ENERGY EFFICIENCY FIRST #EE1ST SUMMIT
Brussels, 31 May – 1 June 2022

Energy Efficiency In Buildings In sEEnergies

Refurbishment measures and their costs and impact on future energy demand in buildings

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1

Introduction

The current world is in turmoil and certainties which have been considered as stable in the past are turned upside down as of today.

The reality with millions of people in Europe forced to leave their homes and find shelter abroad, uncertain about the well being of their relatives was unforeseeable for most of us.

Besides the tremendous impact on personal fates, the war on power and energy will change most of our believes for the coming years as well as it will have a huge impact on European energy policies and efficiency strategies!

In the coming presentation, I will try to briefly assess and contextualize the findings of our results mostly generated in the late months of 2020 and in the first half of 2021 in respect to impacts of the current global situation. The project sEEnergies, and especially the work package 1, analyzing the cost and potentials of energy efficiency and their related impacts was set up in a time where current events were out of thought and the work and results need to be reflected under two major impacts in the recent past.

Starting in autumn 2019, the project team and the project setup could not foresee neither the Covid crises, starting in 2020, nor the current war on European ground. However, these two events do impact the understanding and lessons we have to learn from the project in important aspects.

2

Objective of sEEnergies and WP1

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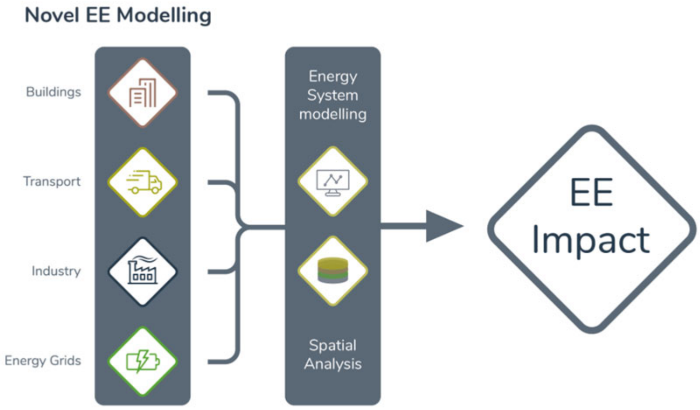
Quantification and operationalization of the potentials for energy efficiency in buildings, transport, and industry.



The project combines sectorial bottom-up knowledge with hour-by-hour modeling of the energy systems and spatial analysis in the EU.

The project includes analysis of non-energy benefits of the energy efficiency first principle in the different demand sectors

3

Objectives

Work package 1, sEEnergies project

sEEnergies

To assess the energy efficiency potentials and their related costs in both residential and non-residential buildings:

- Collecting and developing data from the EU28 countries on energy efficiency potentials in the building sector, which are required for an overall assessment of the efficiency potentials in integrated energy systems.
- To shed light on the cost aspects of different refurbishment measures and their contribution to reduce energy demand. The cost and efficiency assessment is a base for the comparison with the costs of using renewable energies for building related energy services.

Recent impacts

- With the Covid pandemic fading in the last months of 2021 and in the beginning of 2022, we saw relevant increases in material prices for construction and a partial interruption of supply chains. The shift in construction pricing is likely to influence in the short to mid-term the development of the refurbishment sector.
- Energy carrier prices soaring in the last months of 2021 and in the beginning of 2022 could shift the equilibrium towards energy efficiency
  - Policy interventions to be addressed which are currently under discussion

4

Objectives

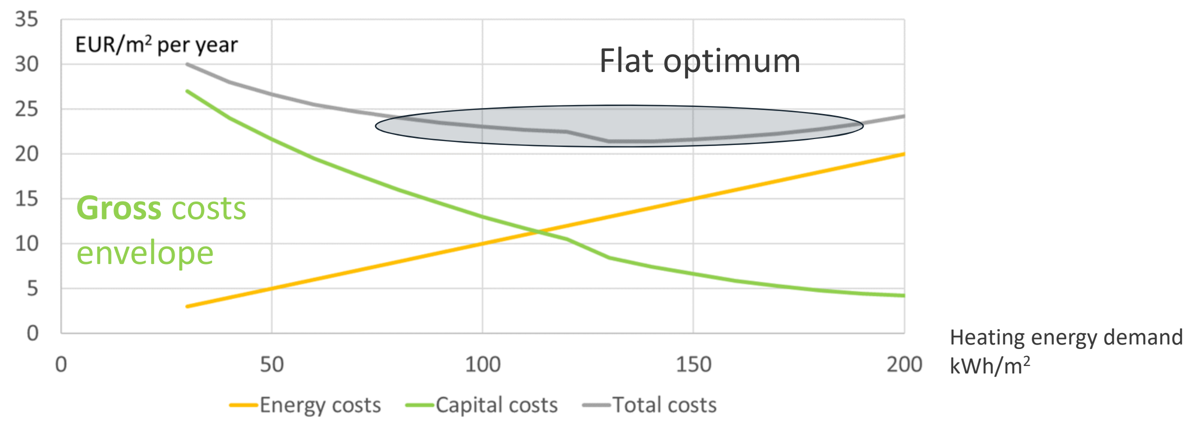
Work package 1, sEEnergies project

For residential and non-residential buildings:
assess energy efficiency potentials and related costs

- Collecting and developing data for the EU28 countries
- Cost of different refurbishment measures and their energy-efficiency contribution
- Provide input to overall assessment of the efficiency potentials in integrated energy systems.
- Cost of efficiency to be compared with costs of using renewable energies (individually or through grids)

Objectives: where is the energy efficiency first optimum?

