2050 scenario analysis using the EU CTI 2050 Roadmap Tool

BUILDINGS sector

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CLIMACT sa
www.climact.com | info@climact.com | T: +32 10 750 740

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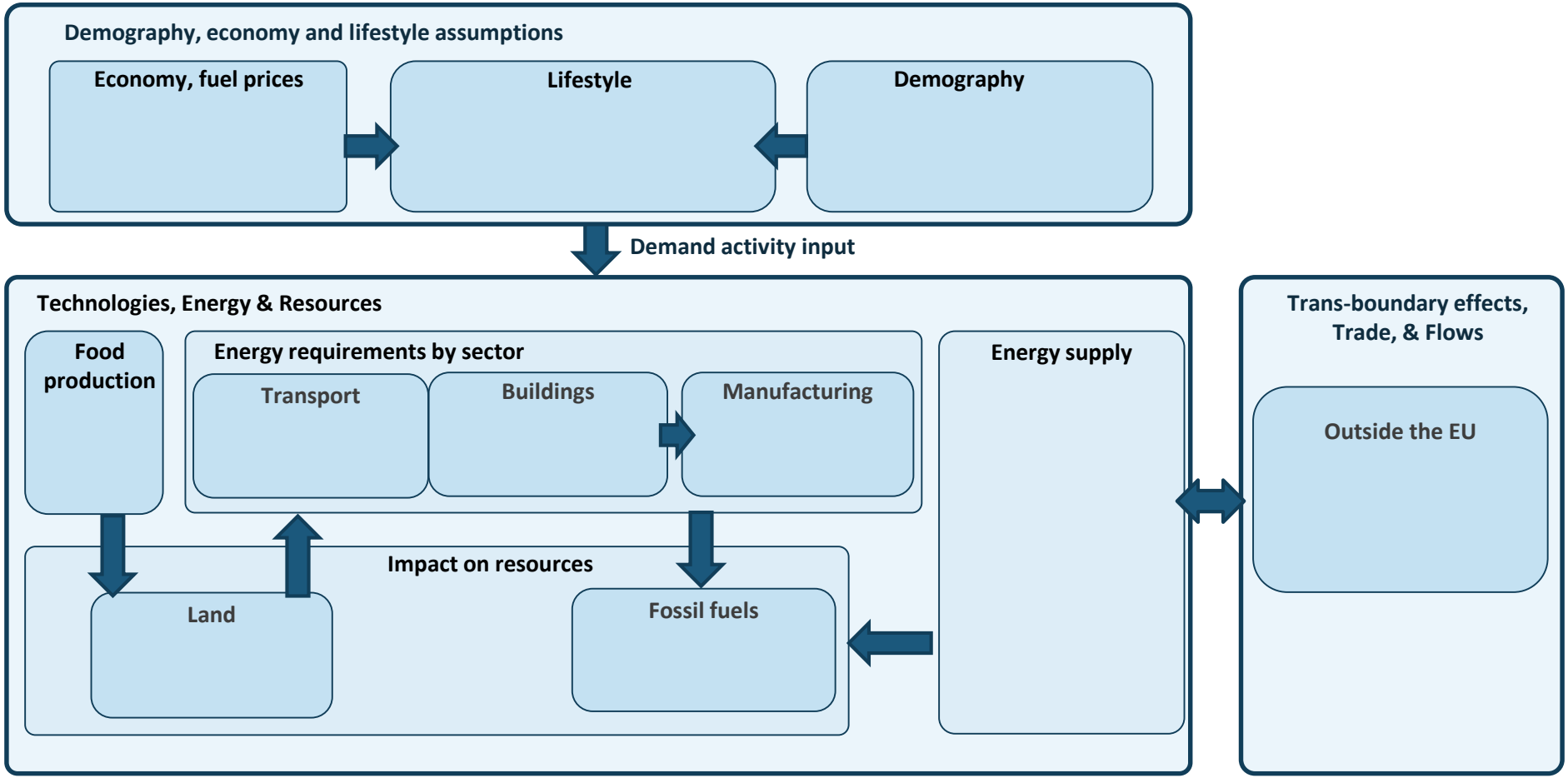
Project context

