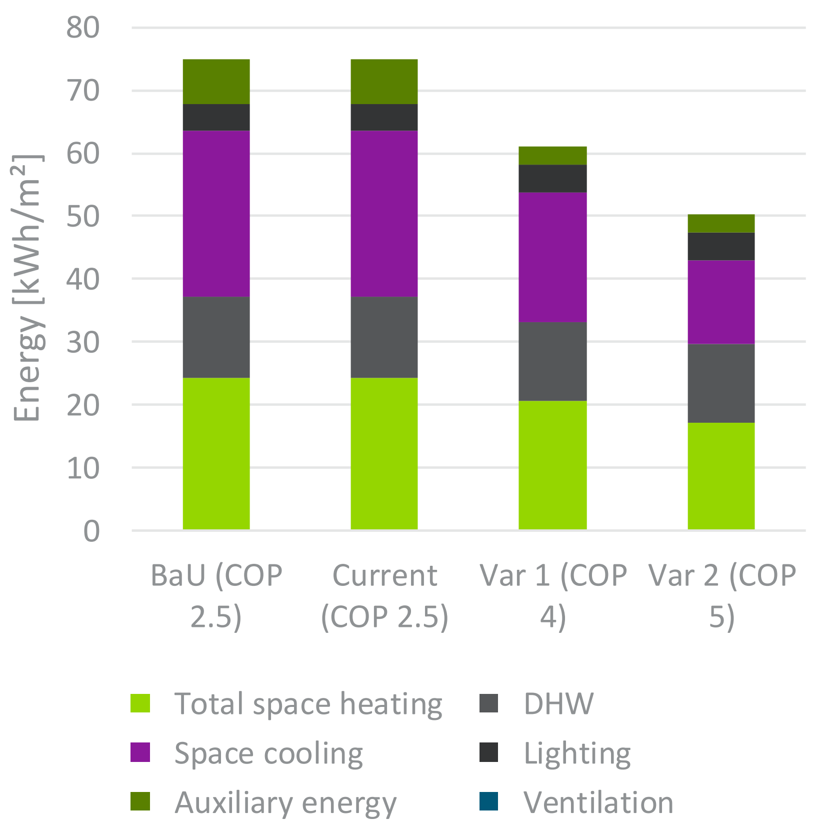
Reversible Unit Heating 4 COP I Cooling 4 COP

Var 2 (best available technology)

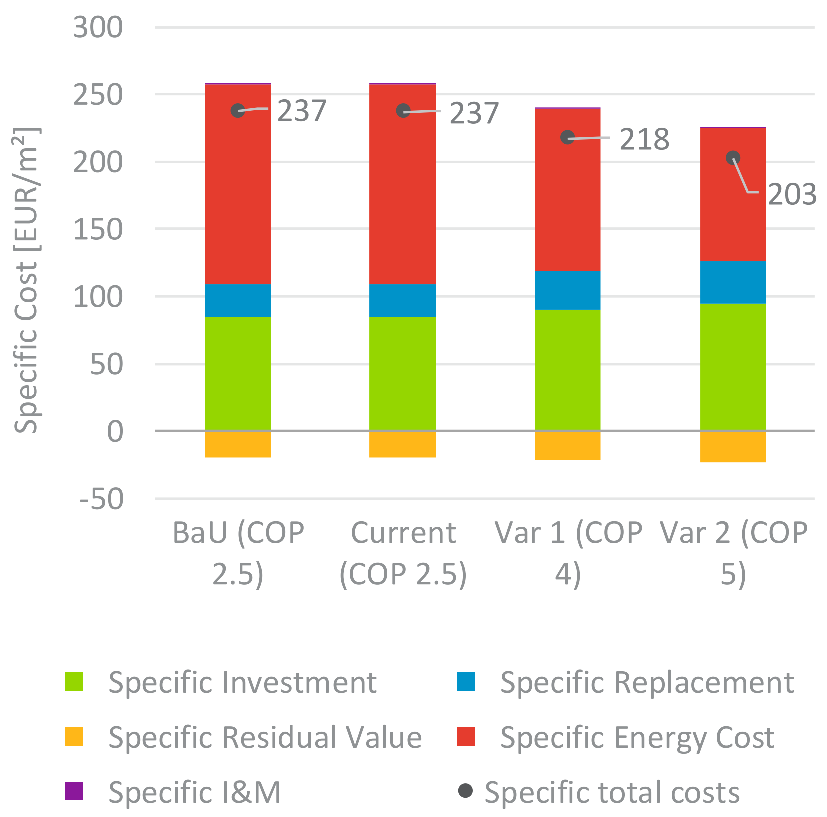
Reversible Unit Heating 5 COP I Cooling 5 COP