Work package 1, sEEnergies project



Objectives: where is the energy efficiency first optimum?

Work package 1, sEEnergies project

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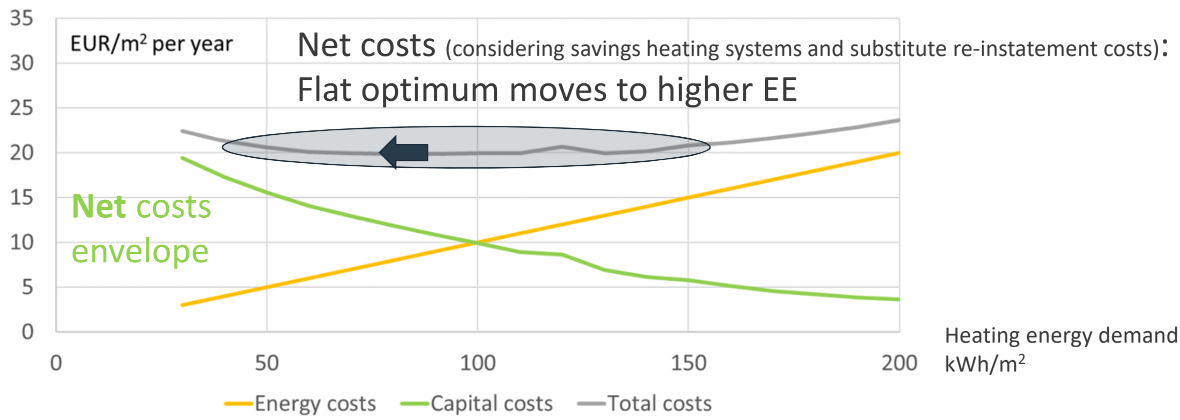

Energy carrier prices

Source trading economics

sEEnergies

Crude oil (brent)

Additional relevance for construction material as input for insulation material such as expanded polystyrene (EPS)

Objectives: where is the energy efficiency first optimum?

Work package 1, sEEnergies project

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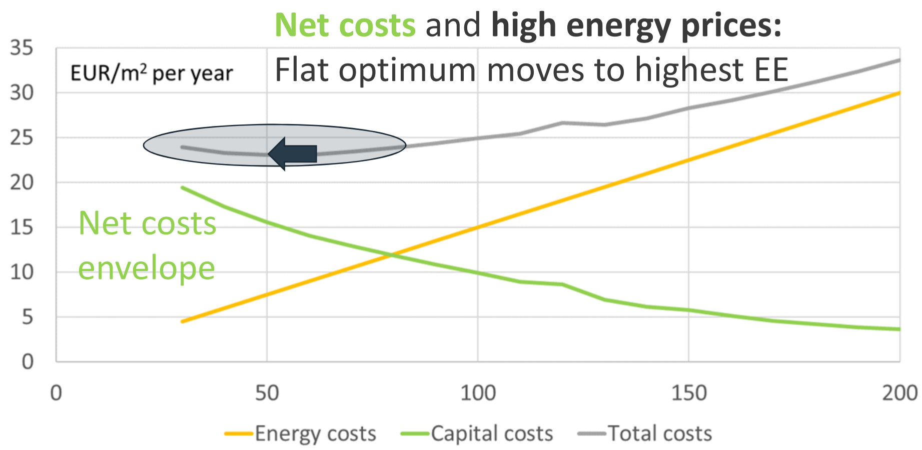

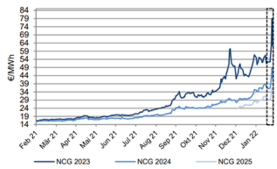

Price trends

Price indices for construction sector

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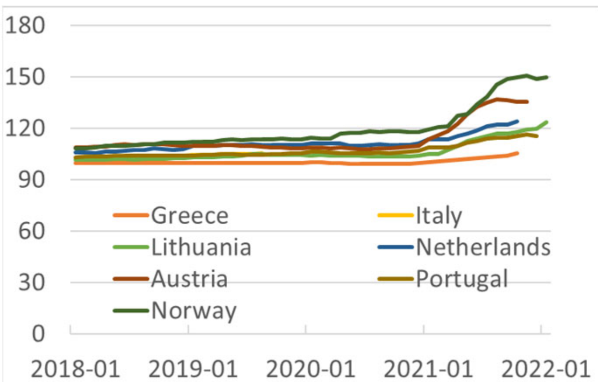
German construction material price index in the last year + 39% for expanded polystyrene insulation material. For other materials similar price trends.