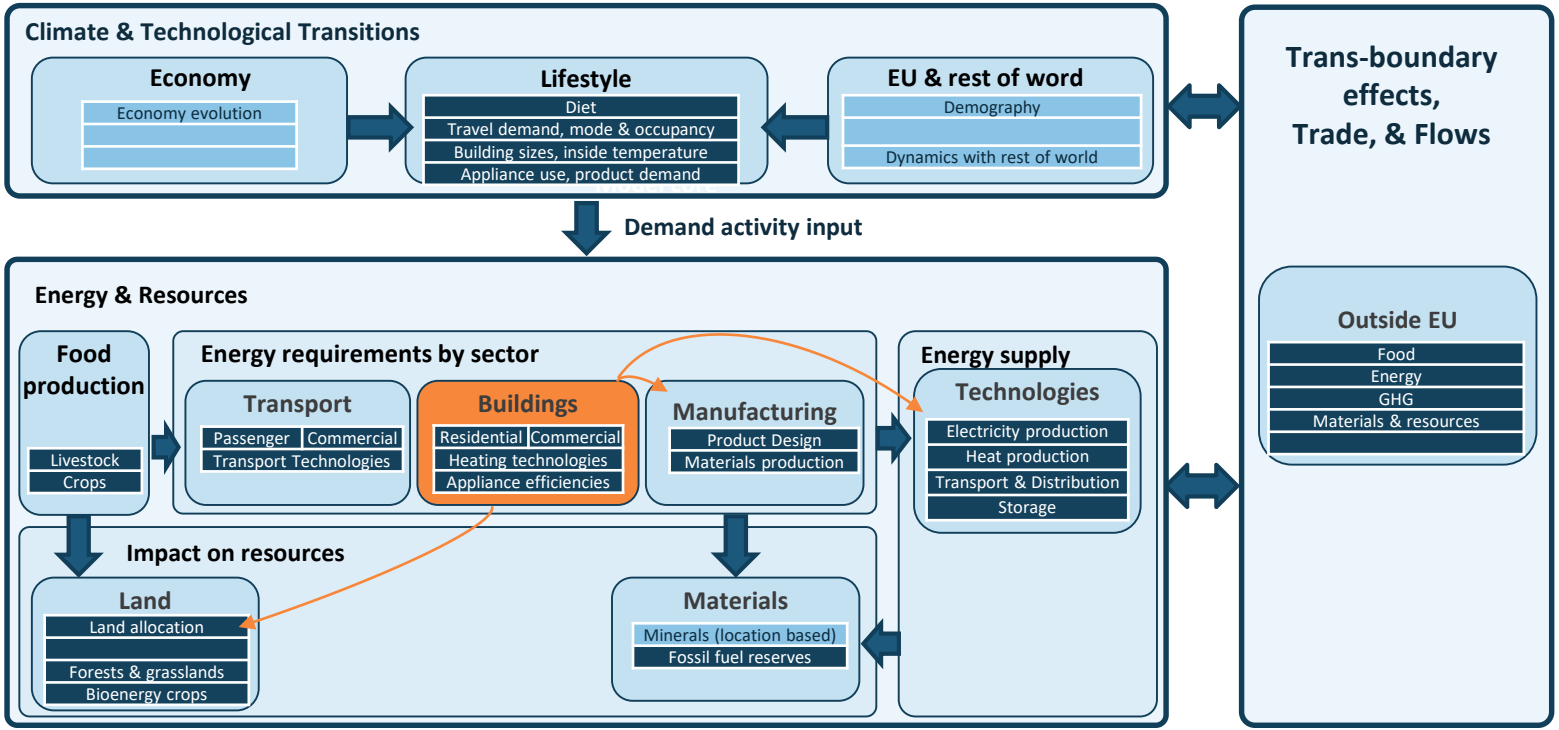
The approach for the buildings sector

Description of the levers

Structure of the ECF EU CTI 2050 Roadmap model



Structure of the ECF EU CTI 2050 Roadmap model



4 ambition levels are used as boundaries to create scenarios
Any value can be chosen in between