Var 2 (System with COP 5) is the most cost effective measure

Final Energy Demand



Global Cost



Renewables I Solar Thermal

Analysis

Baseline

no ST = electrical inst. heater

Current Situation

ST - 5m²

Var 1

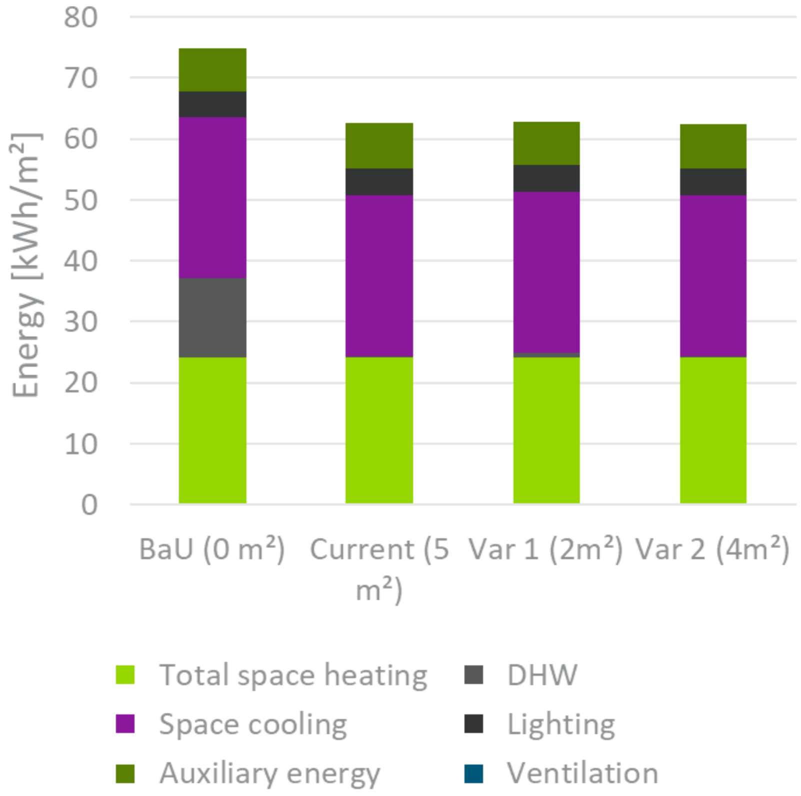
ST – 2 m²

Var 2

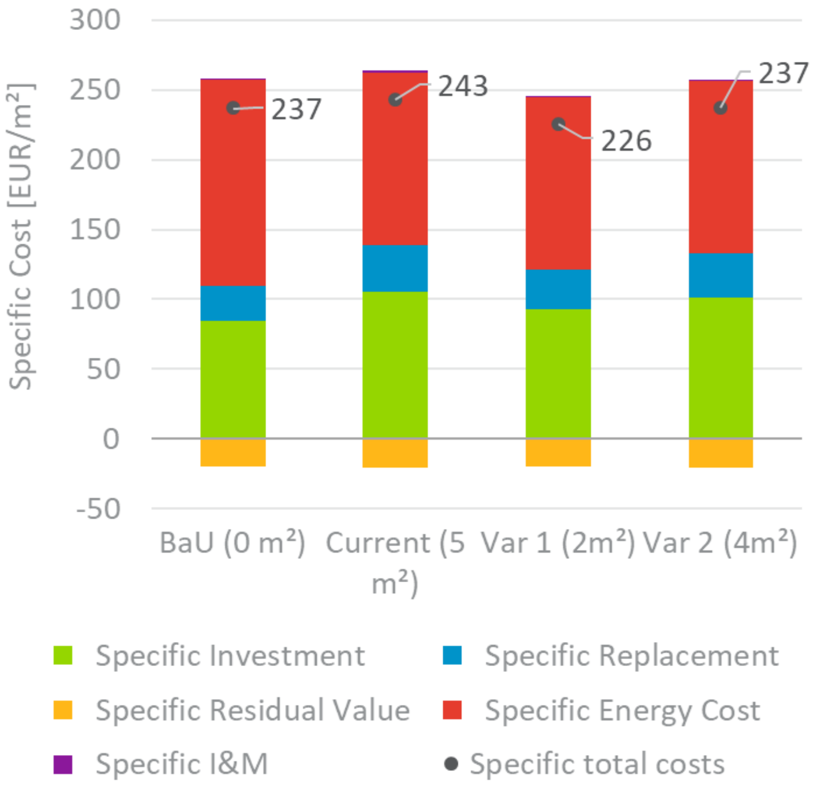
ST – 4m²

Var 1 (2 m² collector area) is the most cost effective measure

Final Energy Demand



Global Cost



Renewables I PV

Analysis

Sizing (net metering as assumption)