Eurostat monthly index for input prices for materials (national currency, 2015 = 100)



Objectives: where is the energy efficiency first optimum?

Work package 1, sEEnergies project

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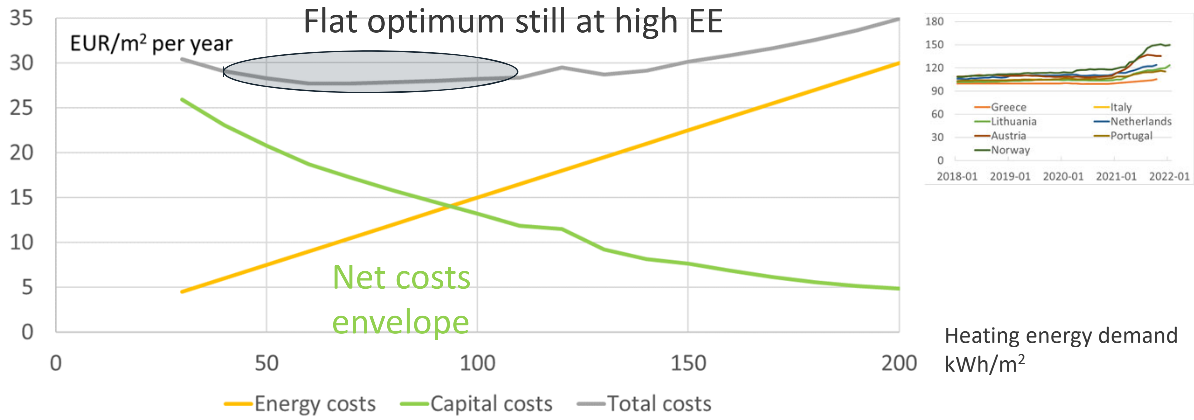
Net costs, high energy prices and high construction costs:
Flat optimum still at high EE



Energy carrier prices

Source EEX, Swiss market

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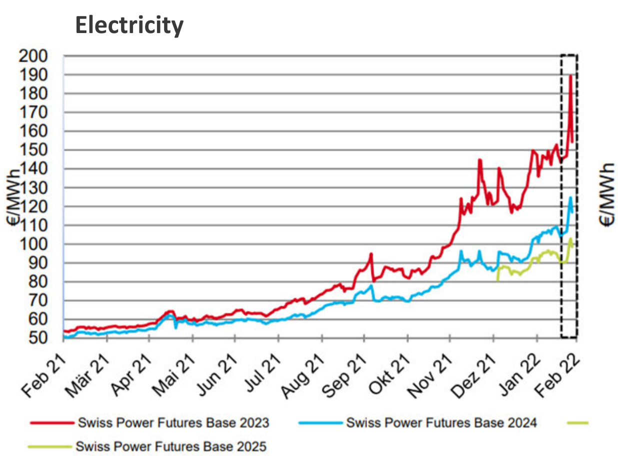
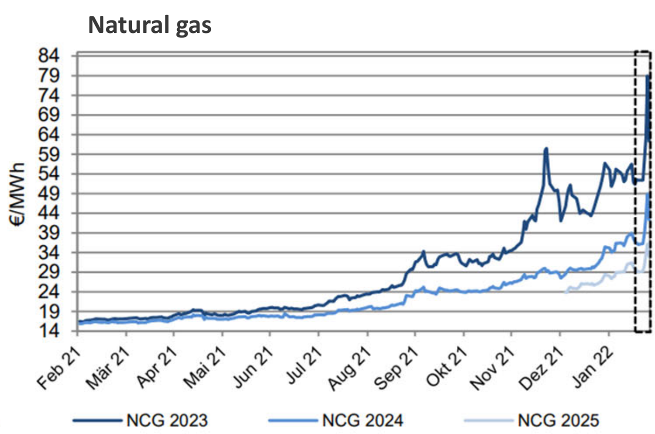
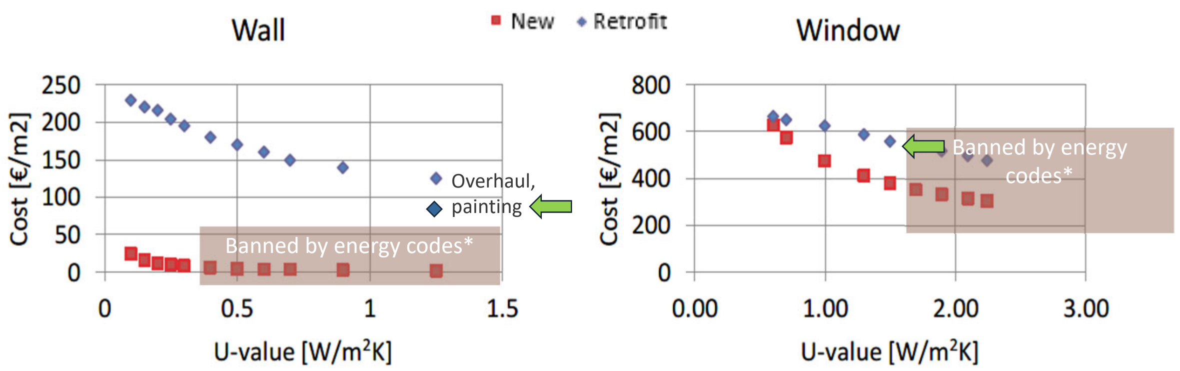




