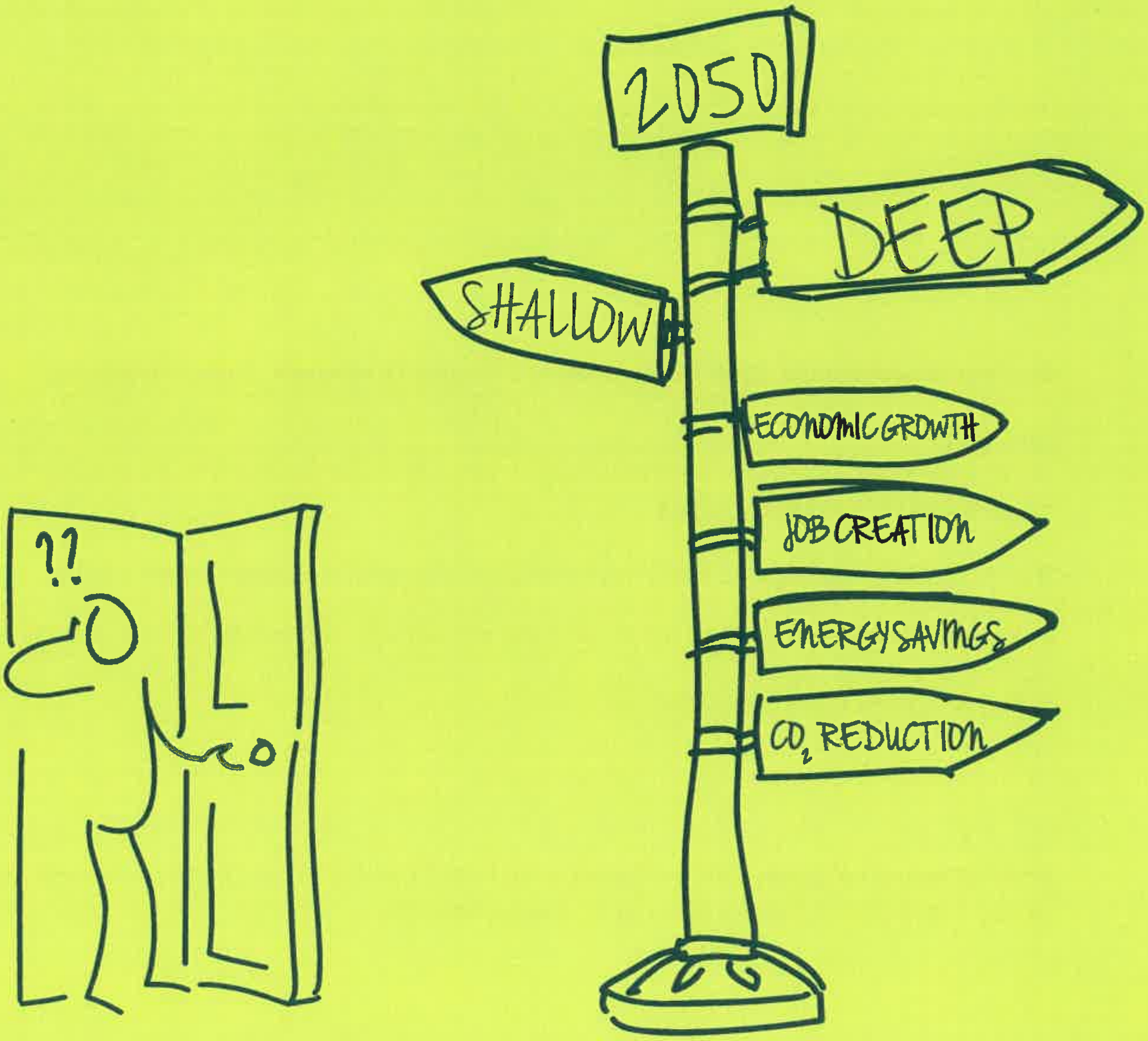
RENOVATION TRACKS FOR EUROPE UP TO 2050

Building renovation in Europe - what are the choices?



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All views expressed in this report are those of the authors and not necessarily those of Eurima.

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1 Executive Summary

Overview

The present study analyses and compares the possible tracks for the renovation of the EU building stock, quantifying and illustrating graphically energy savings and avoided CO_2 emissions, financial impacts and employment effects. Its findings are straightforward:

- A so-called shallow renovation track will completely miss both environmental targets (CO_2-emission and final energy savings) while not providing substantial economic advantage; and
- a deep renovation track, combining a focus on energy efficiency with high use of renewables can be considered as a financially viable route, meeting CO_2-targets while showing the lowest energy consumption and offering the largest job creation potential of the assessed tracks.

Giving clear guidance and developing suitable policies for deep renovation of the building stock can therefore be seen as an important step of the EU to meet its long term energy and climate objectives.

Background

The importance and potential of reducing CO_2 emissions in the EU building sector is rarely questioned, and has been shown in various studies.[1] The impact is mainly through the renovation of existing buildings, which offers significant potential for both cost effective CO_2-mitigation and substantial energy consumption reduction[2]

At the same time, measures to increase energy efficiency in buildings support several other important societal and individual goals, such as increased employment and a boost to economic activity, improved quality of life, reduction of fuel poverty and better security of supply with its lower dependence on imported (fossil) fuels. At the same time, it provides significantly increased net revenues to public administrations, due to the creation of local jobs, resulting in lower unemployment payments and higher VAT and income tax receipts[3]. This makes policies in the building sector a highly multi-purpose tool to achieve numerous important political targets.

In its "Roadmap for moving to a competitive low carbon economy in 2050"[4] the European Commission established a long-term objective of decreasing the CO_2-emission levels for the building sector by 88%-91% in 2050, compared to 1990 levels. In order to achieve this target, which is also a

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[1] Wesseling, B., Deng, Y. et. al: Sectoral Emission Reduction Potentials and Economic Costs for Climate Change (SERPEC-CC), Ecofys 2009.

[2] Cost-Effective Climate Protection in the Building Stock of the EU Building Stock & New EU Member States, commissioned by Eurima, Ecofys 2005.

[3] Impact on public budgets of KfW promotional programmes in the field of "Energy-efficient building and rehabilitation", Jüllich Research Centre, October 2011

[4] COM(2011) 112 final, A Roadmap for moving to a competitive low carbon economy in 2050.

prerequisite for meeting other EU economic and climate goals, the EU especially needs to tackle the existing building stock and reduce its energy use in the long term.

Crucially, it remains unclear which concrete actions and legislative measures are necessary at the EU level to reach long-term targets of the EU related to GHG-emission reductions and energy savings. Similarly, the question remains open as to how the EU will ensure that the potential for energy savings from the building stock is fully being tapped.

The present study analyses and compares the possible tracks for the renovation of the EU building stock, quantifying and illustrating graphically energy savings and avoided CO_2 emissions, financial impacts and employment effects.

Three Renovation Scenarios

Three renovation scenarios for the period to 2050 were developed and assessed using the Ecofys' Built Environment Analysis Model (BEAM²). They are characterized by two important parameters, which are the speed of renovation (= renovation rate) and the ambition level regarding energy efficiency improvement and use of renewable energy. The 2050 horizon is selected in order to take a long term and strategic view on the sector that reveals long term consequences of choices to be made now and in the next years.

Name	**Scenario**	**Description**
Track 1:	Shallow renovation, low contribution from renewable energy	Fast renovation (renovation rate 3%) & average energy efficiency ambition level (~ 32 % reduction in energy use for space heating by 2050 compared to 2010), taking into account market failures (e.g. failure to treat the building envelope as a whole), low use of renewable energy.
Track 2	Shallow renovation, and high use of renewable energy	Renovation rate 2.3% & average energy efficiency ambition level, taking into account market failures (~ 58 % reduction in energy use for space heating); limited focus on energy efficiency of the building envelope; advanced systems (high use of renewable energy and heat recovery ventilation).
Track 3	Deep renovation and high use of renewable energy	Renovation rate 2.3%, high level of energy efficiency improvement (~80% reduction in energy use for space heating) high focus on energy efficiency of the building envelope; advanced systems (high use of renewable energy and heat recovery ventilation).

It is important to note that the scenarios assume renovation rates not higher than 3% taking into account normal renovation cycles (30 to 40 years), which makes it possible to connect the measures with already anticipated (also non-energy related) renovation activities. The renovation rates in Tracks 2 and 3 ensure that the building stock is renovated before 2050. However, in all 3 scenarios assume a small fraction of buildings will not be improved in the time period (e.g. monument type of buildings or due to compliance issues).

Modelling results

The following table gives an overview of the scenarios and their results for the period 2012 – 2050.

Scenario	Retrofit rate	CO_2-Emissions for space heating and domestic hot water EU27 by 2050 [Mt]	Final Energy use for space heating EU27 [TWh] by 2050 (without new buildings)	related reduction in final energy use by 2050 compared to 2010	Total Costs (investment costs **and** energy costs for space heating and domestic hot water, discounted costs for period 2012-2050) [trillion EURO]
Track 1	3.0%	498	1,987	32%	8.2
Track 2	2.3%	103	1,228	58%	8.8
Track 3	2.3%	93	613	80%	8.5

Conclusions

Based on a detailed analysis of the possible tracks, this report provides answers to the following questions:

1. **Can the 88%-91% CO_2-emission savings target be achieved until 2050?**

   Yes, track 2 and 3 arrive at approximately a 90% emissions savings, while Scenario 1 clearly misses this target.

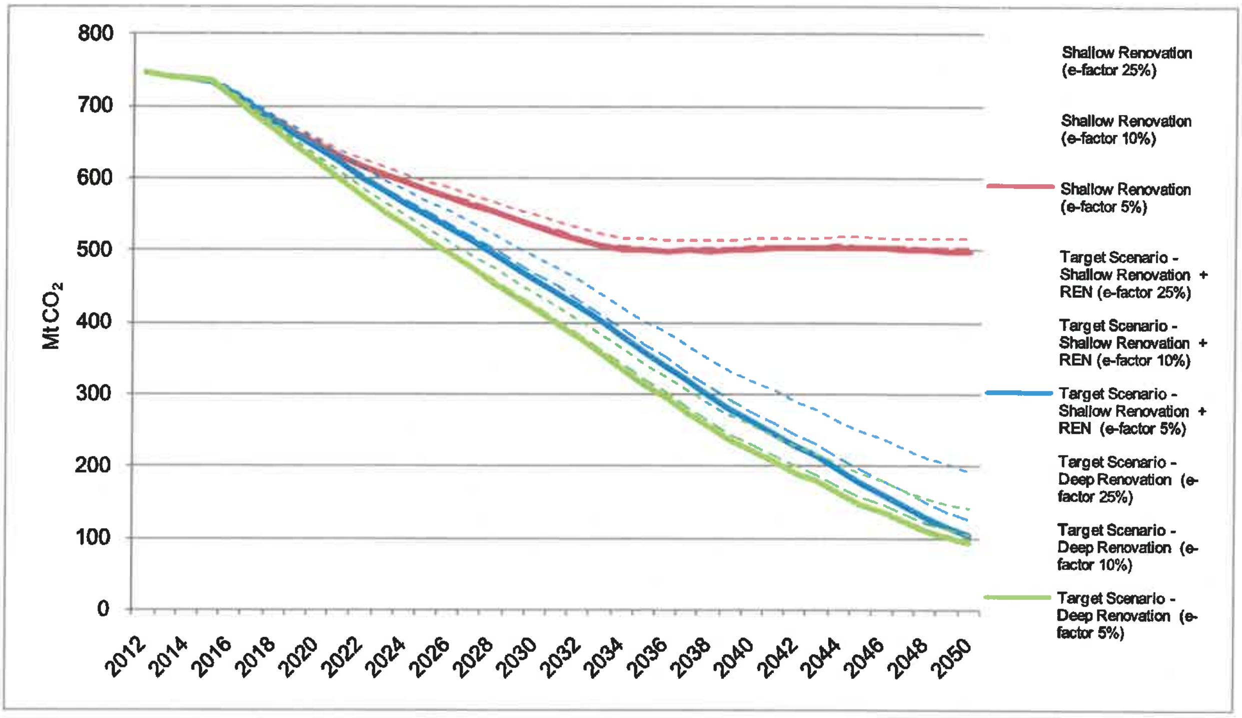

Figure 1 Total CO_2-Emissions EU27 [Mt/a]

2. Is the 80% final energy savings target a suitable target?

Yes, this is the right ambition level, with some considerations.
A substantial reduction of final energy consumption supports the achievement of the CO2 savings target. The 80% final energy savings target (suggested by Parliament's report on the EED[5]) seems suitable, if it relates to energy used for space heating. The deep renovation track delivers such savings. When looking at the sum of space heating and domestic hot water, the deep renovation track delivers -75% savings.

If further energy uses (energy for cooling, auxiliary energy and lighting, all primarily supplied via electricity) are also considered, related final energy saving potentials would need to be considered as well.

However, as (realistically) a small fraction of buildings in the three scenarios is assumed to be not improved in the future (e.g. monument type of buildings or due to compliance issues) somewhat more room for manoeuvre could be given by strictly renovating all buildings without any exceptions.

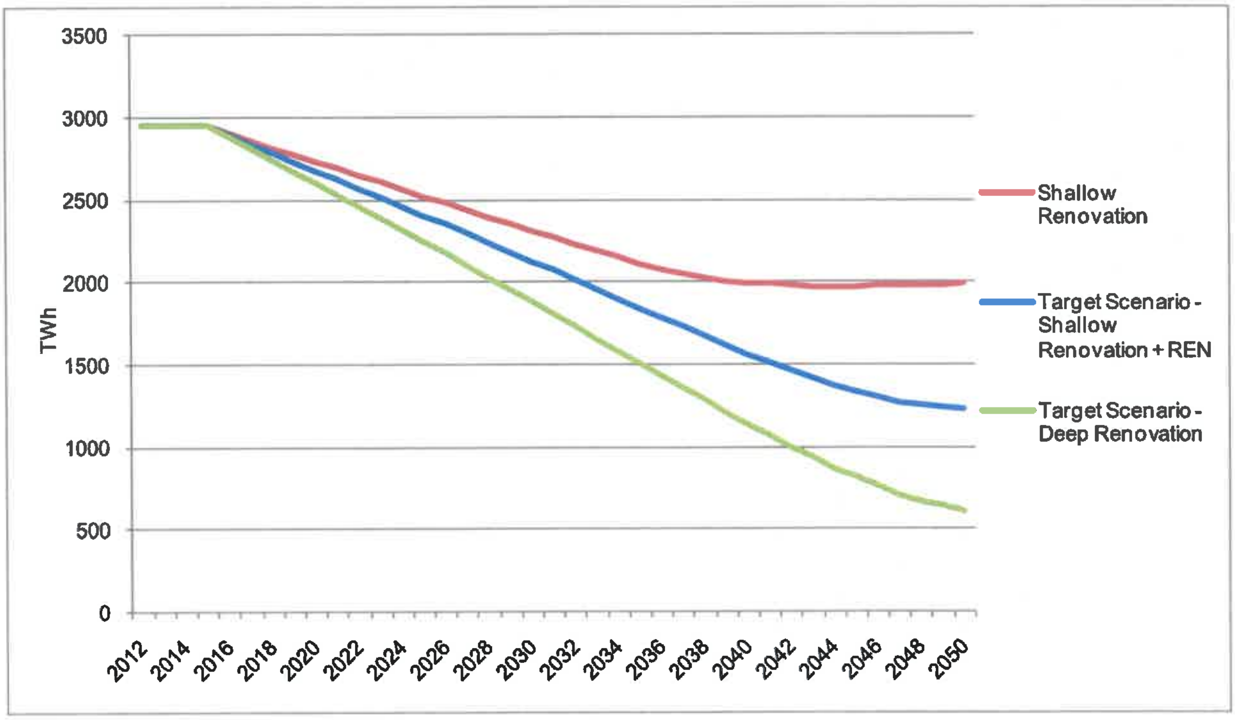

Figure 2 Final Energy for space heating EU27 [TWh/a] without new buildings

[5] The Parliamentary report to the EED uses as measuring parameter the % savings on final energy to be achieved by 2050 compared to 2010 (-80%).

3. Can "deep renovation" be a suitable way to achieve EU targets?

Yes. The combination of extensive energy efficiency measures and high use of renewable energy seems preferable to achieve both, CO_2 and final energy targets.