Baseline

no PV

Current Situation

PV - 3.8 kWp

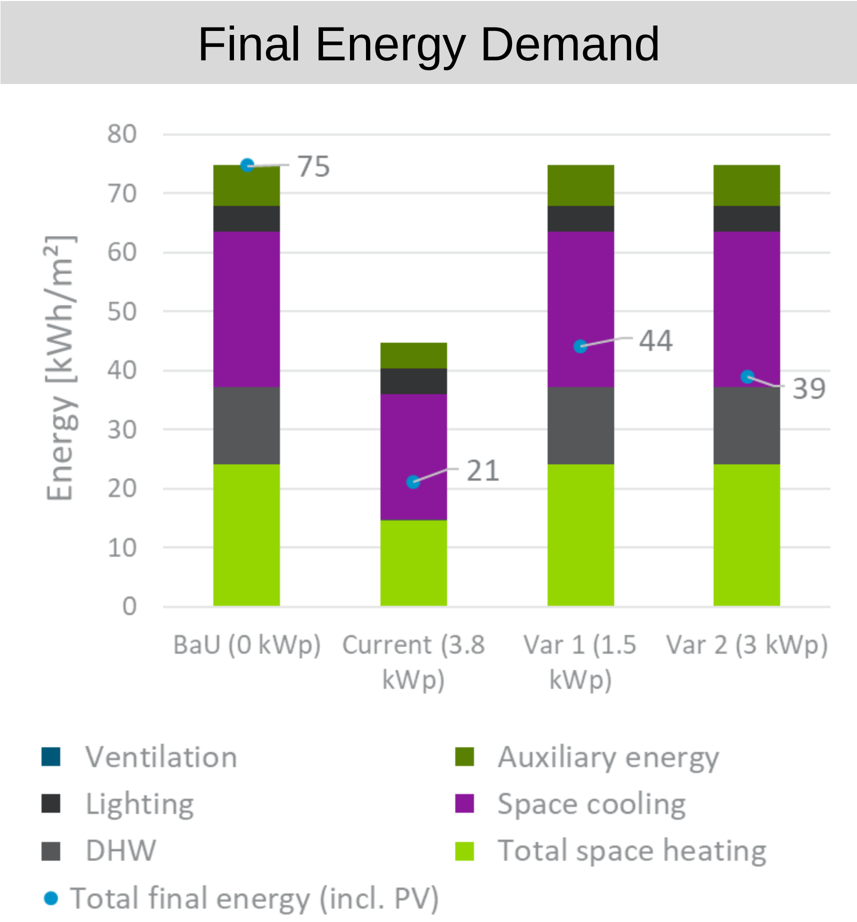
Var 1

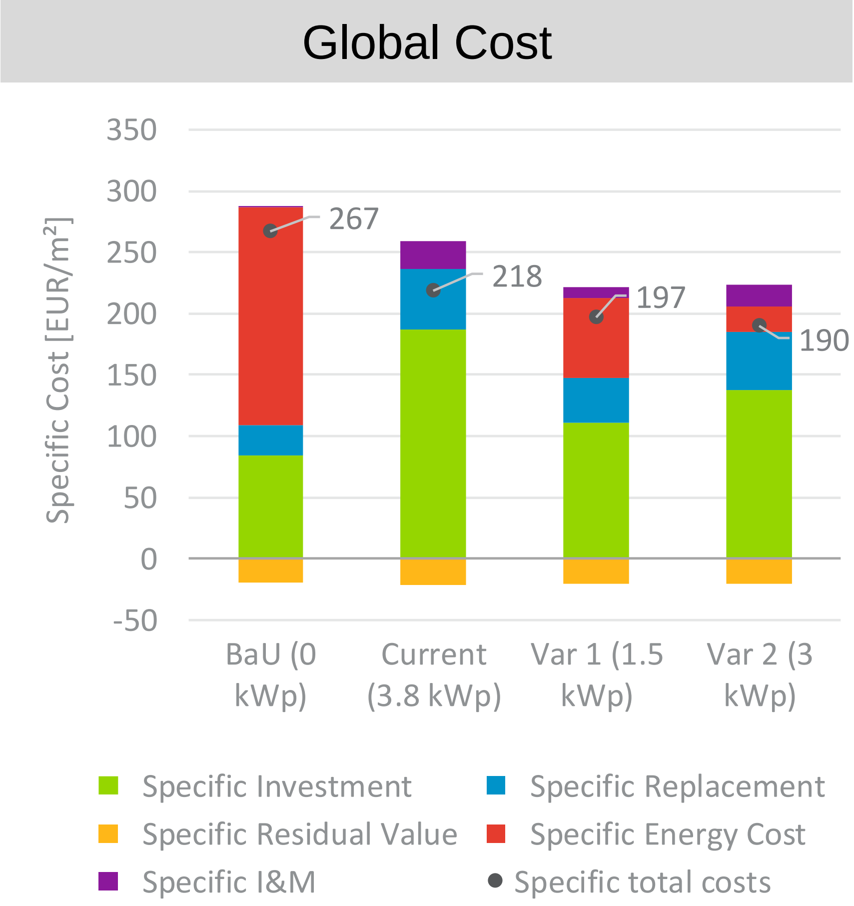
PV – 1.5 kWp

Var 2

PV – 4 kWp

Var 2 (3 kWp PV) is the most cost effective measure, based on the electricity consumption of the BaU!!!





Results &Conclusion

Overview of recommended measures

Four steps to reduce energy demand significantly

Building envelope

- External wall -> ETICS 8 cm
- Roof -> Insulation thickness 10 cm
- Windows -> double glazing (U-Value 1.3 W/m²K, G-Value 0.65)
- Shading -> simple overhangs for south orientation

HVAC

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

Renewable (Solar) Energy

- Solar thermal 2 m²
- PV 1 kWp (without battery since local price systematic reflects storage behavior)