Cost aspects of refurbishment measures

Building element level

sEEnergies



* Depending on the country

Add-on costs attributed to energy-efficiency depending on:

- the case (new build, retrofit)
- the building's needs for repair and overhaul
- energy code requirements
- product availability

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13

Cost aspects of refurbishment measures

Building element level

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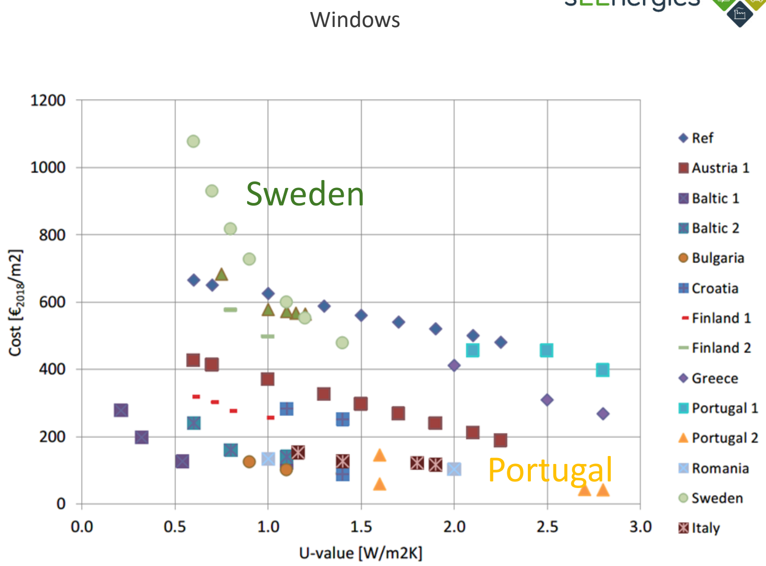
Add-on costs attributed to energy-efficiency depending on:

- Energy code requirements
- Product availability

=> Large difference across countries



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14

Cost aspects of refurbishment measures

Single building level

sEEnergies

Investment in the building envelope

- Per building type
  - Single and multi family houses
- Building age depending
  - 5 different age classes
- Measures for 4 different building elements in building packages (1 to 16, mutually exclusive)
  - Wall
  - Window
  - Roof
  - Basement
- Per EU country (EU28)

Investment in the heating system

- Savings on the heating system investment
- Energy savings
  - Depending on energy carrier price

ID	Package
1	Façade painting
2	Only windows (low)
3	Window and wall (low)
4	Windows and walls and roof (middle)
5	Windows and walls and roof and floor (high)
6	Building on package 5, windows and walls and roof and floor (higher)
7	Building on package 5, windows and walls and roof and floor (highest)
8	Building on package 5, windows and walls and roof and floor ("passivhouse")
9	Windows (high) and roof (higher)
10	Only walls (low)
11	Windows(higher)
12	Windows and wall (higher)
13	Windows (middle) and roof (middle) and floor (high)
14	Windows and roof and floor (higher)
15	Roof (middle) and floor (high)
16	Roof and floor (highest)

EBF = energy reference area

Cost aspects of refurbishment measures

Single building level

sEEnergies

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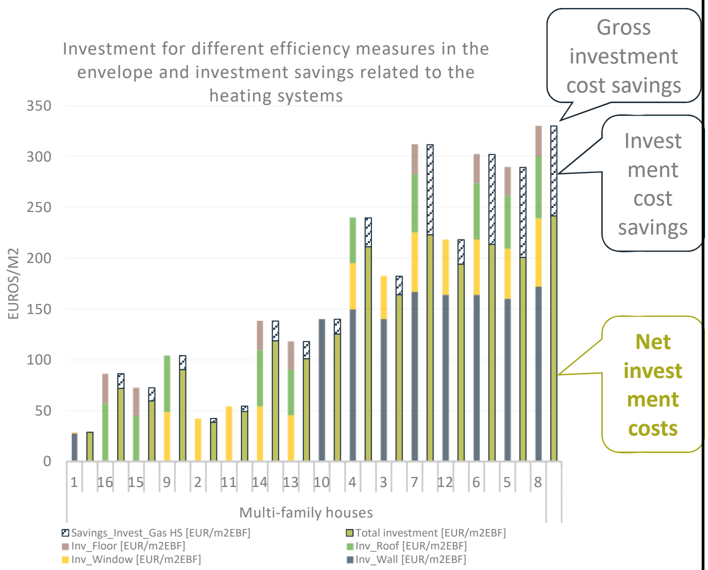
- Measures for 4 different building elements in building packages (1 to 16, mutually exclusive)
  - Wall
  - Window
  - Roof
  - Basement
- Per EU country (EU28)