Track 1 (shallow renovation) misses both environmental targets (CO2-emission and final energy savings) while not providing substantial economic advantage compared to the deep renovation track.
Track 2 (Shallow renovation and high use of renewable energy) meets the CO2-target, but shows significant less energy savings while resulting in slightly higher costs compared to the deep renovation track.
The deep renovation track also offers the largest job creation potential of the three scenarios.

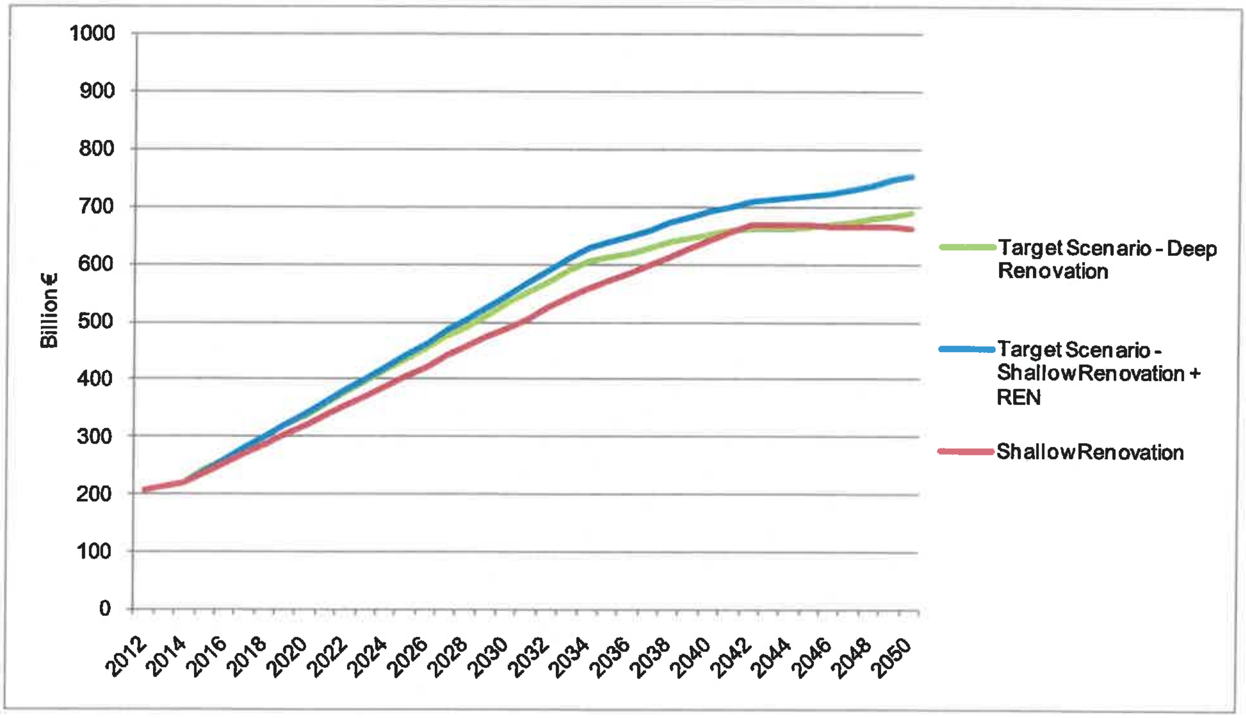

Figure 3 Total yearly Costs EU27 [billion €/a]

2 Background and aim of the study

With the requirement to build all new buildings as "nearly zero energy buildings" from 2021 on, the recast of the EU Energy Performance of Buildings Directive (EPBD recast, Directive 2010/31/EU) set clear timing and also gave a strong indication of the desired ambition level for new buildings. For most of the period leading up to 2020, the principle of "cost optimality" will also be guiding.
For building renovations, the EPBD recast tightened requirements, e.g. by removal of the threshold of 1.000 m² that excluded smaller buildings from requirements during renovation. Concerning the ambition level the principle of "cost optimality" also applies for renovations. However, it has remained unclear which concrete actions and legislative measures are still necessary on EU level to reach long-term targets of the EU related to GHG-emission reductions and energy savings, especially regarding how the EU will ensure that the potential for energy savings from the building stock is actually being tapped. This concerns, in particular, two aspects of building renovation strategies, which are:

- the speed of renovation (number of buildings renovated per year), and
- the future ambition level (within or even possibly as a successor to the "cost optimality" principle).

Beyond regulations at the building level, a clear long-term strategy involving the whole building stock is needed, Otherwise it would be unclear how fast the building stock needs to be and can be refurbished, and in which way performance requirements need to be tightened in the future, to achieve the overarching climate and energy saving goals of the EU.

Such a long term strategy was formulated by the European Commission in its "Roadmap for moving to a competitive low carbon economy in 2050"[6], which suggests decreasing the CO_2-emission levels by 88%-91% for the building sector by 2050, compared to 1990 levels. Nevertheless, this long-term strategy needs to be crystallised into concrete steps to get there. In the context of the revised energy efficiency directive[7] (EED), the European Parliament's Industry Committee made an attempt to progress on the issue by introducing a suggestion, namely that national plans on building level should be prepared by Member States, which "shall aim to reduce, by 31 December 2050, the energy consumption of the existing building stock by 80% compared to 2010 levels" (article 3a of the Parliamentary report).

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[6] COM(2011) 112 final, A Roadmap for moving to a competitive low carbon economy in 2050.

[7] Proposal for a Directive of the European Parliament and of the Council on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC, March 2012

To achieve these targets, significant actions need to be taken in the individual national building markets These markets need clear plans, provisions and guidance to allow building owners and the building industry and financing partners in order to take timely and well founded investment decisions.

Due to the long renovation cycles of buildings (around 30 years for the building envelope and around 20 years for heating, ventilation and air-conditioning systems), there will probably only be one complete renovation cycle in the building stock in the timeframe up to 2050 unless increased action is taken. While making it possible to change more or less all buildings by that time, this makes it also clear that there is probably only one chance to do it right – or wrong.

On the other hand, increased building renovation with a high level of energy efficiency faces various barriers for implementation, such as the need for upfront financing, investor/user conflict, necessary capacity building etc. It is essential that these barriers are properly identified and policies developed to overcome them.

The aim of the present study is to evaluate different building renovation strategies at the EU level with respect to the speed of renovation and the future ambition level. The intention has also been to relate the results to existing and newly discussed targets with a view to create and support a common understanding of the mechanisms (e.g. lock-in-effects) and implications (achieving or missing long-term targets and their financial consequences).

3 Definition of renovation tracks

Three renovation tracks have been chosen. They are characterised by two important parameters:

- the speed of renovation (= renovation rate) and
- the ambition level regarding energy efficiency improvement and use of renewable energy

The following three renovation scenarios are developed:

Track 1: Shallow Renovation
Fast renovation and average (current) energy efficiency ambition level plus market failures (e.g. failing to insulate the facade). Low use of renewable energy.

Track 2: Shallow Renovation and high use of renewable energy
Average speed and average (current) energy efficiency ambition level plus market failures; limited focus on energy efficiency of the building envelope; advanced systems (high use of renewable energy and heat recovery ventilation).

Track 3: Deep Renovation
Average speed and high energy efficiency ambition level; high focus on energy efficiency of the building envelope; advanced systems (high use of renewable energy and heat recovery ventilation).

The three scenarios where developed to analyse the effect of choosing different strategies to reach the 2050 target (Tracks 2 and 3) and to illustrate the effect of not including a high ambition level and focussing only on the renovation speed. The different scenarios are designed to indicate the likely implications of using different approaches to meet the 2050 targets.

All renovation tracks are calculated for the EU-27 building stock. Retrofitting activities (according to the three defined scenarios) are assumed to be implemented in the market from 2015. The activity within new buildings and demolition continues for all three tracks until 2050.

However, all three scenarios assume that a small fraction of buildings will not be improved in the time period (e.g. monument type of buildings or due to compliance issues).

4 Methodology

The different renovation tracks have been assessed using the Ecofys Built Environment Analysis model (BEAM²).

4.1 The BEAM² model

BEAM² is a calculation model that can be applied worldwide. The model calculates a consistent set of data, including energy consumption, CO_2 emissions, running costs, and investment costs for energy efficiency measures and energy supply systems of buildings. For this purpose, all buildings in a given building stock are classified as residential or non-residential, which are adapted to local circumstances. Data on the building stock to be assessed are inputted into the model, distinguished by country, climate region, building type and size, age, insulation level, energy supply, energy carrier, energy costs and emission factors.

The model calculates future developments over time as certain measure packages are applied. If, for instance, the mandatory performance requirements are increased or the refurbishment rate of buildings rises, the model will compare the outcome of this new scenario with that of the default case. Parameters such as demolition rate, new building activity, renovation and energy-efficiency measures in retrofits are also taken into consideration. These parameters can then be adapted, Focusing on the most effective and cost-efficient measures.

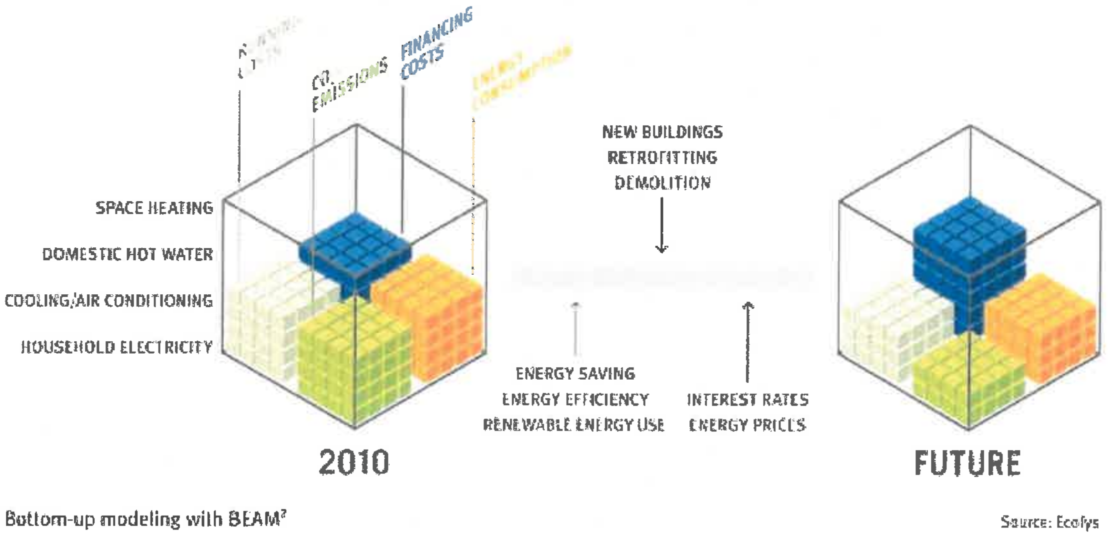

Figure 4 Structure of the Built Environment Analysis Model BEAM²

4.2 Perspective and scope of the assessment

The assessment assumes a private perspective, using investment costs and energy prices including taxes and applying a real interest rate (market interest rate minus inflation) of 4%. Possible subsidies have not been taken into account.

In this study, the energy uses for space heating and domestic hot water have been included. Cooling energy, lighting (for non-residential buildings) and auxiliary energy, which would complete the set of energy uses referred to in the energy performance of buildings directive EPBD) have not been assessed. The reason for this is that their contribution and scenario development requires additional analysis that could not be performed within the framework of this study. However, space heating and domestic hot water do dominate the energy use in the EU building stock.

Still, qualitative statements on cooling, lighting and auxiliary energy uses have been added in relevant parts of the study.

4.3 Model inputs

The different strategies will be described, investigating, for example, limiting factors and setting suitable values for the involved key parameters.

Investment costs and energy costs data are determined in real terms using the base year 2011. Where possible existing data from the Ecofys III and IV studies (Cost-Effective Climate Protection in the EU Building Stock) is used.

The overall interest rate is assumed to be 4.0% (in real terms).

4.3.1 Climate zones and Reference Buildings

The assessment is divided into five climate zones for Europe. The countries within the respective zones are shown in Table 1, while Figure 5 provides the associated map.

A scenario calculation is carried out for each of the zones. Detailed results for each of the zones are given in chapter 5.

Table 1 Definition of zones

Northern	Western	North-Easteri	South-Easteri	Southern
Denmark	Austria	Czech Republic	Bulgaria	Cyprus
Finland	Belgium	Estonia	Hungary	Greece
Sweden	France	Latvia	Romania	Italy
	Germany	Lthuania	Slovenia	Malta
	Ireland	Poland		Portugal
	Luxembourg	Slovakia		Spain
	Nertherlands			
	UK			

Figure 5 Five zones for Europe

The heated floor areas per zone and reference building are the basis for calculation. The distribution along the zones is given in Table 2 and Figure 6.

Table 2 Heated floor area per zone

	Northern	Western	North-Eastern	South-Eastern	Southern
TOTAL [Mio. m²]	1.222	16.341	2.182	1.384	5.010

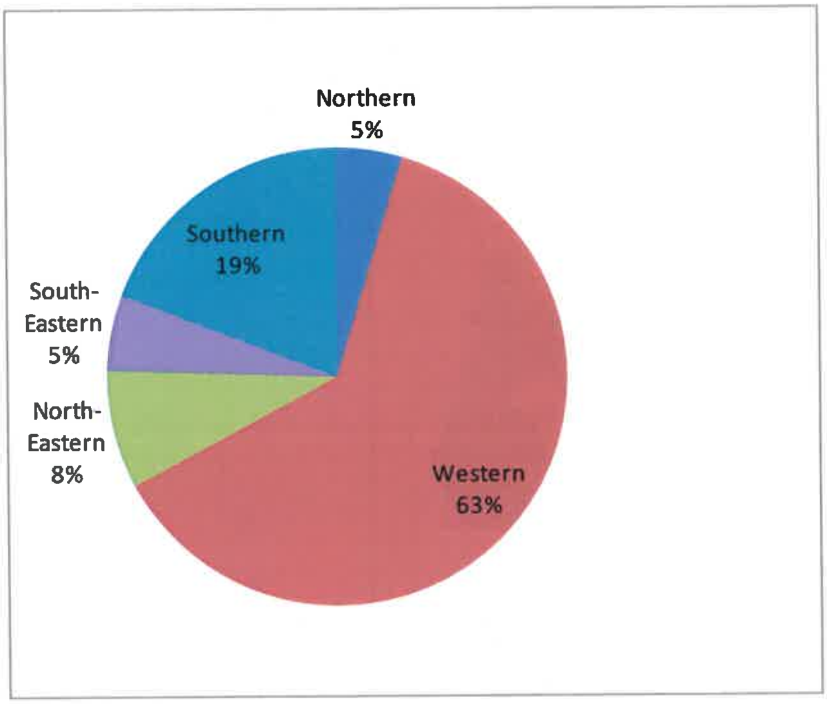

Figure 6 Floor area per zone [m²]

In order to give a detailed picture of the building stocks, four reference buildings for residential and six reference buildings for non-residential buildings are used.

Residential sector:

- Single family buildings (SFH)
- Semi-detached buildings (SDH)
- Small multi-family buildings (SMH)
- Large multi-family buildings (LMH)

Non-residential sector:

- Office buildings (OFB)
- Education buildings (EDB)
- Trade and retail buildings (TRB)
- Touristic buildings (TMB)
- Health buildings (HEB)
- Other non-residential buildings (ONB)

The distribution of floor space per reference building is shown in Figure 7.

The geometry of the reference buildings and their energetic parameters of the building shell (u-values etc.) for the status quo[8] are adjusted to the local situation.