Level 0	Level 1	Level 2	Level 3
• **Current development** scenario (existing legal obligations) • No additional effort • « BAU scenario »	• **Increased ambition** compared to BAU • No breakthrough, but more extensive use of existing technologies	• **Ambitious:** Significant effort requiring extensive changes in the system, leveraging best practices available today • Typically reaching –85%	• **Transformational:** Max potential based on transformational changes but reflecting technical or physical constraints

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Description of the levers

Key issues covered in buildings

End-uses of Residential & Services sector	Current data
Heating	• Energy consumption for the different end – uses
Cooling	
Hot Water	• Number of households and total value added of services sector
Lighting, appliances & cooking	• Based upon recent literature and available data sources

Activity levels

- What is the evolution assumed for **population** and **number of dwellings**?
- Which potential evolution for heating, cooling & hot water **demand**?
- What's the impact of **behavioral changes** on the different end-uses?
- What are possible demand evolutions for **electric appliances & lighting**?

What is possible for 2050 ?

Efficiency

- What's the physical limit or **maximal efficiency** improvement of the different technologies?
- Which levels of **compactness of houses** can be expected in the residential sector?
- How fast can buildings be **renovated**?
- What level of **demolition /new buildings** will be realistic?

What will the situation look like in 2020/30/40/50 ?

Technology and energy vector

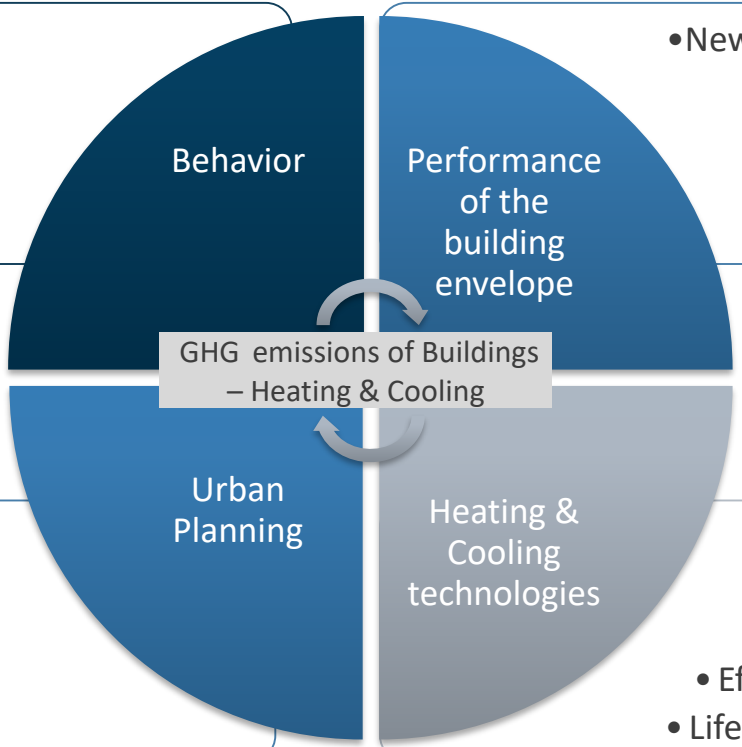
- What can be the maximum and minimum **share of the different heating & cooling technologies** (eg. Individual boilers, district heating)?
- What are the implications of the **fuel & technology shifts** in terms of energy consumption?

Which are the practical implications?