Behavior

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

Optimized Solution (KONN)

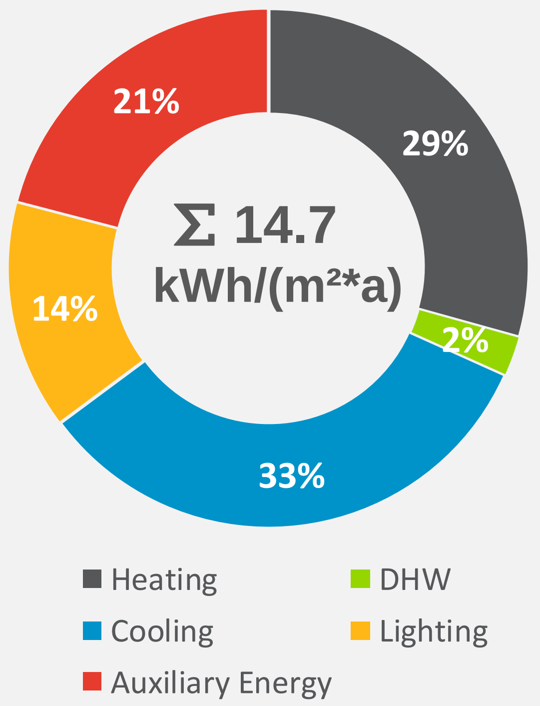
Results

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)	0.34 W/m²K
Wall insulation (U-Value)	0.40 W/m²K
Floor insulation (U-Value)	3.6 W/m²K
Windows (U-Value; G-Value)	1.3 W/m²K; 0.65
Window fraction	Ø 5%
Shading	Overhang South
Air tightness	0.25 1/h
Heat supply	reversible split unit - COP 5
Cold supply	reversible split unit - COP 5
Hot water	electric instantaneous | Solar
Ventilation systems	Natural ventilation
Lighting systems	LED
Renewable energy	1 kWp (PV) | 2m² (Solar Thermal)
Set temperature cooling/heating	26°C / 20°C



Energy Cost
0.65 EUR / (m²*a)

CO_2 - Emission
0.5 kg / (m²*a)