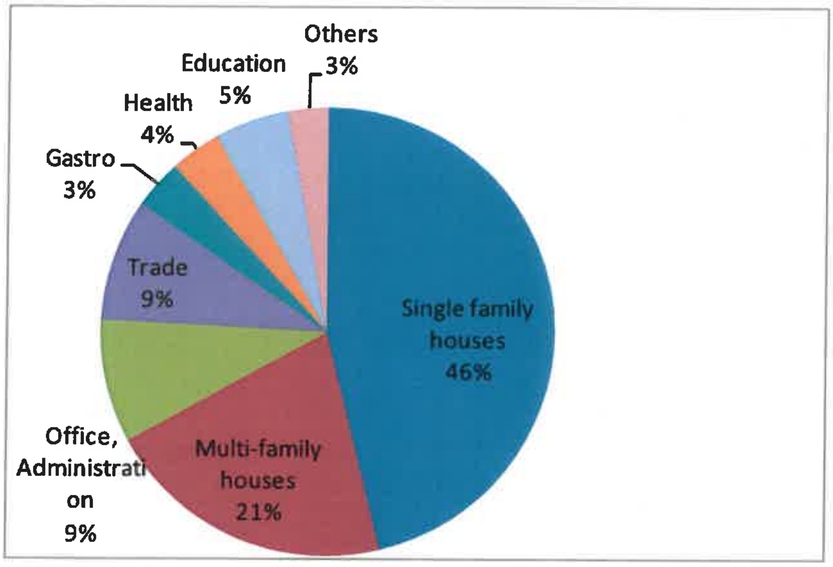

Figure 7 Distribution of floor area per building type [%][1]

4.3.2 CO_2-Emission factors

The CO_2-emission factors are used as average values per year, see Table 3. For all indirect emissions (from electricity and district heat) different emission paths are taken into account up to 2050, reaching an emission level for the scenarios of 25%, 10% or 5% of the 2010 CO_2-emissions, while all other emission factors are considered as constant.

If the power sector reduces CO_2-emissions according to the European targets (-93% to -99% in 2050 of 1990 emissions), the emission factors for electricity and district heat is expected to move towards the 5% value.

[8] Current situation in stock. Assumptions for new buildings and retrofits are defined in the scenario development, section 4.4.

Table 3 CO_2-Emission Factors

Northern, Western and Southern Zone

	Gas	Oil	Pellets	Biomass	Coal
Unit	g/ kWh	g/ kWh	g/ kWh	g/ kWh	g/ kWh
2010	0,202	0,266	0,000	0,000	0,549
2050	0,202	0,266	0,000	0,000	0,549

North-Eastern and South Eastern Zone

	Gas	Oil	Pellets	Biomass	Coal
Unit	g/ kWh	g/ kWh	g/ kWh	g/ kWh	g/ kWh
2010	0,202	0,266	0,000	0,000	0,549
2050	0,202	0,266	0,000	0,000	0,549

Northern, Western and Southern Zone

	Electricity	DH	Electricity	DH	Electricity	DH
	e-factor 5%	*e-factor 5%*	*e-factor 10%*	*e-factor 10%*	*e-factor 25%*	*e-factor 25%*
Unit	g/ kWh	g/ kWh	g/ kWh	g/ kWh	g/ kWh	g/ kWh
2010	0,528	0,167	0,528	0,167	0,528	0,167
2050	0,026	0,008	0,053	0,017	0,132	0,042

North-Eastern and South Eastern Zone

	Electricity	DH	Electricity	DH	Electricity	DH
	e-factor 5%	*e-factor 5%*	*e-factor 10%*	*e-factor 10%*	*e-factor 25%*	*e-factor 25%*
Unit	g/ kWh	g/ kWh	g/ kWh	g/ kWh	g/ kWh	g/ kWh
2010	0,610	0,243	0,528	0,167	0,528	0,167
2050	0,031	0,012	0,053	0,017	0,132	0,042

4.3.3 Energy prices

The current energy prices for gas and electricity are derived from Eurostat data for household consumption. The prices for oil, pellets, heat pump electricity, district heat and biomass are related to these Eurostat prices using former Eurima studies (Ecofys III and Ecofys IV), see Table 4. The energy price rate increases (in real terms, excluding inflation) are chosen at 2.0% for electricity and 2.8% for all other fuels[9].

In the period 2032-2050 (after 30 years of applying such real price increase), constant prices are assumed, which we believe puts estimates on energy costs savings on the save side. All taxes are included in the prices.

[9] http://ec.europa.eu/energy/observatory/trends_2030/index_en.htm

Table 4 Energy prices

€/ kWh	Gas	Oil	Electricity	Pellets	HeatPump El	District heat	Biomass	Coal
Northern								
2010	0,074	0,067	0,195	0,060	0,161	0,091	0,060	0,000
average 2010-2050	0,130	0,119	0,290	0,107	0,241	0,161	0,107	0,001
Western								
2010	0,054	0,050	0,186	0,045	0,119	0,067	0,045	0,000
average 2010-2050	0,096	0,088	0,277	0,079	0,178	0,119	0,079	0,000
Southern								
2010	0,058	0,053	0,181	0,048	0,128	0,072	0,048	0,000
average 2010-2050	0,103	0,094	0,271	0,085	0,191	0,128	0,085	0,001
North-Eastern								
2010	0,046	0,066	0,135	0,029	0,269	0,064	0,029	0,032
average 2010-2050	0,081	0,117	0,201	0,051	0,402	0,114	0,051	0,047
South-Eastern								
2010	0,043	0,061	0,127	0,027	0,250	0,060	0,027	0,029
average 2010-2050	0,075	0,108	0,189	0,047	0,373	0,106	0,047	0,044

4.3.4 Investment Costs

The investment costs for insulation and building equipment for all reference buildings are based on detailed cost data for Germany (IWU 2011, Ecofys 2010). Statistical data from Eurostat on construction costs per country have been used to calculate the weighted average per zone, based on the countries. Costs always cover material and labour costs.

Taxes are included in the investment cost data.

There is no investment costs increase or decrease over time implemented (insulation and equipment).

The specific costs (market prices, including taxes) that are given in the following spreadsheets by system component and exemplary for two reference buildings (a single family house (SFH) with 116 m² and a multi-family house (MFH) with 707 m²) and for two cases (retrofit situation and new building situation). This data is derived for every reference building.

Table 5 Investment costs for heating systems (€/m² floor area) and windows (€/m² component area)

	Unit	Northern							
		SFH				MFH			
		Retrofit situation		New building situation		Retrofit situation		New building situation	
		excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar
heating system									
Gas (condensing boiler)	€/m² floor area	77	135	85	219	31	67	30	39
oil (condensing boiler)	€/m² floor area	119	176			44	80		
pellets	€/m² floor area	179	236	169	270	62	98	55	64
heat pump (air/water, in	€/m² floor area	197	255	225	282	109	145	72	81
heat pump (brine/water)	€/m² floor area	242	299	258	315	109	145	72	81
district heat	€/m² floor area	73		144		36		20	
Ventilation									
w/ heat recovery	€/m² floor area	90		77		78		65	
Heat distribution	€/m² floor area	52		6		36		4	
Windows									
2 glass (u=1.2)	€/m² component	409				315			
3 glass (u= 0.9)	€/m² component			475				383	

	Unit	Western							
		SFH				MFH			
		Retrofit situation		New building situation		Retrofit situation		New building situation	
		excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar
heating system									
Gas (condensing boiler)	€/m² floor area	60	105	66	172	24	52	23	31
oil (condensing boiler)	€/m² floor area	93	138			35	63		
pellets	€/m² floor area	140	184	132	211	48	77	43	50
heat pump (air/water, in	€/m² floor area	154	199	176	221	85	114	56	64
heat pump (brine/water)	€/m² floor area	189	234	202	247	85	114	56	64
district heat	€/m² floor area	57		113		28		15	
Ventilation									
w/ heat recovery	€/m² floor area	70		60		61		51	
Heat distribution	€/m² floor area	41		4		28		3	
Windows									
2 glass (u=1.2)	€/m² component	320				246			
3 glass (u= 0.9)	€/m² component			371				299	

	Unit	Southern							
		SFH				MFH			
		Retrofit situation		New building situation		Retrofit situation		New building situation	
		excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar
heating system									
Gas (condensing boiler)	€/m² floor area	42	73	46	119	17	36	16	21
oil (condensing boiler)	€/m² floor area	65	96			24	44		
pellets	€/m² floor area	97	128	91	146	34	53	30	35
heat pump (air/water, in	€/m² floor area	107	138	122	153	59	79	39	44
heat pump (brine/water)	€/m² floor area	131	162	140	171	59	79	39	44
district heat	€/m² floor area	39		78		20		11	
Ventilation									
w/ heat recovery	€/m² floor area	49		42		42		35	
Heat distribution	€/m² floor area	28		3		20		2	
Windows									
2 glass (u=1.2)	€/m² component	222				171			
3 glass (u= 0.9)	€/m² component			257				207	

	Unit	North-Eastern							
		SFH				MFH			
		Retrofit situation		New building situation		Retrofit situation		New building situation	
		excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar
heating system									
Gas (condensing boiler)	€/m² floor area	39	67	42	109	15	33	15	19
oil (condensing boiler)	€/m² floor area	59	88			22	40		
pellets	€/m² floor area	89	118	84	135	31	49	27	32
heat pump (air/water, in	€/m² floor area	98	127	112	141	54	72	36	41
heat pump (brine/water)	€/m² floor area	120	149	129	157	54	72	36	41
district heat	€/m² floor area	36		72		18		10	
Ventilation									
w/ heat recovery	€/m² floor area	45		39		39		32	
Heat distribution	€/m² floor area	26		3		18		2	
Windows									
2 glass (u=1.2)	€/m² component	204				157			
3 glass (u= 0.9)	€/m² component			237				191	

	Unit	South-Eastern							
		SFH				MFH			
		Retrofit situation		New building situation		Retrofit situation		New building situation	
		excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar	excl. Solar	incl. Solar
heating system									
Gas (condensing boiler)	€/m² floor area	30	52	33	85	12	26	12	15
oil (condensing boiler)	€/m² floor area	46	69			17	31		
pellets	€/m² floor area	70	92	66	105	24	38	21	25
heat pump (air/water, in	€/m² floor area	77	99	88	110	42	57	28	32
heat pump (brine/water)	€/m² floor area	94	116	100	123	42	57	28	32
district heat	€/m² floor area	28		56		14		8	
Ventilation									
w/ heat recovery	€/m² floor area	35		30		30		25	
Heat distribution	€/m² floor area	20		2		14		1	
Windows									
2 glass (u=1.2)	€/m² component	159				122			
3 glass (u=0.9)	€/m² component			185				149	

		energy related fixed costs			
		facade (cavity)	facade (thermal comp. System)	roof	cellar
Northern Europe	€/m² component	23,0	47,6	22,4	24,4
Western Europe	€/m² component	16,9	35,1	16,5	18,0
North-eastern Europe	€/m² component	14,0	17,5	15,1	18,2
South-eastern Europe	€/m² component	13,1	16,3	14,1	17,0
Southern Europe	€/m² component	15,0	18,8	16,3	19,6

		costs additional cm			
		facade (cavity)	facade (thermal comp. System)	roof	cellar
Northern Europe	€/m² component/ cm	1,2	1,9	1,3	1,7
Western Europe	€/m² component/ cm	0,9	1,4	1,0	1,2
North-eastern Europe	€/m² component/ cm	0,9	1,2	1,1	1,1
South-eastern Europe	€/m² component/ cm	0,9	1,1	1,0	1,0
Southern Europe	€/m² component/ cm	1,0	1,3	1,2	1,2

Table 6 Investment costs for insulation (in €/m² component area)

4.4 Scenario Development

The following sections give an overview on the definition of the renovation tracks. The scenarios assume that implementation of the renovation track starts in 2015, which is a simplification of the development in reality that is assumed to develop from the current situation (approximately 1% renovation) in a steady increase to a desired renovation rate within about 5 years.

For all scenarios a new building rate of 1.0% per year and a demolition rate of 0.1% per year are assumed.

4.4.1 Track 1: Shallow renovation

Fast renovation & average ambition level + market failures
Retrofit rate: 3.0% per year
Retrofit standard (demand side): Average standard, accompanied by market failures where certain measures are not carried out due to perceived barriers[10].

Table 7 U-values of the residential and non-residential reference buildings (in W/m²K)

	Northern Europe	Western Europe	Southern Europe	North eastern Europe	South eastern Europe
Ambient wall	not replaced	not replaced	not replaced	not replaced	not replaced
Roof	0.26	0.3	0.43	0.34	0.39
Cellar	not replaced	not replaced	not replaced	not replaced	not replaced
Windows	1.3	1.3	1.3	1.3	1.3

Renewable energy: Low contribution, no ventilation systems with heat recovery
Future heating systems for retrofits:[11]

- 75% Gas condensing boiler
- 15% Oil condensing boiler
- 3% Air-water heat pump
- 3% Ground-water heat pump
- 4% Biomass boilers

Solar thermal systems for domestic hot water: none

Due to the fact that nearly all existing buildings are retrofitted in the "Shallow renovation" scenario until 2045, no further retrofits are implemented from 2045-2050. However, the activity with new buildings and demolition continues.

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[10] Market failures described effects, where e.g. measures that are in principle financially feasible from a lifecycle perspective are not carried out, due to various barriers (e.g. high upfront investment/financing needs, lack of information, aesthetics/tradition, investor user conflict, technical limitations etc.).
[11] The same systems are added to all zones to show the "bandwidth" in heating systems between "shallow" and "deep" renovation.

4.4.2 Track 2: Target Scenario, Shallow renovation + REN

Doubling of renovation rate & average ambition level + market failures; no focus on energy efficiency; use of renewable energy

Retrofit rate: 2.3% per year (which is approximately a doubling of the current renovation rate).

Retrofit standard (demand side): accompanied by market failures where certain measures are not carried out due to perceived barriers. The demand side level (related to the building envelope) of the shallow renovation is the same level as applied in Track 1.

Table 8 U-values of the residential and non-residential reference buildings (in W/m²K)

	Northern Europe	Western Europe	Southern Europe	North eastern Europe	South eastern Europe
Ambient wall	not replaced	not replaced	not replaced	not replaced	not replaced
Roof	0.26	0.3	0.43	0.34	0.39
Cellar	not replaced	not replaced	not replaced	not replaced	not replaced
Windows	1.3	1.3	1.3	1.3	1.3

Renewable energy: high contribution

All retrofits with ventilation systems and heat recovery

Future heating systems for retrofits:

- 40% Air-water heat pump
- 40% Ground-water heat pump
- 15% Biomass boilers
- 5% District heat (with growing share of renewable energy)

Solar thermal systems for domestic hot water (max. DHW coverage 60%): 80% of all retrofits have solar thermal systems installed.

4.4.3 Track 3: Target Scenario, Deep renovation

"Doubling" of renovation rate & high ambition level; focus on energy efficiency; use of renewable energy

Retrofit rate: 2.3% per year (which is approx. a doubling of the current renovation rate).
Retrofit standard (demand side): Very ambitious standard (reflects the level of Passive House[12] standard for the building envelope and equals the level of new buildings described in 3.2.4)

Table 9 U-values of the residential and non-residential reference buildings (in W/m²K)

	Northern Europe	Western Europe	Southern Europe	Northeastern Europe	Southeastern Europe
Ambient wall	0.11	0.12	0.15	0.12	0.15
Roof	0.11	0.12	0.15	0.12	0.15
Cellar	0.11	0.12	0.15	0.12	0.15
Windows	0.85	0.85	1.8	0.85	1.8

Renewable energy: high contribution
All retrofits with ventilation systems and heat recovery

Future heating systems for retrofits:[13]

- 35% Air-water heat pump
- 35% Ground-water heat pump
- 15% Biomass boilers
- 15% District heat (with growing share of renewable energy)

Solar thermal systems for domestic hot water (max. domestic hot water coverage of 60%): 33% of all retrofits have Solar Thermal systems installed.

It is important to note that all three scenarios assume renovation rates of no more than 3% taking into account normal renovation cycles (30 to 40 years), which enables to connect the measures with already anticipated and (also non-energy related) renovation activities. The renovation rate in Tracks 2 and 3, namely 2.3% per year (which is approx. a doubling of the current renovation rate) still ensures that the building stock is renovated before 2050.

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[12] Passive houses typically have a final energy demand for heating and cooling below 15 kWh/m²a.
[13] The same systems are added to all zones to show the "bandwidth" in heating systems between "shallow" and "deep" renovation.

4.4.4 New building standards

High ambition level for new buildings
New building rate: 1.0% per year
New building standard (demand side): Ambitious standard[14]

	Northern Europe	Western Europe	Southern Europe	Northeastern Europe	Southeastern Europe
Ambient wall	0.11	0.12	0.15	0.12	0.15
Roof	0.11	0.12	0.15	0.12	0.15
Cellar	0.11	0.12	0.15	0.12	0.15
Windows	0.85	0.85	1.8	0.85	1.8

Table 10 U-values of the residential and non-residential reference buildings (in W/m²K)

Renewable energy: High contribution
All new buildings with ventilation systems and heat recovery

Future heating systems new builds:

- 5% Gas condensing boiler
- 15% Biomass boilers
- 40% Air-water heat pump
- 40% Ground-water heat pump

Solar thermal systems for domestic hot water (maximum DHW coverage 60%): 66% of all new buildings have solar thermal systems installed.