In practice, 4 main group of factors will be covered to test the potential for decarbonizing the heating/cooling of the building sector

Exogenous factors: Evolution of the population & Number of dwellings; Evolution of the services sector

- Cooling demand(*)
- Hot water demand(*)



- New buildings & existing buildings
- Renovation rate
- Speed of demolition/new buildings

- Evolution of surface per building

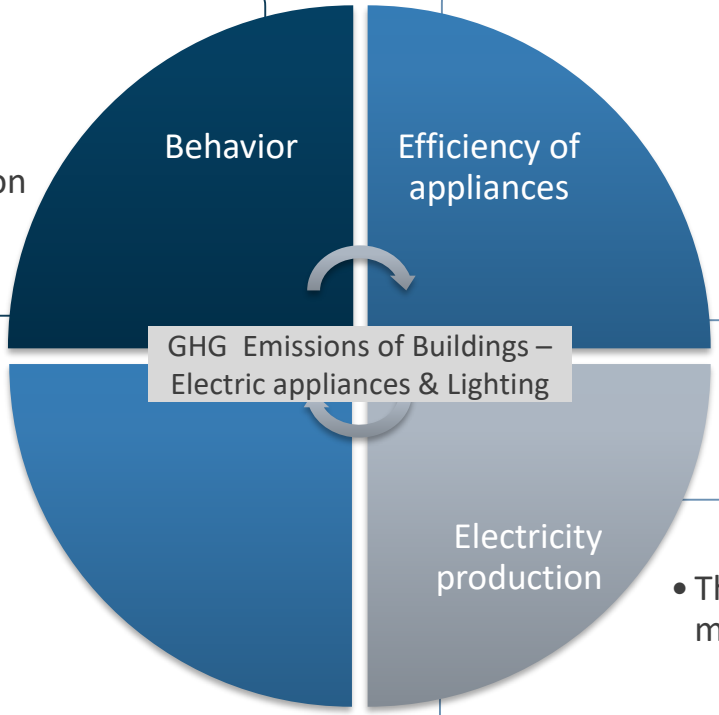
- Evolution of type of heating/cooling/hot water technologies
- Efficiency of these technologies(*)
- Life span of heating technologies(*)

(*) Not implemented

In practice, 3 main group of factors will be covered to test the potential for decarbonizing the electric appliances in the building sector

Exogenous factors: Evolution of population & number of households; Evolution of the services sector (value added)

- Demand [kWh] for:
  - Black goods - White goods
  - Lighting
  - Cooking
- This demand is dependent on utilisation level, purchase level etc.



- Technological potential of efficiency improvement:
  - Black goods - White goods
  - Lighting
  - Cooking

- The supply side is cover in the model of the Power sector

Levers defined in the EU CTI – Residential buildings

			Values for residential buildings[1]	
Lever category	**Lever name**	**Units**	**Level 0**	**Level 3**
Demand for conditioned areas	Floor area requirements	[CAGR of m²/cap]	0,58%/year	-0,30%/year
	Household size	[CAGR of inhabitant/household]	-0,31%/year	+0,15%/year
Buildings efficiency	Renovation depth	[average % savings realized]	20%	90%
Renovation rate	Renovation rate	[%/year]	1%/year	4%/year
	Demolition rate	[%/year`]	0,10%	0,25%
Decarbonized Heat	New/Renovated/Remaining	[Share of fossil fuels in heat]	58%	0% by 2030
Mix of technologies[3]	Heat districts[4]	[% of heat districts in non fossil]	Options between 15% and 35%	
	RES-based single heating systems (SHS) [4]	[% of RES-based systems in non fossil]	Options between 50% and 65% Limited by the heat district contribution.	
	Heat pumps	[% of heat-pumps in RES-based SHS]	19%[2]	80%
	Bioenergy[5]	[% of biomass-firing RES-based SHS]	81%[2]	10%
Appliances	Appliance utilization growth rate	[CAGR on 2015-2050]	2,5%/year	-1%/year
	Appliance standards	[% improvement in 2050 vs 2015]	-33%	-50%
	Cooking electrification	[% of fossil fuel w.r.t. baseline]	100%	0%