Investment in the heating system

- Savings on the heating system investment (lower heat power demand)
- Energy savings
  - Depending on energy carrier price



EBF = energy reference area

Cost-effectiveness of refurbishment measures

On the building stock

sEEnergies

Cost-effectiveness depends on:

- Energy carrier price
- Marginal heat generation cost
- Discount rate (mortgage rate)
- Assumed lifetime

=> Net present value (NPV) of measures can be positive or negative for identical buildings

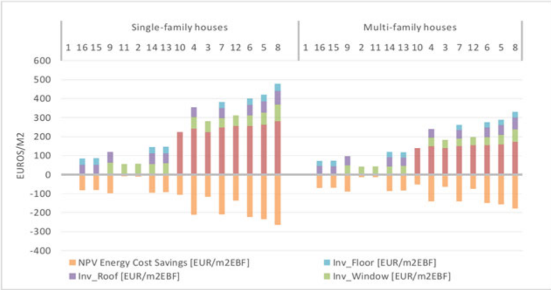
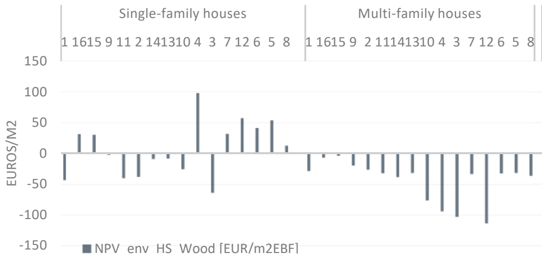


Figure 4. Investment and savings for different refurbishment measures in the envelope for the country of Austria



Aggregated cost curves

On the building stock

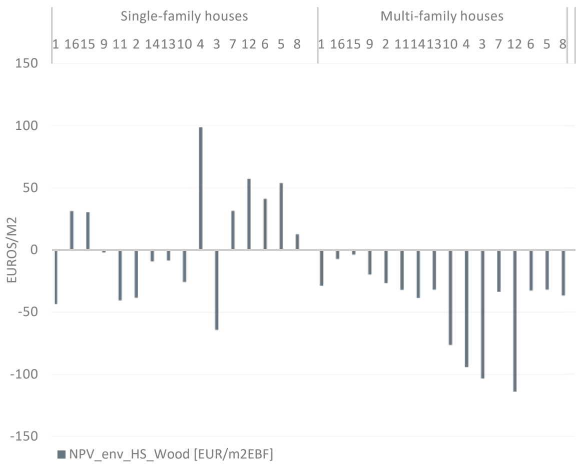
sEEnergies

Connection to WP6

- Depending on energy carrier price and marginal heat generation cost, the NPV of the measures can be positive or negative for identical buildings
- **In WP1 we provide cost curves for building envelope measures only**

Investment in the building envelope

- Based on approach for single building
- Aggregation on building stock level
- Providing additional savings to a baseline



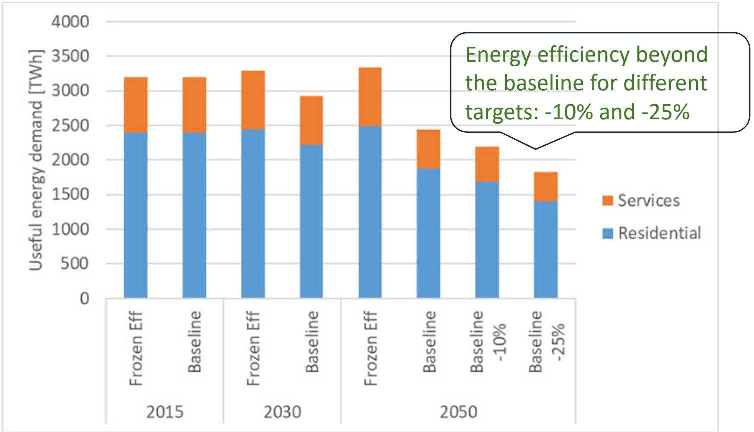
Energy efficiency potentials in the built environment

sEEnergies

Starting from frozen efficiency (FE) demand (i.e., buildings not undergoing energy refurbishment until 2050; incl. new buildings)

Baseline scenario includes moderate energy refurbishment of the building stock

- Per building type and building age class
- Does not include ambitious energy efficiency improvements (e.g., further changes in building codes)
- Does not include the targets of the renovation wave



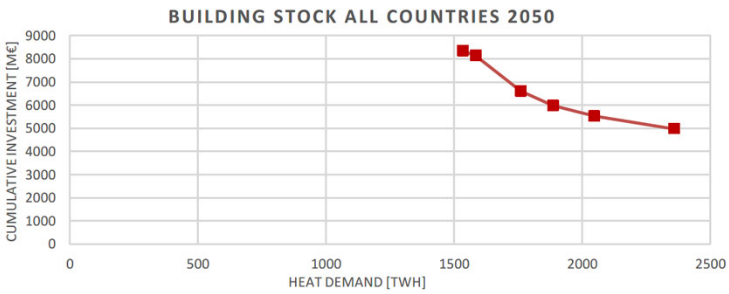
Energy efficiency potentials in the built environment