District heating systems for new buildings have not been included in the scenarios, as newly setup collective/district heating systems can be done in various forms and with various (renewable) sources, with different cost/price structures etc. This would need a deeper assessment of these aspects, which was not in the scope of this study. Especially in densely populated areas or any other beneficial local circumstances (e.g. waste heat nearby) green district heat for new (nearly zero energy) buildings can be a very interesting option and should be taken into consideration.

[14] New buildings typically with final energy demand for heating and cooling below 15 kWh/m²a.

5 Results

The possible development of the different tracks regarding space heating and domestic hot water for the following parameters:

- CO_2-emissions
- final energy consumption
- necessary investments and related job creation

are assessed for the three different tracks using the Ecofys BEAM² model. The calculations are based on the five climate zones within the EU27.[15]

5.1 Floor Area Development

The following figures illustrate the development of the heated floor areas in the EU27 countries.

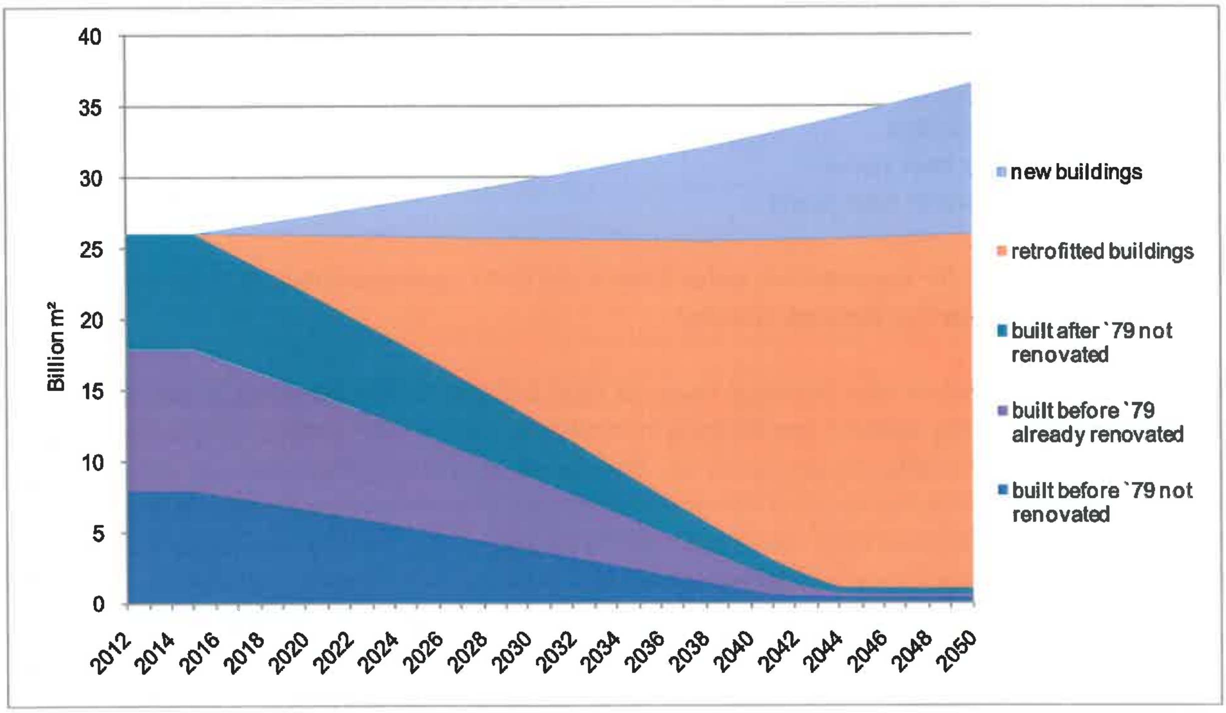

Figure 8 Heated floor area EU27 – track "Shallow Renovation" [billion m²]

[15] As for most statistics 1979 is a crucial date (i.e. introduction of the Thermal Insulation Ordinance in Germany) and from then on mandatory requirements for the building shell have been introduced, we distinguish buildings before and after 1979.

In the shallow renovation scenario, the stock is completely renovated by 2045, with a very small share of buildings assumed to have not been renovated. About one quarter of the building stock in 2050 will be new buildings.

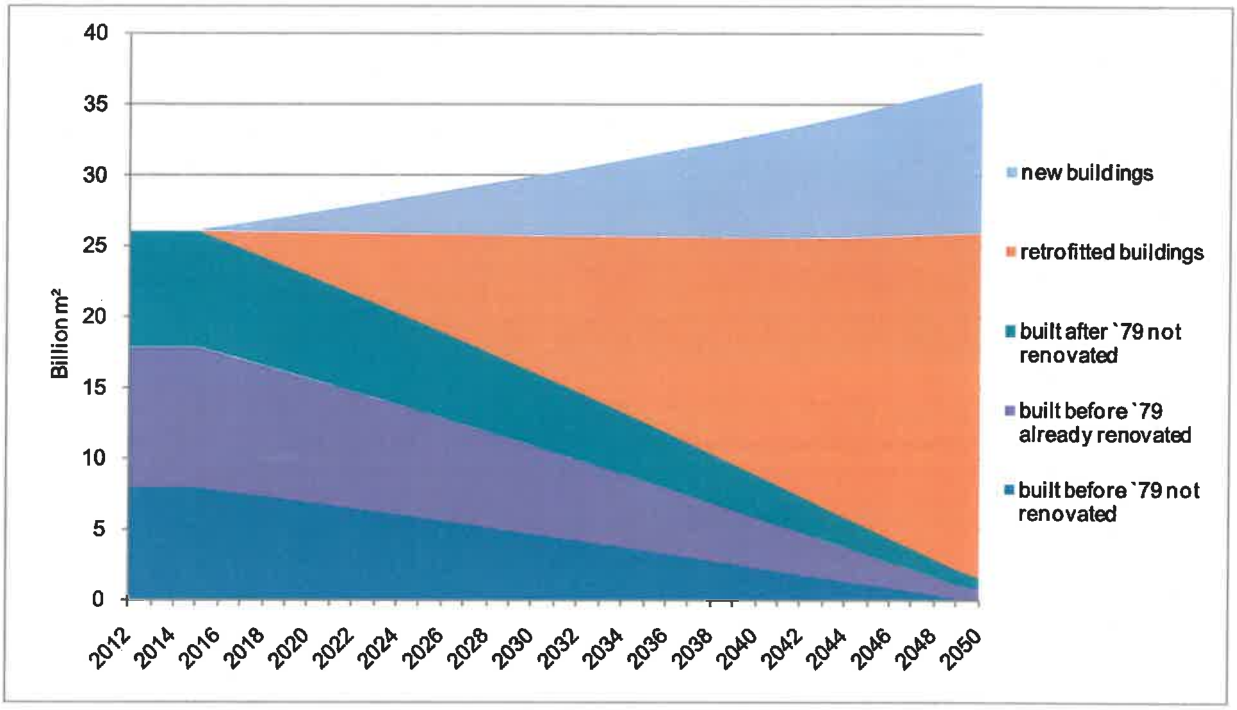

Figure 9 Heated floor area EU27 – track "Target Scenario, Shallow Renovation + REN" [billion m²]

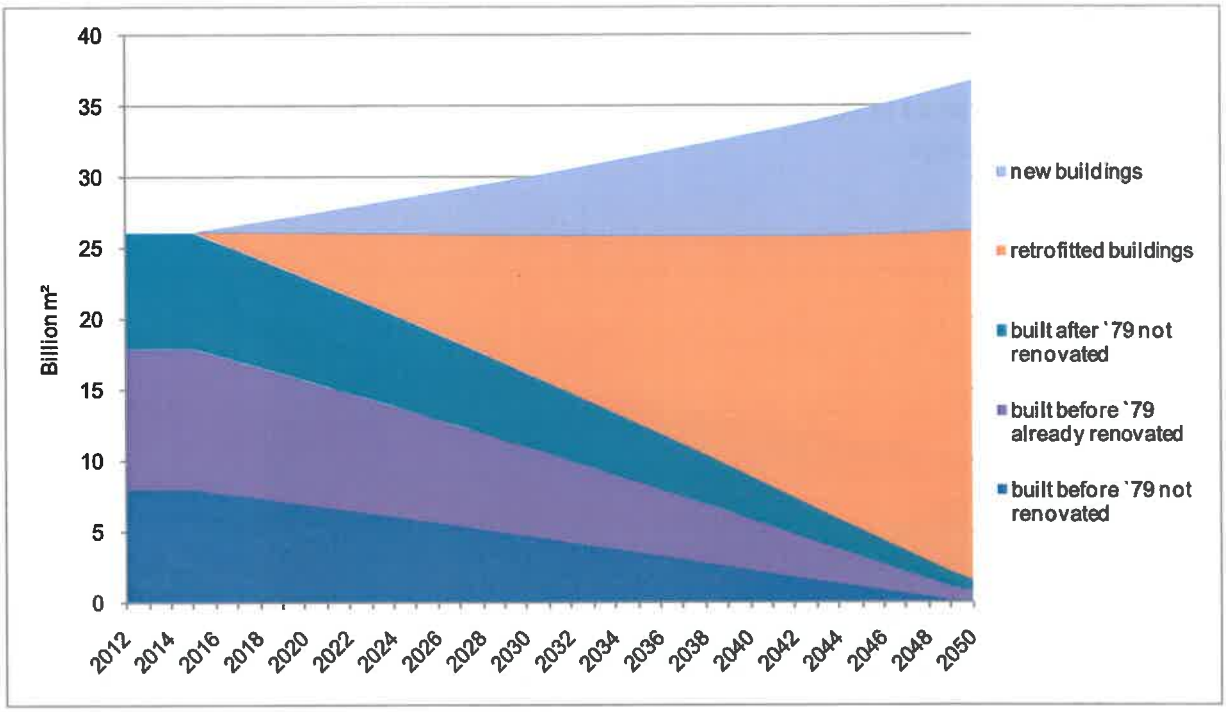

Figure 10 Heated floor area EU27 – track "Target Scenario, Deep Renovation" [billion m²]

In the two target scenarios, the stock is completely renovated by 2050, with a small share of buildings assumed to have not been touched.

5.2 CO_2-Emissions

Figure 11 to Figure 14 give an overview on the total CO_2-emissions for space heating and domestic hot water in the EU27 countries for the 5% emission path[16], including the sensitivity for the 10% and 25% emission paths for indirect emissions for all three scenarios.

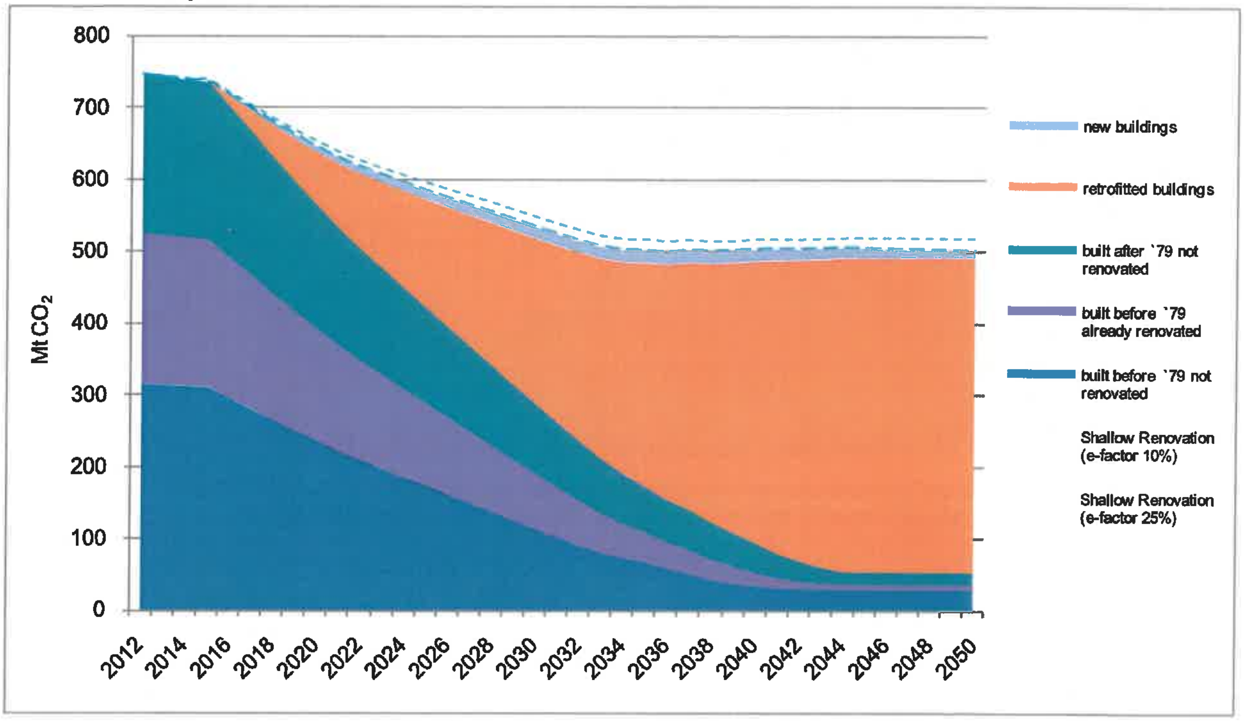

Figure 11 Total CO_2-Emissions EU27 – track "Shallow Renovation" [Mt/a]

In the "shallow renovation" scenario, the CO_2-emissions drop from today's level by approximately one third, to 500 Mt in 2050. As a large fraction of the building stock in the shallow renovation scenario is assumed to be equipped with gas and oil boilers, the influence of different emission factors for electricity and district heat is limited.

[16] Reduction of the emission factor of eletricity and district heat to 5% of 2010 values, see chapter 4.3.2

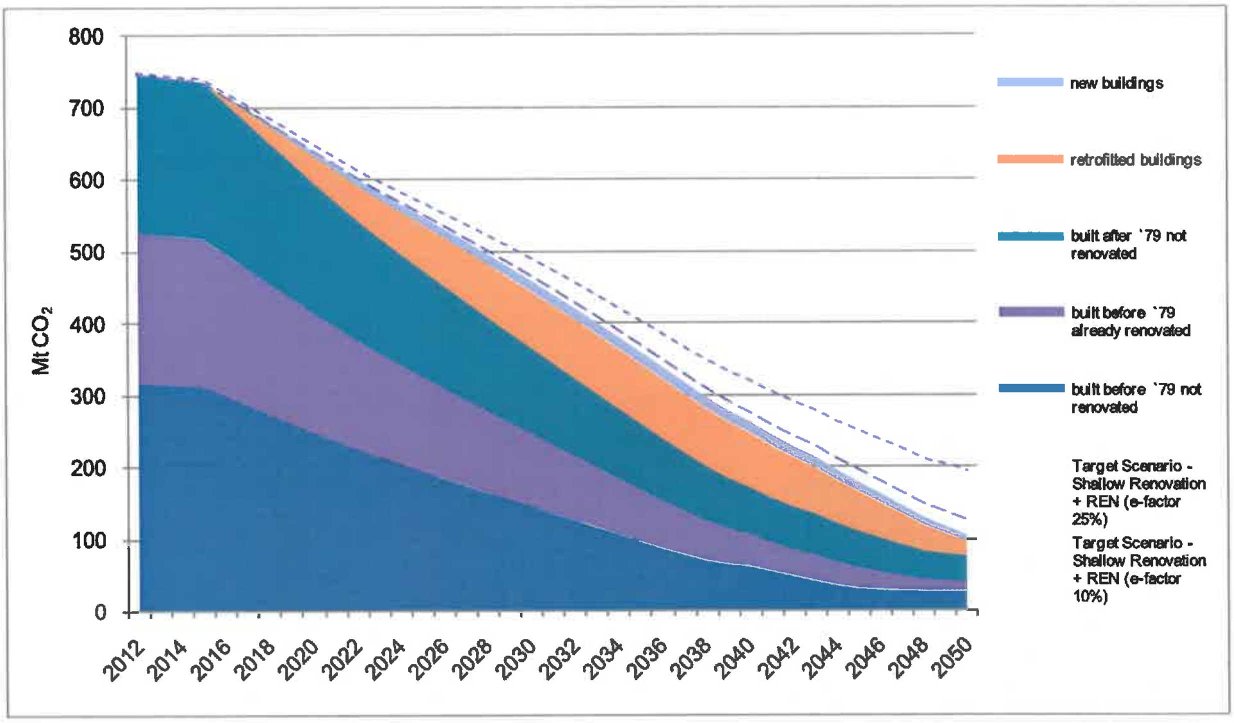

Figure 12 Total CO_2-Emissions EU27 – track "Target Scenario, shallow renovation + high use of renewable energy" [Mt/a]

The target scenario "shallow renovation + renewable energy" brings emissions down to approximately 103 Mt in 2050, reaching the 88%-91% CO_2-emission savings target (compared to 1990). Due to an assumed high share of electric heat pumps, the achievement of the emission saving targets of the power sector (and specifically for electricity) is of crucial importance in order to reduce direct and indirect emissions in the building sector. Missing the target in these areas could double the emissions in 2050.