NOTE : (1) values are considered to be reached by 2050 if not specified otherwise (2) for space heating, similar logic for water heating (3) The remaining is covered by direct electricity heating (4) These are options rather than ambitions (5) Linked to the 'heat pump' lever, solar thermal then used as buffer

Levers defined in the EU CTI – nonresidential buildings

			Values for residential buildings[1]	
Lever category	**Lever name**	**Units**	**Level 0**	**Level 3**
Demand for conditioned areas	Floor area requirements	[CAGR of m²/cap]	1%/year	-1%/year by 2030
Buildings efficiency	Renovation depth	[average % savings realized]	20%	90%
Renovation rate	Renovation rate	[%/year]	1%/year	4%/year
	Demolition rate	[%/year`]	0,10%	0,25%
Decarbonized Heat	New/Renovated/Remaining	[Share of fossil fuels in heat]	69%	0% by 2030
Mix of technologies[3]	Heat districts[4]	[% of heat districts in non fossil]	Options between 15% and 35%	
	RES-based single heating systems (SHS) [4]	[% of RES-based systems in non fossil]	Options between 50% and 65% Limited by the heat district contribution.	
	Heat pumps	[% of heat-pumps in RES-based SHS]	33%[2]	80%
	Bioenergy[5]	[% of biomass-firing RES-based SHS]	65%[2]	10%
Appliances	Appliance utilization growth rate	[CAGR on 2015-2050]	2,5%/year	-1%/year
	Appliance standards	[% improvement in 2050 vs 2015]	-33%	-50%
	Cooking electrification	[% of fossil fuel w.r.t. baseline]	100%	0%

NOTE : (1) values are considered to be reached by 2050 if not specified otherwise (2) for space heating, similar logic for water heating (3) The remaining is covered by direct electricity heating (4) These are options rather than ambitions (5) Linked to the 'heat pump' lever, solar thermal then used as buffer

Links between levers and end-uses

Lever category	Lever name	Space heating	Water heating	Cooling	Lighting	Appliances	Cooking
Compactness	Floor area requirements	v		v	v		
	Household size		v			v	v
Buildings efficiency	Renovation depth	v		v			
	Renovation rate	v		v			
	Demolition rate	v		v			
Decarbonizing heat	New/Renovated/Remaining	v	v	Elec only			
Mix of technologies	Heat districts	v	v				
	RES-based individual heating	v	v				
	Heat pumps/Bioenergy	v	v				
Appliances	Appliance utilization growth					v	
	Appliance standards		v	for exist. systems	v	v	
	Cooking electrification						v

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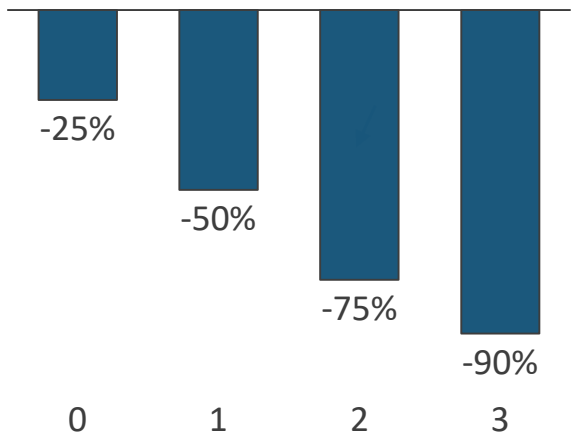
The approach for the buildings sector

Description of the levers

- **Buildings efficiency**
- Decarbonizing heat
- Mix of technologies
- Appliances

Renovation depth: Ambition levels

Average energy savings of renovation in the EU
[% reduced w.r.t. initial consumption]



Rationale for the levels:

Level 0. Current average energy savings of building renovation occurring at a 1%/year rate

Level 1. Factor 2: Existing growing initiatives (e.g. RenoWatt (BE), Picardie Pass Renovation (FR),