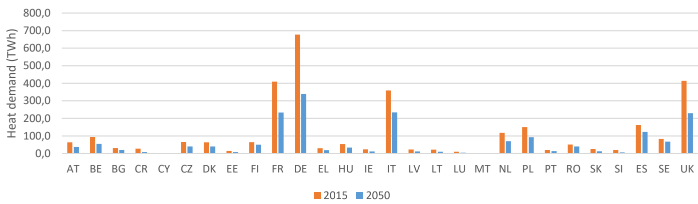
sEEnergies

Additional savings are substantial, but nevertheless limited

- Up to 2050 less than 30 years left
- Due to lifecycles and various barriers (technical, social, awareness, financial) retrofit rate may be increased to a limited extent only, despite the targets of the renovation wave

=> **Also in 2050 there is still heat to be deployed**





Energy efficiency potentials in the built environment

Result work package 6

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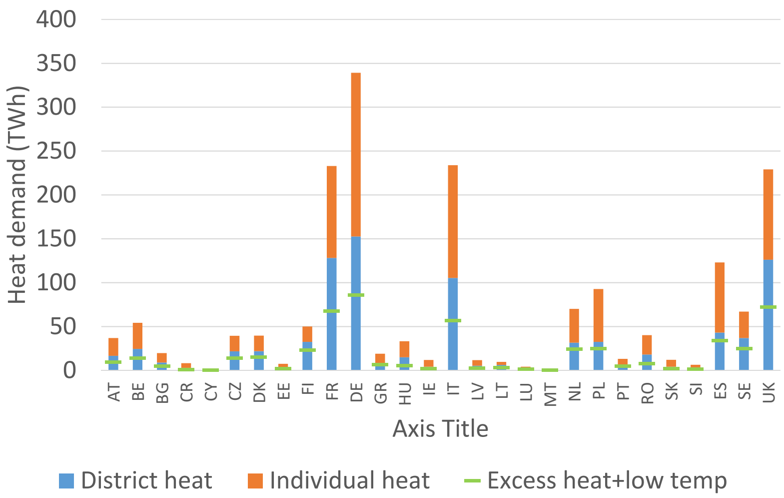
Heat supply from individual and district heating

- Cost effective to develop a 50% share of district heat in 2050
- Around 60% of district heat can be supplied with excess heat from other processes (e.g. industry) and low temperature heat (e.g. sewage)
- Individual heat is supplied mostly with heat pumps



Aggregated cost curves

On the building stock

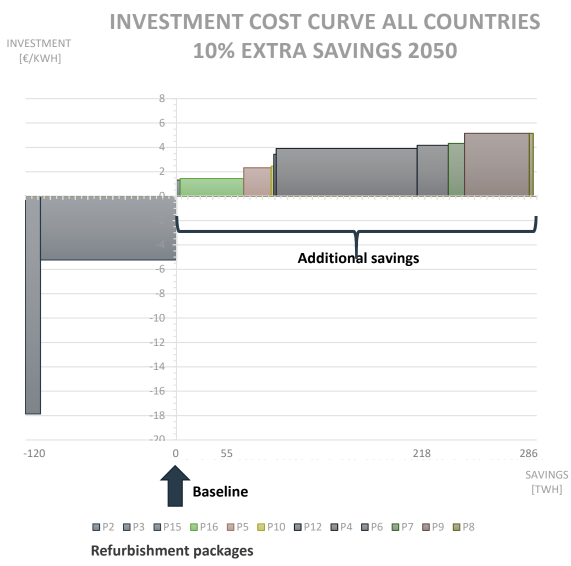
sEEnergies

Connection to other WPs

- We provide aggregated cost curves for building envelope measures per country for additional savings beyond the baseline
- We provide energy reference area and average useful energy demand per m² and building type

Investment in the building envelope

- Based on approach for single building
- Aggregation on building stock level and country
- Providing additional savings to a baseline
  - Negative savings for packages in the baseline which currently (in the baseline) are not considered
  - Positive savings for additional measures and additional costs
- Cost structure depending on the set of measures and starting point of building stock



Aggregated cost curves

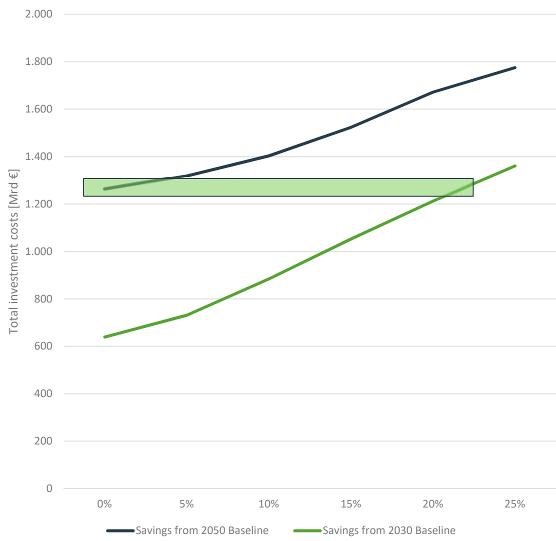
On the building stock

sEEnergies

Investment in the building envelope

- To achieve 25% additional useful energy savings, additional investments at the level of +40% are needed in 2050
    - More buildings are undergoing refurbishment, therefore more cost effective measures applicable
- To reach the 20% additional savings in 2030 doubles the overall investment costs, but respective investments are also needed in the baseline until 2050 to reach similar demand reductions (green bar)