It is also noticeable that a significant share of emissions is caused by the small fraction of buildings that are not upgraded (e.g. monument type of buildings or due to compliance issues). It is clear that such cases must be limited to an achievable minimum.

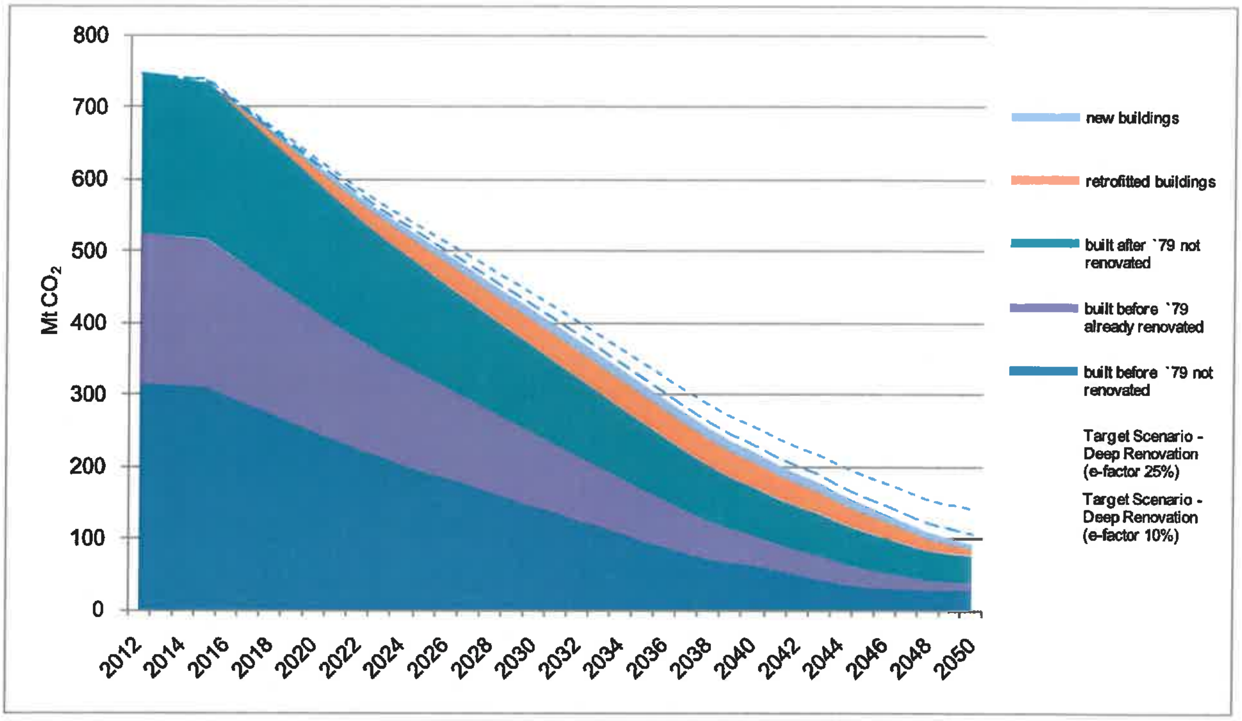

Figure 13 Total CO_2-Emissions EU27 – track "Target Scenario, Deep Renovation" [Mt/a]

The "deep renovation" scenario leads to emissions of around 93 Mt CO_2 in 2050, also reaching the 88%-91% CO_2-emission savings target (compared to 1990). Since the focus here is more on energy savings, dependency of the performance of the power sector (in terms of lowering emissions for the production of electricity and district heat) is lower than in the Track 2 scenario.

Missing the target in these areas would have significant lower influence in this scenario, which makes this track less dependent on the achievements in the power sector.

The following graph compares the three different tracks (and sensitivities).

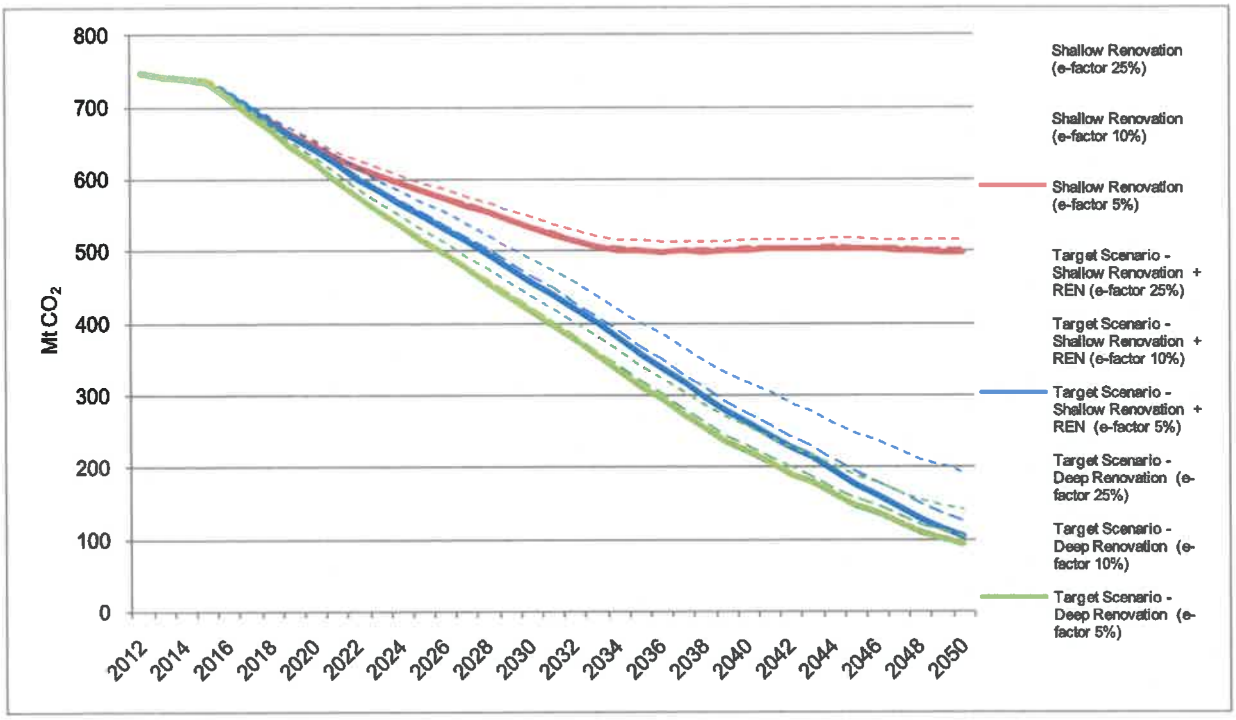

Figure 14 Total CO_2-Emissions EU27 [Mt/a]

The "shallow renovation" scenario results in substantially higher emissions by 2050 compared to the two target scenarios. As the stocks have been fully renovated in all scenarios, it will be very difficult and/or expensive to change that picture after 2050, leading to **a sectorial lock-in effect of approximately 400 Mt of CO_2 in 2050.**

Looking at the **cumulated** emissions for the period 2012 to 2050 of the different tracks, scenario 1 (shallow renovation) results in 22,3 Gt, scenario 2 (shallow renovation + high use of renewable energy) in 17.3 and scenario 3 (deep renovation) in 16.8 Gt.

Both, scenarios 2 (shallow renovation + high use of renewable energy) and 3 (deep renovation) result in approx. 90% savings of CO_2 compared to 1990 and thereby achieve the 88%-91% CO_2-emission savings target.

This results in an average "allowed" CO_2-emission in the building sector of 3 $kgCO_2/m^2a$, see specific CO_2-emissions in following graph.

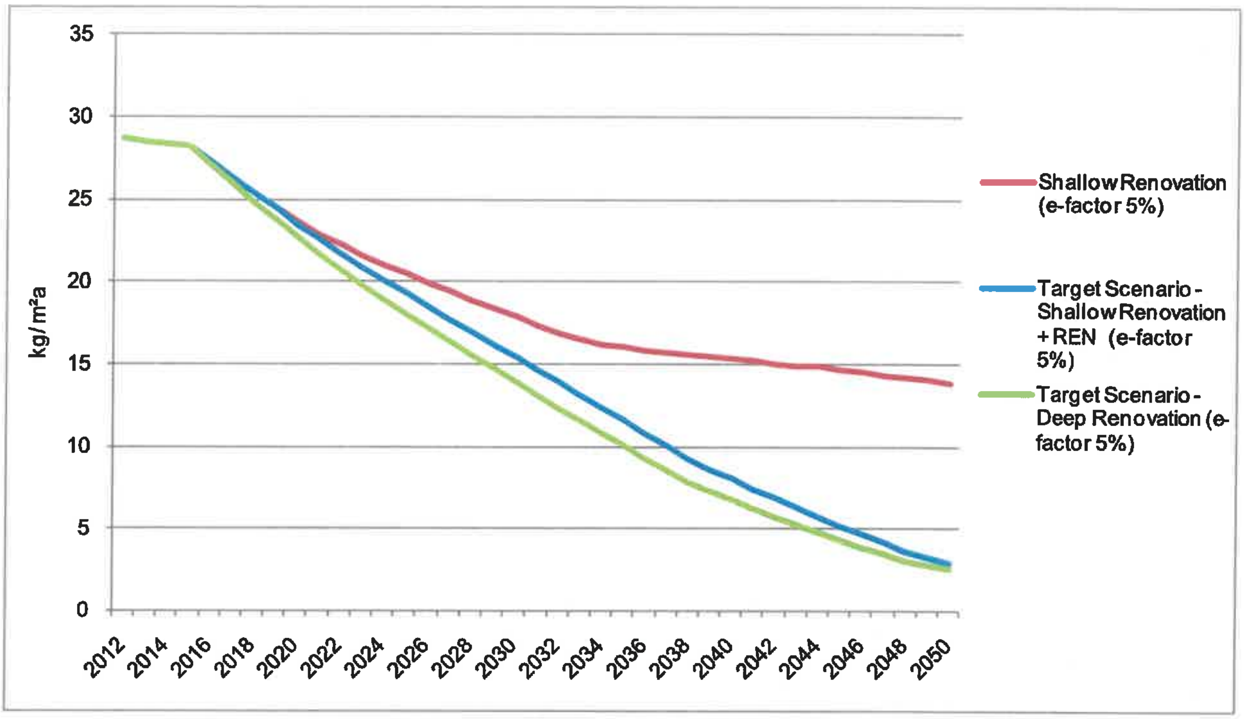

Figure 15 Specific Total CO_2-Emissions EU27 for the "5% emission path" [$kgCO_2/m^2a$]

While cooling, lighting and auxiliary energy are not included in this assessment, these energy uses are unlikely to change the picture on CO_2-esmissions significantly, as long as the power sector complies with its target to supply low carbon electricity/district cooling.

5.3 Final energy

Figure 16 to Figure 18 provide an overview of the final energy demand for space heating for the different scenarios. These are summarised in Figure 21.

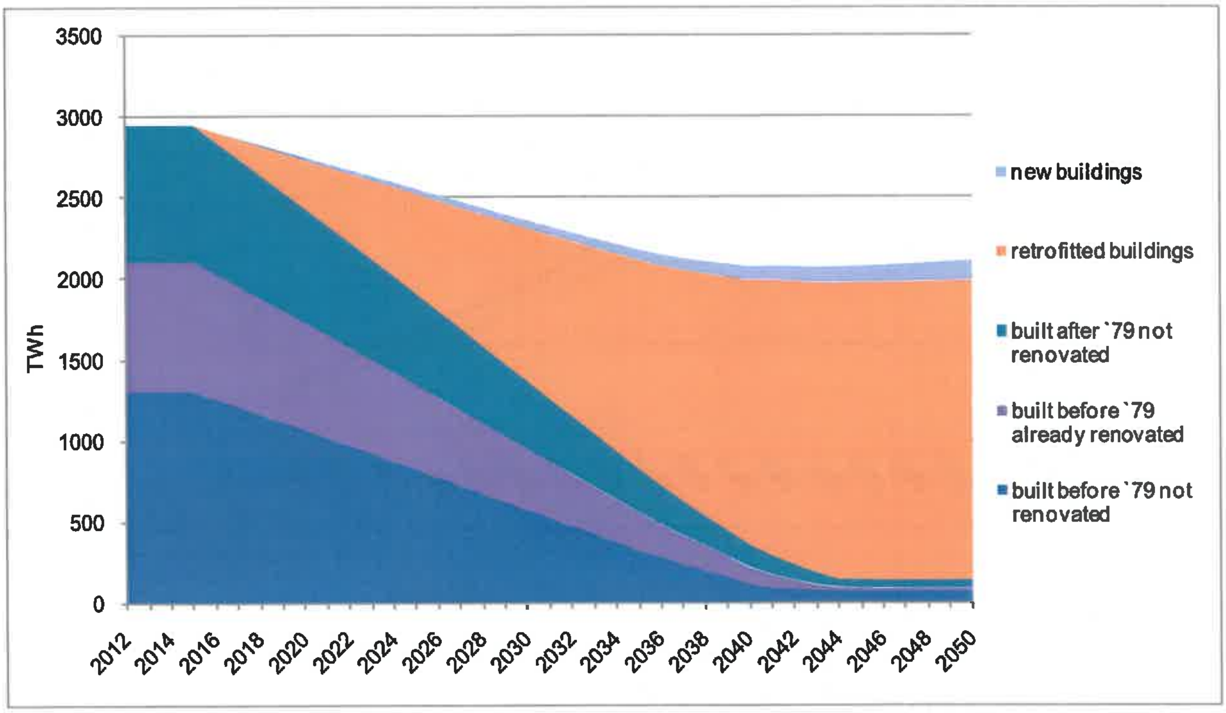

Figure 16 Final Energy for space heating EU27 – track "Shallow Renovation" [TWh/a]

In the "shallow renovation" scenario, the energy use for space heating is dominated by the retrofitted buildings, as the energy use in those is still considerably high (approx. 25% reduction compared to 2010). Heating energy use for new buildings is only around 5% of the total in 2050, due to the assumed high standard (nearly zero energy buildings).