Comparative overview

Baseline vs. Current vs. Optimized

Conclusion

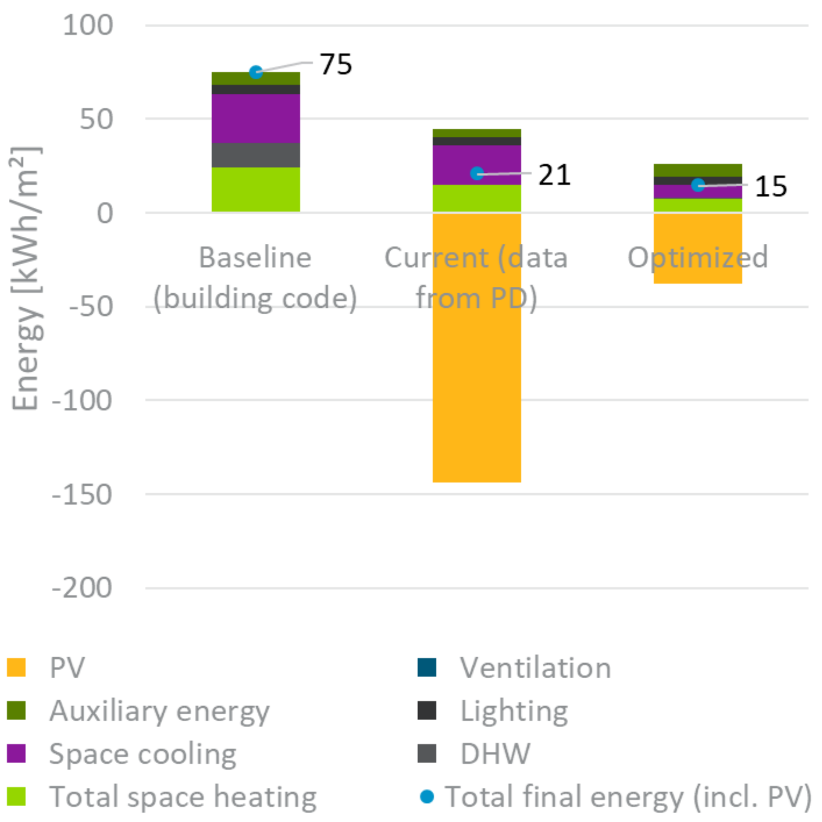
- The suggested measures and the current situation lead to a **significant decrease in energy demand**
- The optimized solution, detected **the most cost effective efficiency measures**

Savings

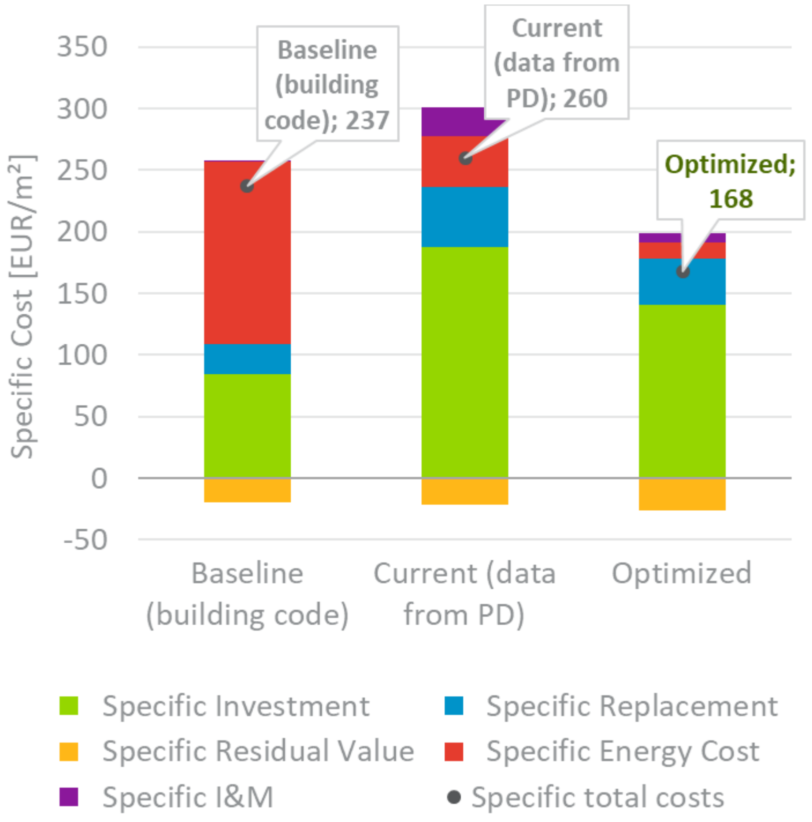
Energy: 141 / 14 kWh/a

Cost: 162 / 216 EUR/a

Final Energy Demand



Global Cost



Key conclusion

Main take aways for the KONN Project

Improve further the building envelope

- Increase the insulation thickness of roof and external wall -> energy savings up to xx % are possible
- Simplify the structure of layers in roof and external wall -> reduction of investment costs
- Utilize low-E Windows with a U-Value better or equal than 1.3 W/m²K -> energy savings up to xx % are possible

Use Top performer - HVAC

- Use Top performer in the market as the price increase compared to inefficient, cheaper appliances will be recompensated throughout ist lifetime

Size renewable (Solar) to demand

- Both the solar thermal and PV systems seemed to be oversized and not matching the demand,, so that oversupply of generated energy was not able to be harvested

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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