-> One can either refurbish buildings to higher standards or refurbish more buildings to achieve similar levels of energy demand



Non-energy co-benefits

Assessment

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Literature review non-energy benefits (and barriers)

- Economic impacts
    - Disposable income and alleviation of energy poverty
    - Job creation
    - GDP
    - Asset value and increased rental prices
- Social and health impacts
    - Thermal comfort
    - Reduced air and noise pollution
    - Social displacement
- Rebound effects
    - Higher energy demand
    - Increased demand for energy intensive goods
    - Increased demand for additional surface
- Landlord-tenant split incentive
    - Who is paying for the investment (regulations)

- Quantification of non-energy benefits in buildings
    - Willingness to pay
    - Direct quantification

Main non-energy Benefit	Showcase	Reference
Increased disposable income and alleviation of energy poverty	The relative change of disposable income due to energy efficiency measures in residential buildings is by far the highest in low-income households, where they can increase by up to 50%, compared to high-income households where it might even decrease.	(Figus et al., 2017)
Job creation	RE and EE are more labour intensive in terms of electricity generated or saved than traditional fossil-fuel generation. Therefore, building refurbishment can lead to a net job creation.	(Blyth et al., 2014; Iten, Jakob, et al., 2017)
Higher property and rental prices	In a case study in Italy, they found that when a building gets the best energy performance label, its value can increase by approximately 27%.	(Morano et al., 2020)
Increased energy security	Energy prices are dependent on fossil fuel prices. Given that these are very variable, especially of crude oil, reducing their usage stabilizes energy prices and the dependence on other countries' economies.	(Gamtessa & Olani, 2018)
GDP	Energy efficiency can increase the GDP and economic activity up to a point that household incomes profit more from this GDP growth than from the efficiency improvement itself.	(Figus et al., 2017)
Increase in public budgets	Public budgets can be significantly increased through higher tax income or through energy savings due to energy efficiency measures in public buildings.	(Annunziata et al., 2014; Kuckshinrichs et al., 2010)
Thermal comfort and its impacts on health and safety	The health of residents mainly benefits from energy efficiency due to a reduction of cold-related illnesses and associated stress. Especially low-income households and children are positively affected.	(Maidment et al., 2014)
Reduced indoor and outdoor air pollution	Inadequate ventilation and fossil heating systems are primary causes of indoor air pollution. The positive impact of upgrading ventilation systems heavily depends on the outdoor air quality, which can be enhanced by reducing the burning of volatile content solid fuels.	(Spiru & Simona, 2017)
Reduced noise pollution	The ability of insulation materials to absorb outdoor noise correlates with their capacity to reduce thermal transmission.	(Pisello et al., 2016)
Improved productivity and reduced health impact	Reducing overheating in buildings can enhance employees' performance by up to 3.5%. However, avoiding too cold temperatures increases productivity through reduced illness and stress. Additionally, improved ventilation rates are favourable for reducing illness, improving concentration levels and others.	(Kockat et al., 2018; Maidment et al., 2014)

Non-energy co-benefits

Quantification

Quantification of non-energy benefits

- Based on Reuters et al.
- Adjusted for building specific parameters such as useful energy demand or energy reference area

- Quantification of non-energy benefits in buildings
  - In connection with energy system models

  -> from useful energy demand to final energy demand, incl. fuel prices per energy carrier

  -> sector overarching parameters (e.g., emission factors)