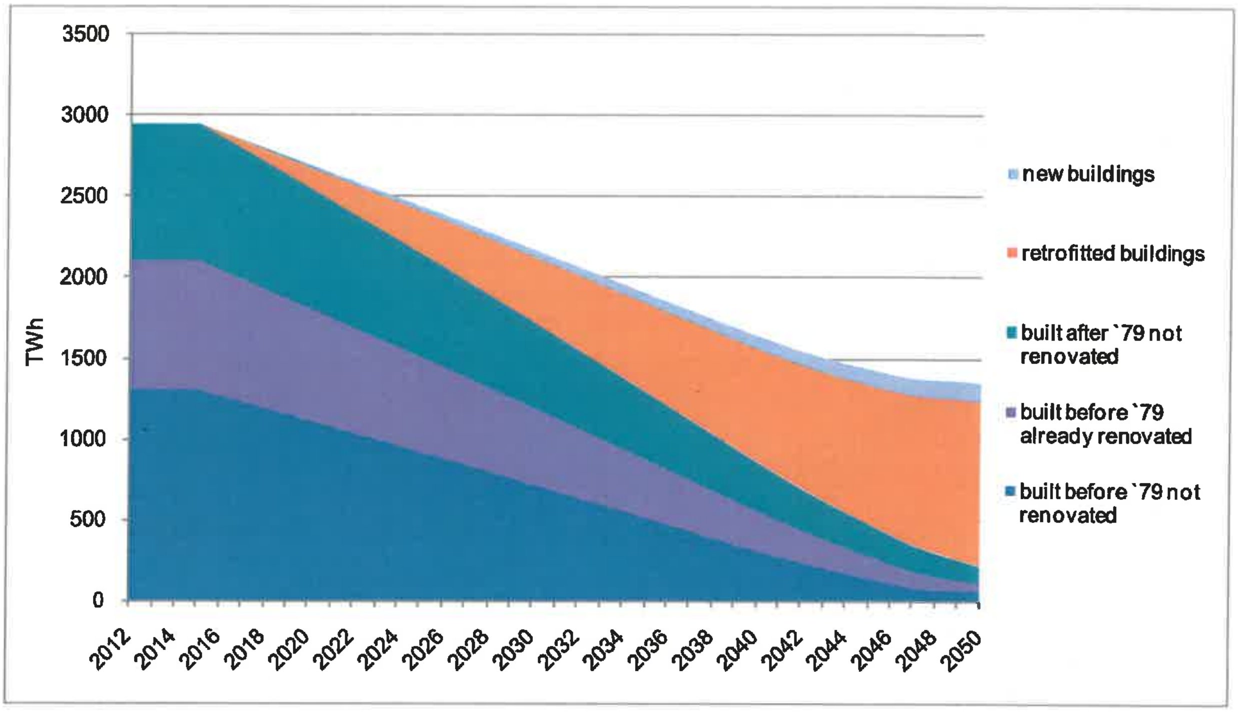

Figure 17 Final Energy for space heating EU27 – track "Target Scenario, Shallow Renovation + REN" [TWh/a]

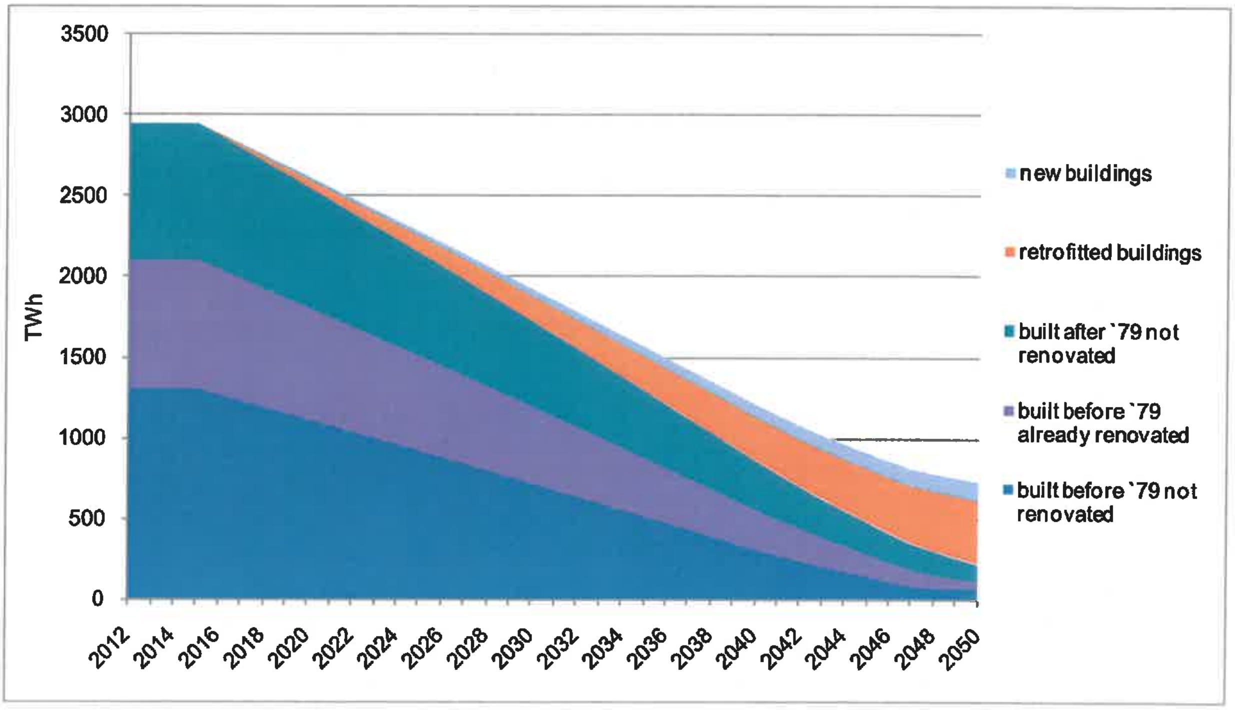

Figure 18 Final Energy for space heating EU27 – track "Target Scenario, Deep Renovation" [TWh/a]

In the "shallow renovation + high use of renewable energy" scenario, energy use for space heating is reduced by approximately 55% compared to 2010. In the "deep renovation" scenario, final energy use for space heating is reduced by approximately 75%.

The development of specific final energy demands per m² of floor area (including new buildings) is given in the following figures.

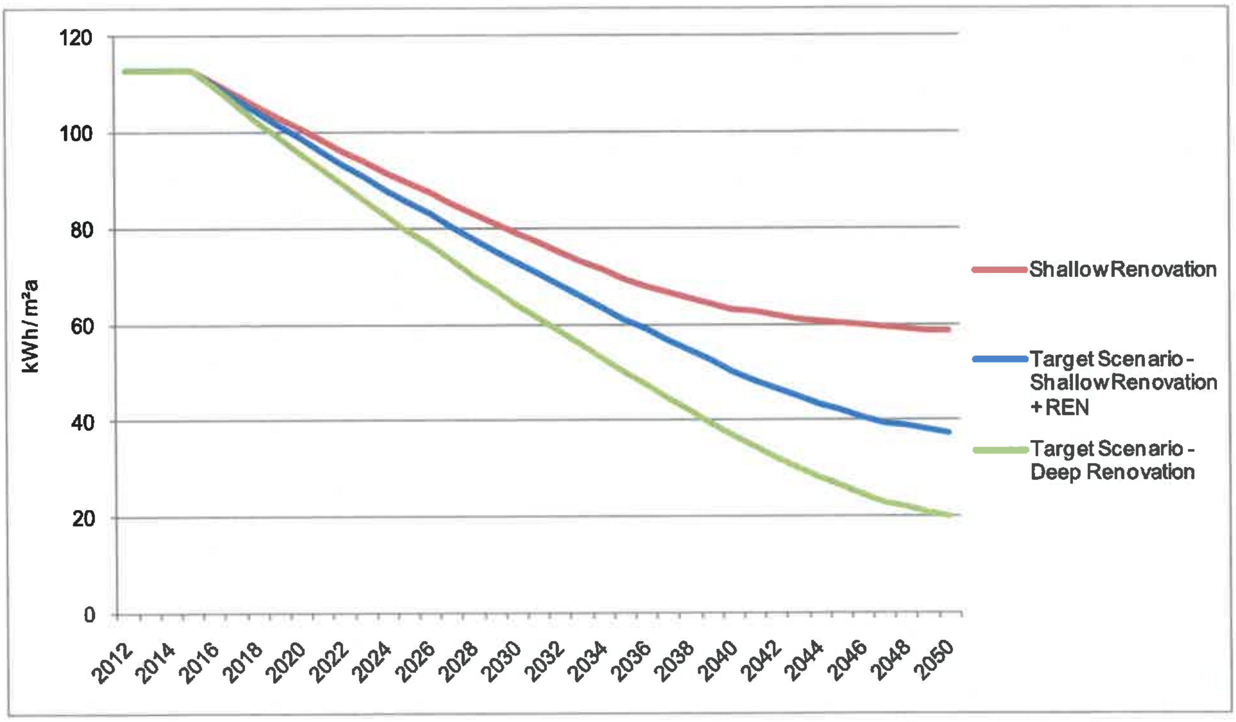

Figure 19 Specific final energy for space heating EU27 [kWh/m²a]

The following graphs describe the final energy use for domestic hot water for the 3 scenarios.

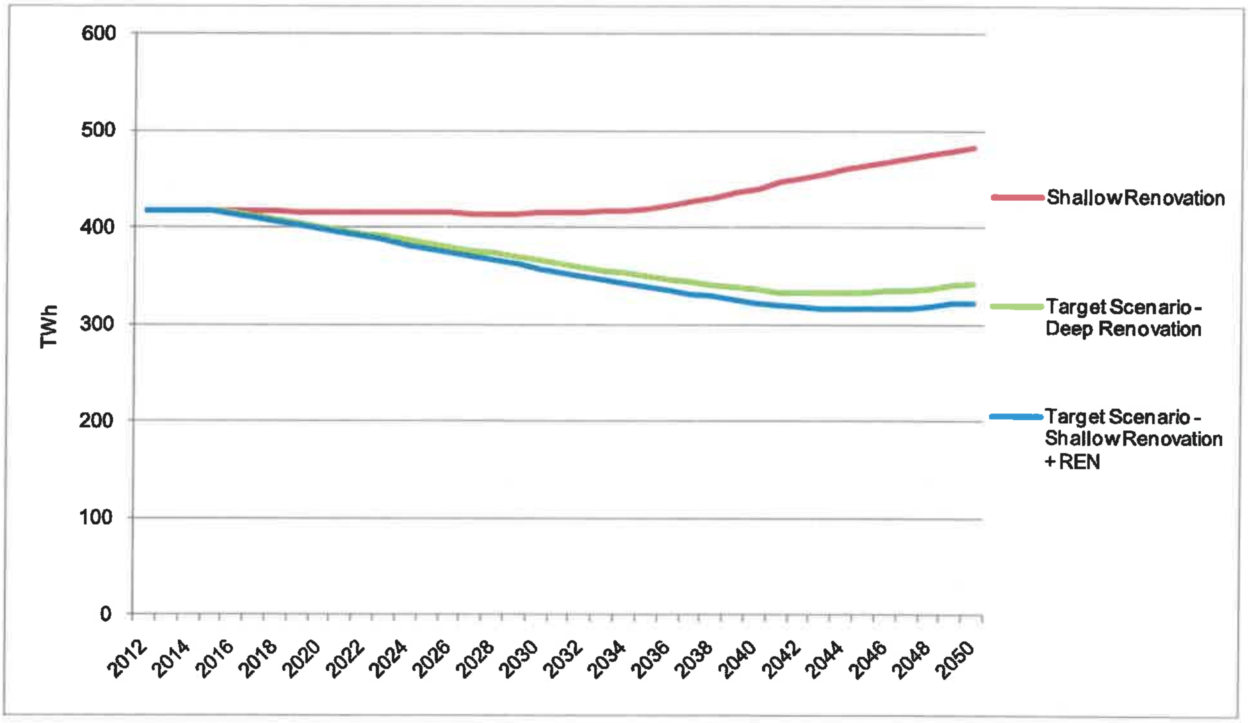

Figure 20 Final energy for domestic hot water EU27 [TWh]

To reduce final energy consumption of the existing building stock by 80% in 2050 (compared to 2010) has been suggested by the European Parliament in the context of the revision of the Energy Efficiency Directive (EED). The following graph looks at this situation for the three scenarios for space heating (excluding new buildings as the Parliament's suggestion is on the existing building stock only).

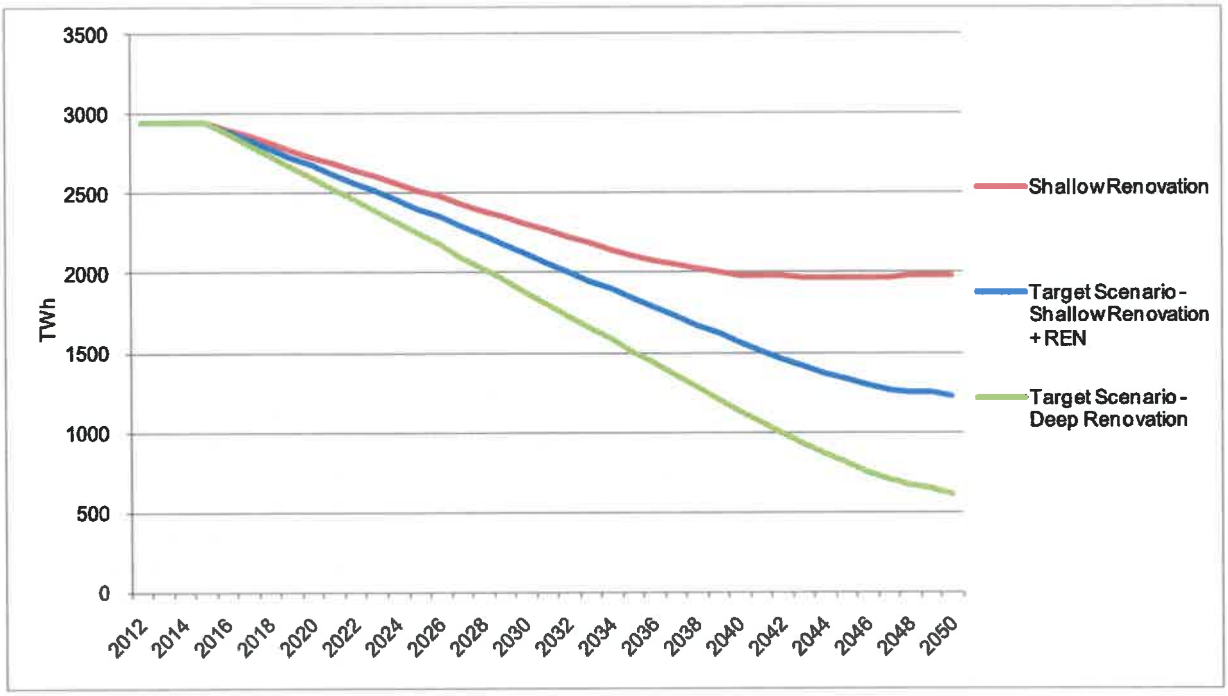

Figure 21 Final Energy for space heating EU27 [TWh/a] without new buildings

The "deep renovation" scenario reduces energy consumption for space heating by approximately 80% of the 2010 level, the "shallow renovation + high use of renewable energy" scenario by 58% and the "shallow renovation" scenario by 32%.

The picture changes somewhat if domestic hot water is also considered, as shown in the next graph.

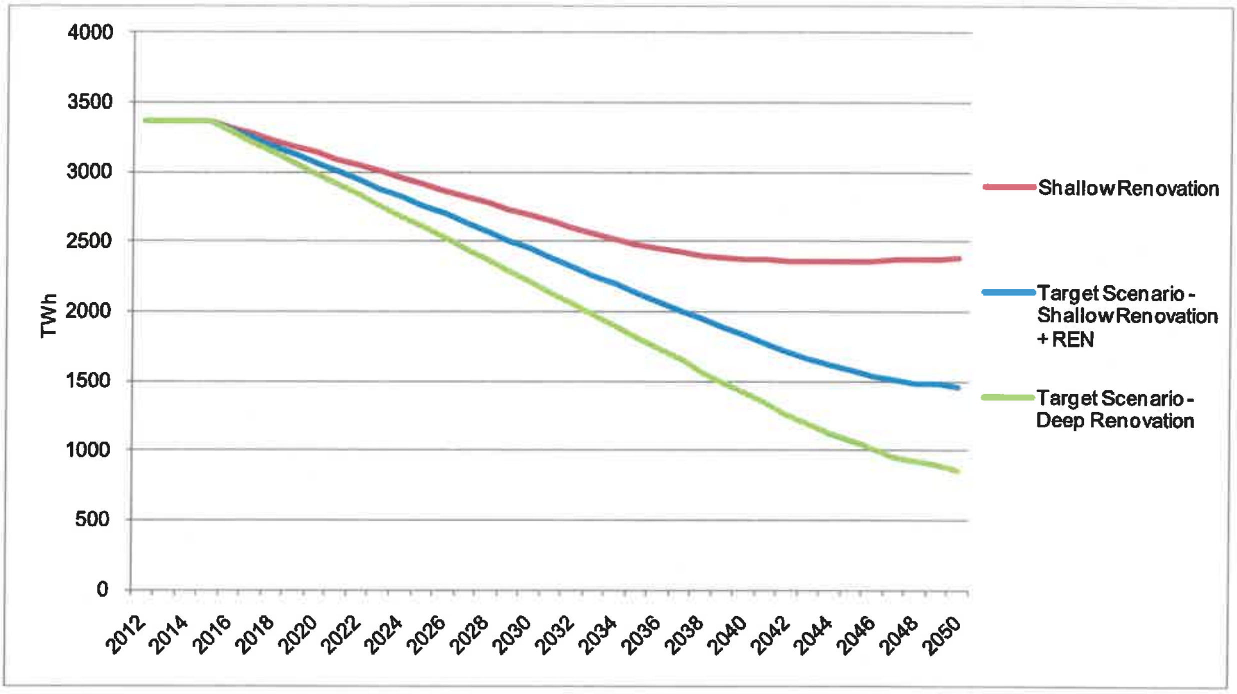

Figure 22 Final Energy for space heating and domestic hot water EU27 [TWh/a] without new buildings

In this case, the sum of final energy use for space heating and domestic hot water is reduced by approx. 75% (deep renovation scenario), 56% (shallow renovation + high use of renewable energy) or 30% (shallow renovation) in 2050 compared to 2010.