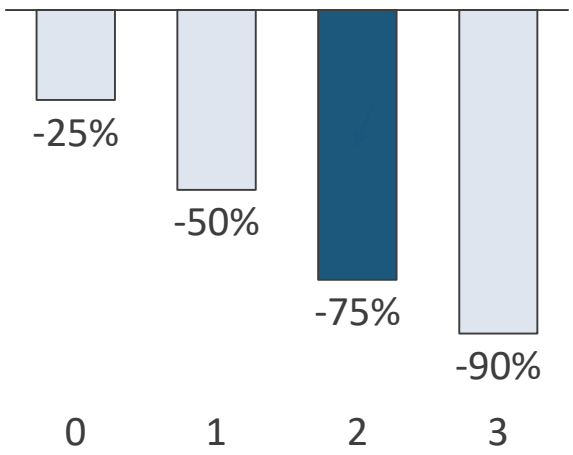
Level 2. Factor 4: High political ambition and best-practices initiatives
(Renovation strategies (BE, FR), DoRéMi (FR), EnergySprong (NL, UK, FR))

Level 3. Factor 10: Scaling up pilot projects

Example of Level 2 vs Level 3: Building Sector

Level 2: Factor 4 energy renovation is ambitious but realistic

Average energy savings of renovation in the EU
[% reduced w.r.t. initial consumption]

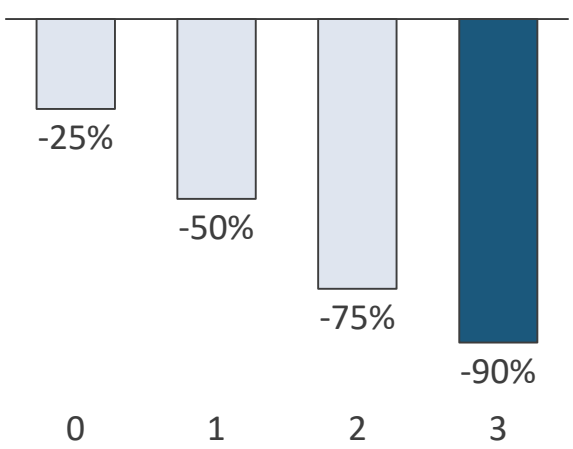


- **There is a growing political will laid down in renovation strategies** (2050 targets):
  - FR: Renovation of all the buildings stock at BBC level (80kWh/m²/year)(i)
  - BE (Wallonia): Reaching in average 85kWh/m²/year for residential buildings(ii), net zero energy for non-residential ones(iii)
- Best-practice initiatives rely on different strategies, involving stakeholders differently:
  - EnergieSprong: standardized procedures , **industrialization and pre-fabricated** modules
  - DoRéMi: **capacity buildings for local labor force**

Notes: (i) with variations according to climate zones (ii) heating, cooling and ancillaries (iii) idem residential + lighting

Level 3: Factor 10 energy renovation is feasible but requires transformational changes for deployment

Average energy savings of renovation in the EU
[% reduced w.r.t. initial consumption]



- **There exist pilot projects** targeting the diversity of typologies (see next slide)
- Factor 10 needs **disruptive technologies and processes,** so support to R&D and pilot projects (see e.g. P2ENDURE and links on next slides for examples of technical solutions)
- It can probably be rolled-out **only with industrialized solutions** (so lower benefits for local actors/SMEs)
- It needs **strong building codes for renovation** compared to Factor 4 renovation (Level 2)

Factor 10 energy renovation is feasible but needs strong support and (reinforced) building codes for renovation

Selection of factor 10 renovation examples
[% reduced w.r.t. initial consumption]

Residential
-87% of 3 story multifamily terrassed houses (link)