Indicator	Calculation Approach
Final energy savings	$EES_{j,BT} = \sum^{j} EES_{useful,H,BT} * \eta_{H,BT}$ EES_{useful} = Energy efficiency savings of useful energy demand per building heat supply system (HS) and building type (BT) η_H = conversion efficiency of heating system typlology
Impact of EE on RES target achievement in the building sector	$\Delta RES_{target} = actual\ RES\ share - \frac{FEC_{RES\,final,BT}}{FEC_{total,wo,BT}}$ $FEC_{total,wo,BT}$ = Final energy consumption without savings (total, wo, BT) based on "frozen efficiency"
Avoided CO_2 emissions from energy savings per building type	$EM_{BT} = EES_{fossil,j,BT} * emf_j$ EM_{BT} = CO_2-emissions per building type (BT) emf_j = average emission factor for energy carrier j
(Local) air pollution per m² ERA and year per building type	$E_n = \frac{\sum_j EES_j * emf_{j,n}}{ERA_{BT}}$ E_k= Emissions of pollutant n per building type ERA_{BT} = Energy reference area per building type
Turnover of energy efficiency goods in the building sector for building envelope measures	$TO_{BT} = EES_{BT} * SSH * f_{in} * IN_{env,BT}$ EES = Energy savings per building type SSH = share of space heating in national energy consumption f = share of savings due to insulation & efficient heating systems IN = investments in refurbishment measures of the building envelope per building type
Impact of sector specific GVA on GDP	$\frac{GVA\ (TO)_{Sec} + taxes_{Sec} - subsidies_{Sec}}{GDP_{tot}}$ $GVA(TO)_{Sec}$ = Sector specific gross value added related to building refurbishment measures and turnover
Impact on public budgets due to reduced demand in public buildings	$FES_{EE} = ERA_{Pb} * f_{in} * SUED_{PB} * \eta_{HS,BT,j}$ FES = Final energy savings in public buildings f = share of savings due to insulation & efficient heating systems SUED = Specific useful energy demand per building typology of public buildings
Asset value of buildings aggregated on country level	$\Delta AV = \frac{\sum_j^n FES_j * p_j}{cr}$ P_j = price for each energy carrier j cr = capitalisation rate n = number of buildings/dwellings
Health benefits (avoided premature deaths)	$AD_{n,BT} = \Delta EM_{n,BT,HS} * cf * m_i$ AD_n = avoided premature deaths related to pollutant n $EM_{n,BT,HS}$ = reduced emissions of the pollutant in relation to ERA and HS per building type (BT) cf = concentration factor m_i = mortality rate of the pollutant

Non-energy co-benefits

Quantification

sEEnergies

Impact on economic turnover

- Addressing different sectors (e.g. installation, production of materials and transport)
- **Additional** investments on top of baseline for building envelope measures (in Mrd €)
- In average 58% to 61% labour cost, 42% to 39% material cost

Other co-benefits could be in the same order of magnitude than energy cost savings

To be quantified in further research

Member State	Additional savings from 2030 Baseline					Additional savings from 2050 Baseline				
	5%	10%	15%	20%	25%	5%	10%	15%	20%	25%
AT	2	6	13	15	17	1	2	6	11	13
BE	2	4	8	13	16	1	2	3	6	8
BG	1	1	2	2	3	1	2	3	4	5
CR	0	0	1	1	1	0	0	1	1	1
CY	0	0	0	0	1	0	0	0	0	0
CZ	1	2	3	4	5	1	3	4	5	6
DK	2	6	13	15	17	1	3	5	11	12
EE	0	0	1	1	1	0	0	1	1	0
FI	3	8	12	17	19	1	4	7	14	15
FR	10	22	35	52	85	5	11	17	29	39
DE	17	46	85	126	159	7	19	32	56	85
EL	0	1	2	4	4	0	1	1	2	4
HU	1	3	3	4	5	1	2	4	5	4
IE	1	4	7	10	11	1	1	2	4	7
IT	11	35	58	71	82	9	32	49	68	82
LV	0	0	1	1	1	0	1	1	1	1
LT	0	1	2	2	3	1	2	2	3	2
LU	0	0	1	1	1	0	0	0	0	1
MT	0	0	0	0	0	0	0	0	0	0
NL	3	10	12	20	30	2	4	6	12	16
PL	3	8	10	13	16	3	6	12	15	14
PT	1	1	3	4	5	1	1	2	3	5
RO	1	2	3	3	4	2	3	5	6	5
SK	1	2	3	4	5	1	2	3	4	5
SI	0	0	1	1	1	0	0	1	1	1
ES	8	21	36	43	54	5	15	38	45	51
SE	6	17	27	41	49	3	8	17	31	41
UK	17	45	74	106	123	7	16	37	70	91
Total	**92**	**245**	**413**	**573**	**721**	**55**	**140**	**260**	**409**	**512**

Closing remarks

Linking WP1 to other work packages

sEEnergies

WP1: Energy efficiency potentials

- Data exchange with WP6 AAU

WP5: Mapping of EE potentials

- Mapping of potentials and costs at a 1-hectare level
- Aggregation of cumulative efficiency and district heat potentials by country

Your contacts

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Closing remarks

This project has received funding from the European Union's Horizon 2020 Research and Innovation Action under Grant Agreement No 846463

27

Considered building envelope refurbishment packages

Low - middle – high - highest refers to the energy-efficiency ambition levels

sEEnergies

ID	Package
1	Façade painting
2	Only windows (low)
3	Window and wall (low)
4	Windows and walls and roof (middle)
5	Windows and walls and roof and floor (high)
6	Building on package 5, windows and walls and roof and floor (higher)
7	Building on package 5, windows and walls and roof and floor (highest)
8	Building on package 5, windows and walls and roof and floor ("passivhouse")
9	Windows (high) and roof (higher)
10	Only walls (low)
11	Windows(higher)
12	Windows and wall (higher)
13	Windows (middle) and roof (middle) and floor (high)
14	Windows and roof and floor (higher)
15	Roof (middle) and floor (high)
16	Roof and floor (highest)

28