If further energy uses (energy for cooling, auxiliary energy and lighting, all primarily supplied via electricity) are considered, related final energy saving potentials would also need to be considered.

For cooling, despite improvement of current systems and possibilities to avoid cooling via passive measures, an increase of cooling energy over time is likely, with a demand for increased comfort given more extreme heat periods in summer due to climate change.

Auxiliary energy is being more used e.g. for fans in ventilation systems, but also improvement potentials are given, for example, by changing pumps in the heating system.

For lighting, significant energy reductions are possible, by use of more efficient lighting systems.

5.4 Energy Costs

The following figures describe the development over time of energy cost for the different scenarios.

The "deep renovation scenario" shows the lowest energy costs for space heating, reducing costs by approximately 30% compared to today's situation. The other two scenarios lead to an increase of 40% (shallow renovation + renewables track) and 55% (shallow renovation track).

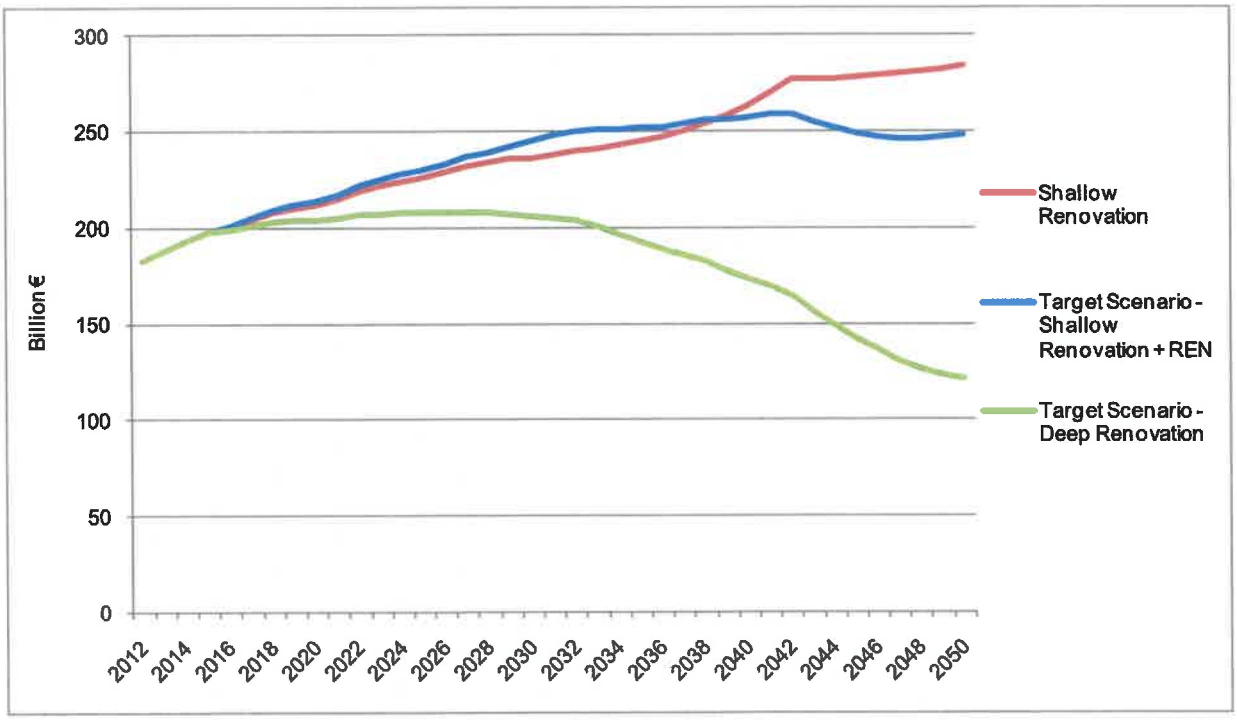

Figure 23 Energy Costs space heating EU27 [billion €/a]

Figure 24 shows the energy costs for hot water. There was little difference in energy costs between the scenarios, unlike the situation for heating. Differences between the scenarios are mainly caused by the difference in supply options and costs for related energy carriers.

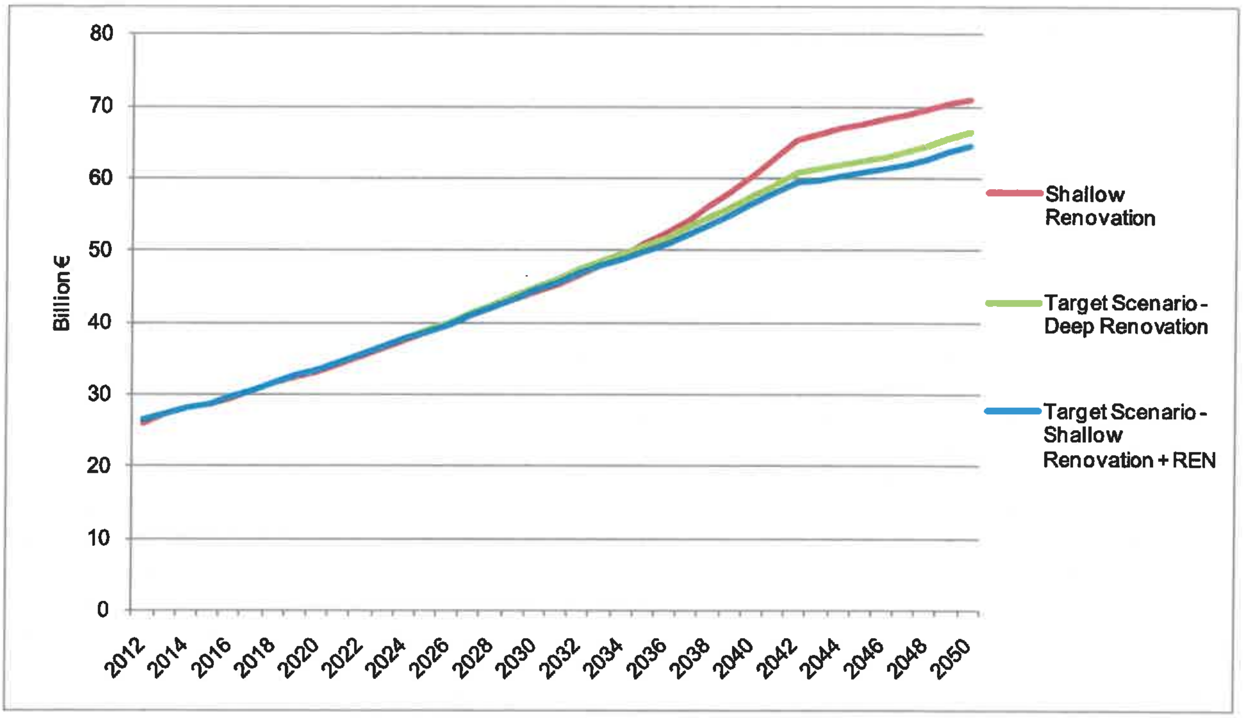

Figure 24 Energy costs hot water EU27 [billion €/a]

5.5 Investments and job creation

Based on investment costs for windows, insulation and building equipment (heating systems, etc.), the following Figure 25 and Figure 26 show the total investment costs per year required for the different scenarios.

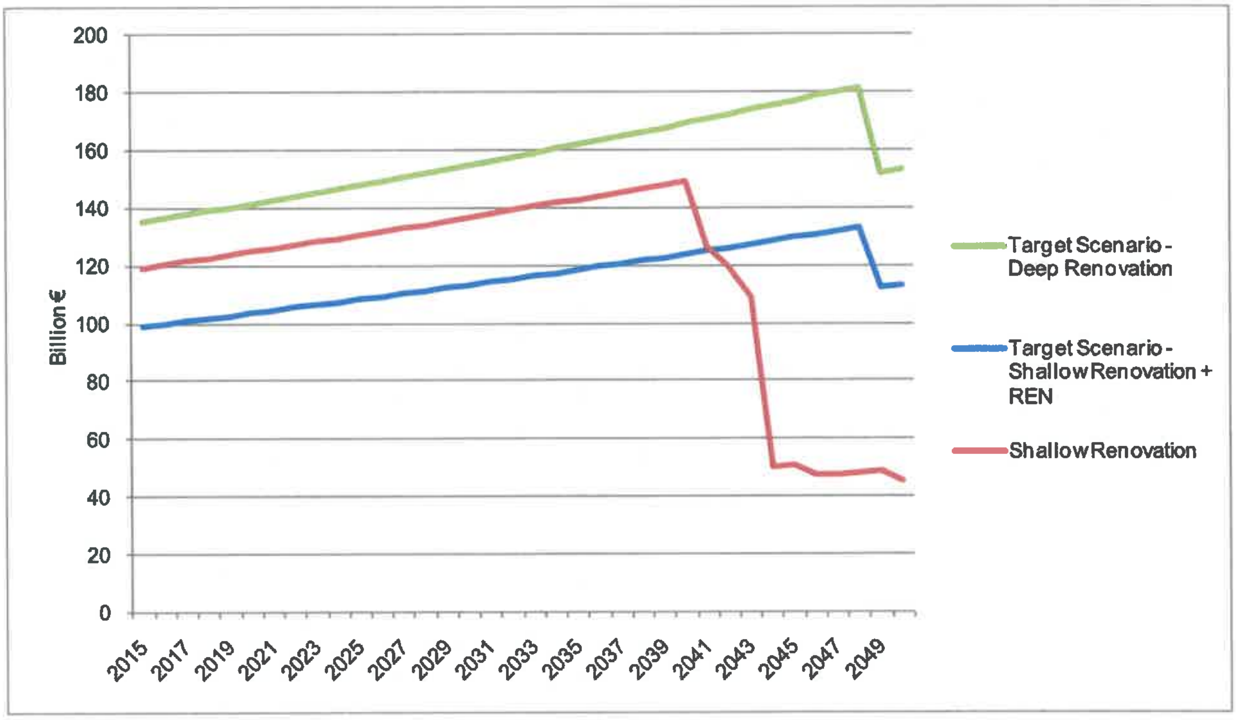

Figure 25 Investments for Insulation and Windows per year EU27 [billion €/a]

In the "shallow renovation" scenario (Track 1), higher investments are necessary (lower investments per building but more renovations per year assumed) until approximately 2044. After that time, the whole building stock is retrofitted in the shallow renovation scenario and investment costs are dropping. Just the part for new buildings is remaining.

For the "Target" scenarios (Tracks 2 and 3) retrofit activities continue to 2050. The "deep renovation" scenario shows higher investments in the building envelope.

Figure 26 shows the investments for heating and ventilation systems.

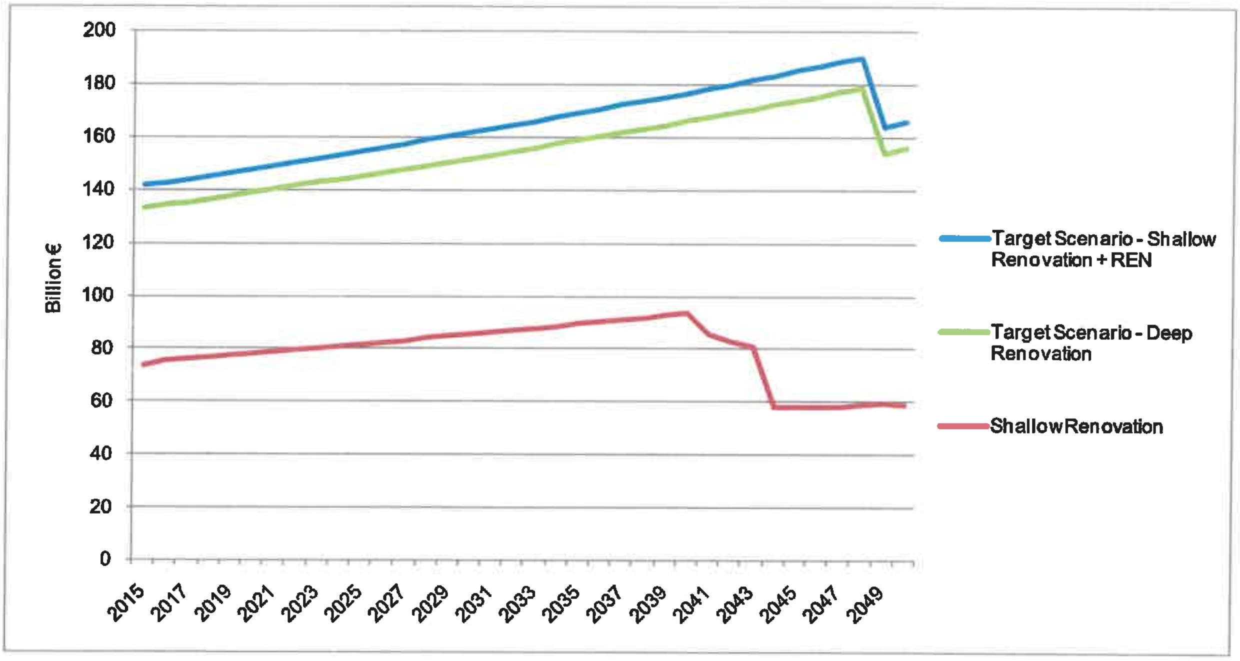

Figure 26 Investments for heating and ventilation systems per year EU27 [billion €/a]

Related to heating and ventilation system, the "shallow renovation" scenario (Track 1) shows lower necessary investments. This is a result of staying with standard fossil systems and not implementing ventilation systems in a large scale.

The following graph shows the total investment necessary for the different scenarios.

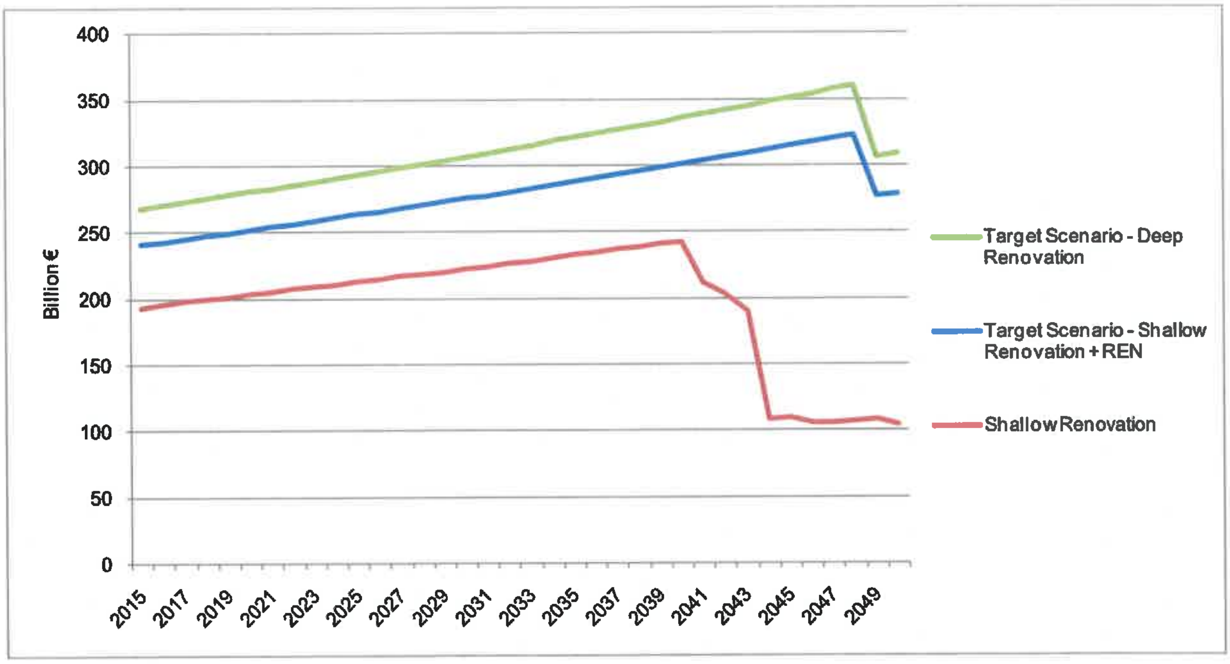

Figure 27 Investments for building envelope (insulation + windows) and heating + ventilation systems per year EU27 [billion €/a]

The "shallow renovation" scenario shows lower investments due to less extensive measures that are not overcompensated in terms of investments by the higher speed of implementation. Around 2044, the "shallow renovation" scenario drops in investments, because most retrofit activities will have finished, except at a low (shallow) ambition level.

The "shallow renovation + renewables" track shows approximately 50 billion EURO of additional investments per year compared to the "shallow renovation" track, while the "deep renovation" track triggers additional investments of approximately 80 billion EURO per year compared to the "shallow renovation" track.

Based on the assumption of approximately 17 jobs created per million invested[17] that would lead to 0.9 million additional jobs (compared to the "shallow renovation" scenario) created and maintained in the "shallow renovation + high use of renewable energy scenario" and 1.4 million additional jobs in the "deep renovation scenario". After 2044, the difference will get even more significant, when investments drop in the "shallow renovation" scenario while renovations continue for the other tracks.

[17] Source: Urge-Vorsatz, D. (2011) et al. Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary. Center for Climate Change and Sustainable Energy Policy - Central European University & European Climate Foundation.

5.6 Total yearly costs

The overall financial performance of the different tracks can be compared by looking at the total costs (annuities to pay for the investments plus energy costs).

Figure 28 shows a comparison between the three scenarios in terms of the total yearly costs.

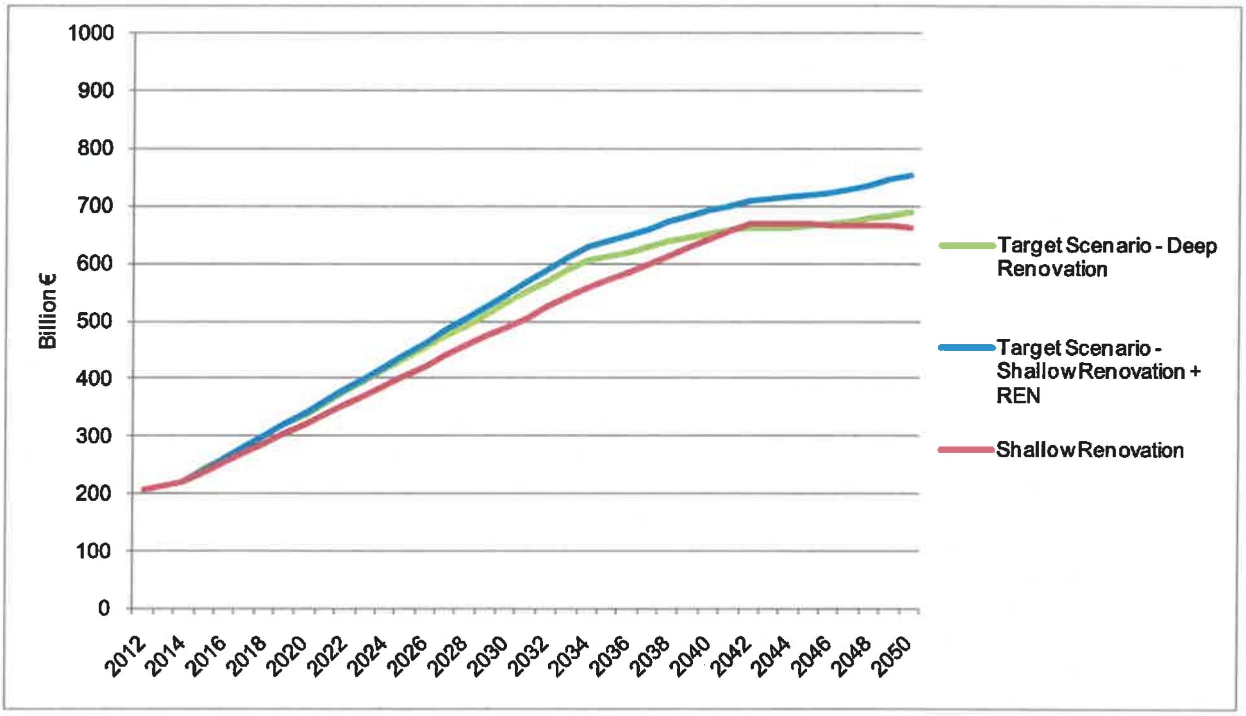

Figure 28 Total yearly Costs EU27 (accumulated) between scenarios [billion €/a]

The graph shows that the three curves are not that far apart from each other; however, the "shallow renovation" scenario comes with the lowest costs, closely followed by the "deep renovation" scenario and the "shallow renovation + high use of renewable energy" scenario.

Track 1 (shallow renovation) misses both environmental targets (CO_2-emission and final energy savings) while not providing substantial economic advantage compared to the deep renovation track.

Track 2 (Shallow renovation + high use of renewable energy) meets the CO_2-target, but shows significantly less energy savings while resulting in slightly higher costs compared to the deep renovation track.

A deep renovation scenario combining a focus on energy efficiency together with high use of renewables, therefore, seems to be the most promising option that should be further explored, also at national level.

As in all scenarios, the entire building stock will have gone through a complete renovation cycle, and the curves will stabilise after 2050, before going down again after some years, when investments have been fully depreciated. The deep renovation track, showing the lowest energy consumption of the three scenarios, will thereby be the least vulnerable against possible further energy price increases and/or inflation.

5.7 Ad-hoc implementation potential

Based on the scenario results from the analysis of the three renovation tracks, the technical potential of an ad-hoc implementation for the measures has been calculated.

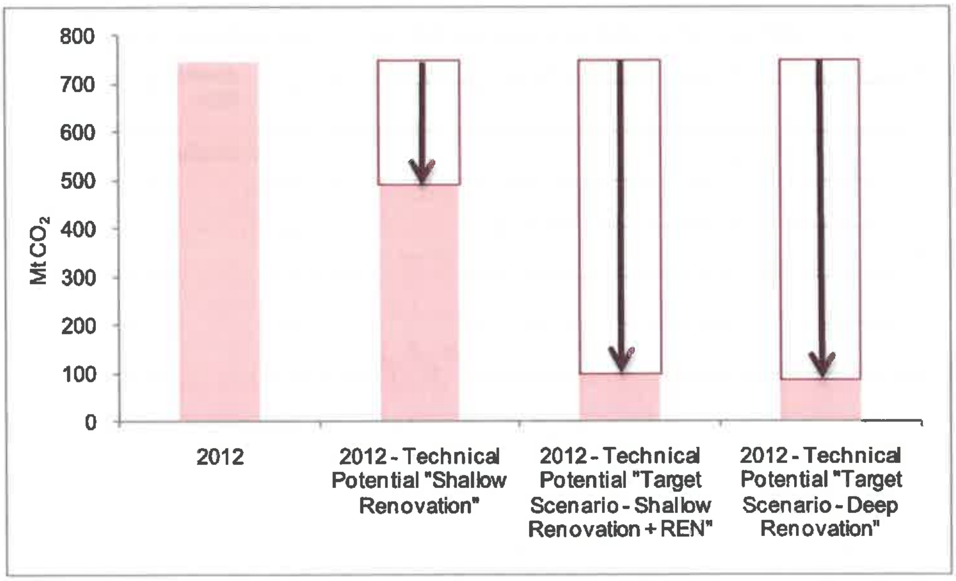

Figure 29 Technical Potential – Effects on the total CO_2-emissions for space heating and domestic hot water (5% emission path) [Mt/a]

Figure 29 shows the CO_2-Emission mitigation potential for the different renovation tracks, which is about 240 Mt for the "Shallow renovation" scenario, about 640 Mt for the "Shallow renovation + high use of renewable energy" and 650 Mt for the "Deep renovation" scenario.

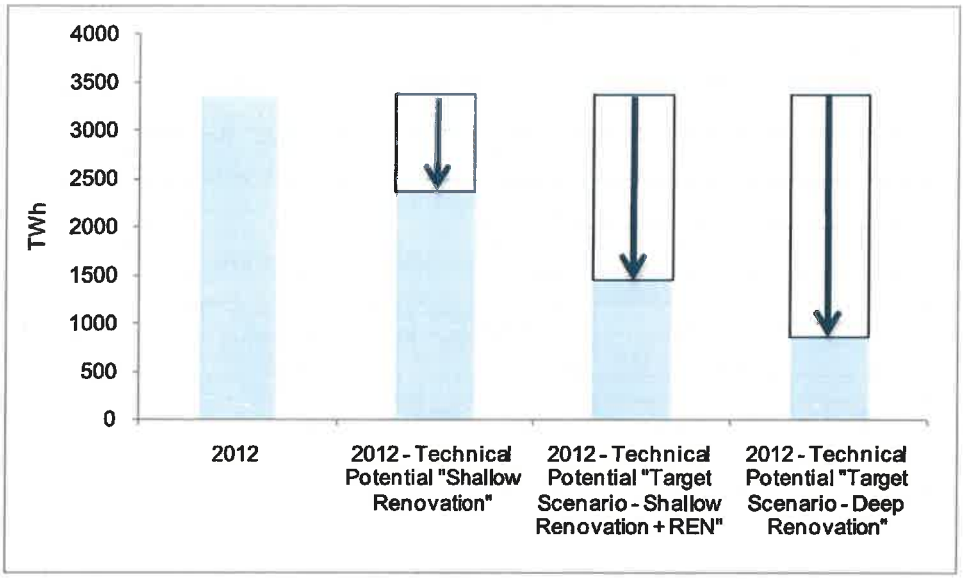

Figure 30: Technical savings potential – Effects on final energy demand for space heating and domestic hot water [TWh/a]

The technical savings potential for the final energy savings is about 1000 TWh for the "shallow renovation" scenario, 1900 TWh for the "shallow renovation + high use of renewable energy" scenario and approximately 2600 TWh for the "deep renovation" scenario.

5.8 Effects on individual building level

Table 11 and Table 12 show the effects on individual building levels. An "average" building in stock has been considered, meaning the heating system, for example, is not a specific one but the "average" heating system in stock for that year.

Table 11 Final Energy Demand and investment costs on building level (derived from reference buildings used in BEAM² model)

Zone	Building	Floor Area	Scenario	Final Energy Demand Heating & Hot Water	Investitionen Insulation	Heating & Ventilation Systems	Annuities Insulation	Heating & Ventilation Systems
				kWh/(m²a)	€/m²	€/m²	€/(m²a)	€/(m²a)
Northern Europe	SFH	125	Not renovated	245	-	-	-	-
			Shallow Renovation	251	459	195	23	14
			Target Scenario - Deep Renovation	61	662	519	33	38
			Target Scenario - Shallow Renovation + REN	138	459	596	23	44
	LMH	3.811	Not renovated	154	-	-	-	-
			Shallow Renovation	124	218	27	11	2
			Target Scenario - Deep Renovation	44	306	188	15	14
			Target Scenario - Shallow Renovation + REN	69	218	216	11	16
Western Europe	SFH	125	Not renovated	307	-	-	-	-
			Shallow Renovation	208	154	62	8	5
			Target Scenario - Deep Renovation	26	226	159	11	12
			Target Scenario - Shallow Renovation + REN	113	154	176	8	13
	LMH	3.811	Not renovated	134	-	-	-	-
			Shallow Renovation	92	72	9	4	1
			Target Scenario - Deep Renovation	21	103	57	5	4
			Target Scenario - Shallow Renovation + REN	51	72	62	4	5
Southern Europe	SFH	125	Not renovated	181	-	-	-	-
			Shallow Renovation	155	148	62	7	5
			Target Scenario - Deep Renovation	10	192	156	10	11
			Target Scenario - Shallow Renovation + REN	61	148	169	7	12
	LMH	3.811	Not renovated	83	-	-	-	-
			Shallow Renovation	69	70	11	4	1
			Target Scenario - Deep Renovation	12	91	59	5	4
			Target Scenario - Shallow Renovation + REN	28	70	64	4	5
North-East Europe	SFH	125	Not renovated	301	-	-	-	-
			Shallow Renovation	186	75	35	4	3
			Target Scenario - Deep Renovation	28	95	145	5	11
			Target Scenario - Shallow Renovation + REN	102	75	99	4	7
	LMH	2.825	Not renovated	159	-	-	-	-
			Shallow Renovation	84	43	7	2	1
			Target Scenario - Deep Renovation	23	54	34	3	2
			Target Scenario - Shallow Renovation + REN	47	43	38	2	3
South-East Europe	SFH	125	Not renovated	308	-	-	-	-
			Shallow Renovation	210	91	32	5	2
			Target Scenario - Deep Renovation	31	119	81	6	6
			Target Scenario - Shallow Renovation + REN	114	91	88	5	7
	LMH	4.796	Not renovated	141	-	-	-	-
			Shallow Renovation	86	45	6	2	0
			Target Scenario - Deep Renovation	24	58	29	3	2
			Target Scenario - Shallow Renovation + REN	47	45	34	2	2

Taking the single-family house (SFH) in Western Europe as an example (see Table 11), the final energy use for a deep renovation drops from 307 kWh/m²a (final energy for space heating and domestic hot water for a non renovated building built before 1979) to 26 kWh/m²a, representing a reduction by 92%.

Table 12 CO_2-emissions (5% emission path) and Energy costs on building level

				CO_2-Emissions			Energy costs		
Zone	Building	Floor Area	Scenario	2015	2030	2050	2015	2030	2050
				kg/(m²a)	kg/(m²a)	kg/(m²a)	€/(m²a)	€/(m²a)	€/(m²a)
Northern Europe	SFH	125	Not renovated	44	27	5	28	27	29
			Shallow Renovation	52	51	50	22	32	44
			Target Scenario - Deep Renovation	15	10	2	8	11	14
			Target Scenario - Shallow Renovation + REN	36	23	4	19	25	33
	LMH	3.811	Not renovated	24	15	3	17	24	16
			Shallow Renovation	26	25	25	11	16	22
			Target Scenario - Deep Renovation	11	7	1	6	8	10
			Target Scenario - Shallow Renovation + REN	18	12	2	9	13	16
Western Europe	SFH	125	Not renovated	62	46	5	20	29	20
			Shallow Renovation	43	42	41	13	19	27
			Target Scenario - Deep Renovation	6	4	1	2	3	5
			Target Scenario - Shallow Renovation + REN	30	19	3	11	15	20
	LMH	3.811	Not renovated	27	21	2	9	13	9
			Shallow Renovation	19	19	18	6	9	12
			Target Scenario - Deep Renovation	5	3	1	2	3	4
			Target Scenario - Shallow Renovation + REN	14	9	2	5	7	9
Southern Europe	SFH	125	Not renovated	44	23	3	16	17	16
			Shallow Renovation	32	32	31	11	16	22
			Target Scenario - Deep Renovation	3	2	0	1	1	2
			Target Scenario - Shallow Renovation + REN	17	11	2	7	9	12
	LMH	3.811	Not renovated	20	11	2	7	8	7
			Shallow Renovation	14	14	14	5	7	10
			Target Scenario - Deep Renovation	3	2	0	1	2	2
			Target Scenario - Shallow Renovation + REN	8	5	1	3	4	5
North-East Europe	SFH	125	Not renovated	88	118	219	16	20	24
			Shallow Renovation	39	38	30	12	17	23
			Target Scenario - Deep Renovation	8	5	1	4	6	8
			Target Scenario - Shallow Renovation + REN	31	20	4	19	25	32
	LMH	2.825	Not renovated	46	62	115	9	10	12
			Shallow Renovation	18	17	16	5	8	12
			Target Scenario - Deep Renovation	6	4	1	4	5	6
			Target Scenario - Shallow Renovation + REN	15	9	2	9	12	15
South-East Europe	SFH	125	Not renovated	56	38	6	16	24	43
			Shallow Renovation	44	43	42	37	17	23
			Target Scenario - Deep Renovation	9	6	1	5	6	8
			Target Scenario - Shallow Renovation + REN	35	22	4	19	26	33
	LMH	4.796	Not renovated	26	17	3	7	11	20
			Shallow Renovation	18	18	17	5	7	10
			Target Scenario - Deep Renovation	7	4	1	4	5	6
			Target Scenario - Shallow Renovation + REN	15	9	2	8	11	14

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