Frankfurt

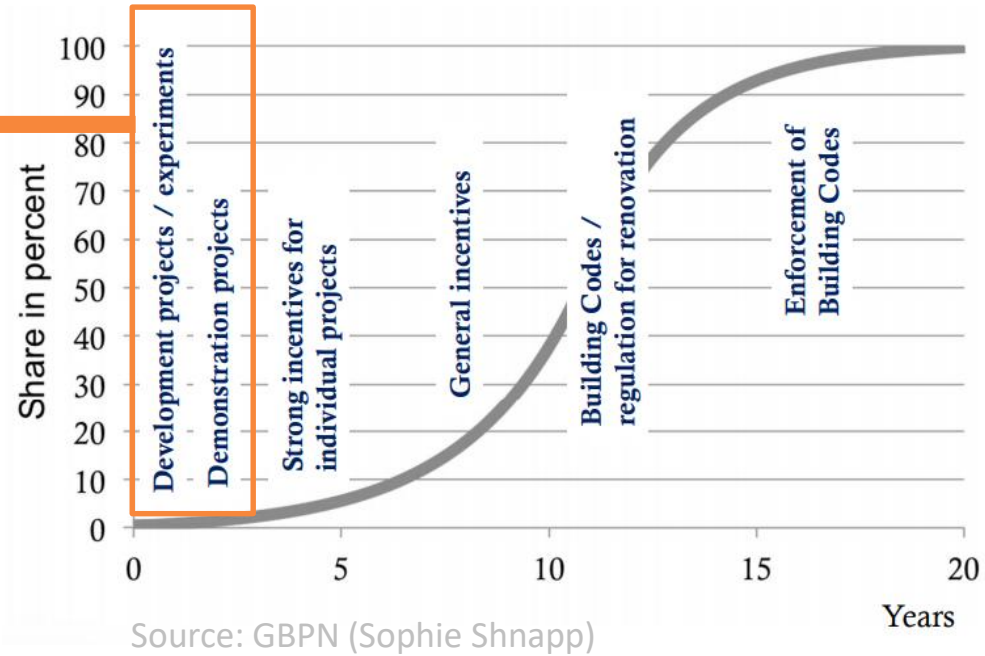

Paris

Office building
413 > 37kWh/m²/year
1.900€/m², 5€/saved kWh
(link)

School
220 > 28kWh/m²/year
(6 class rooms, 733m²)
(link)


Portugal

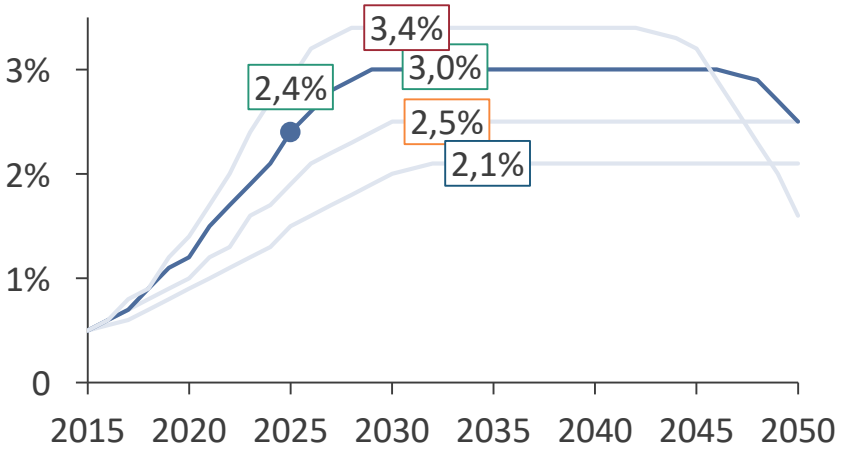
Potential time evolution for the penetration of factor 10 renovation



Source: GBPN (Sophie Shnapp)

The renovation rate needs to be significantly increased to renovate the whole park by 2050. Level 3 allows to go even faster.

Renovation rate in the EU in the 4 ambition levels
[%/year]



Rationale for the levels:

Level 0. Low ambition/realization of current policies: Even if MS are required to develop renovation strategies, results have not been proven on the field yet. **60%** is renovated by 2050

Level 1. Best-practice policies are deployed and deliver: 2,5%/year by 2030, **75%** is renovated by 2050

Level 2. Optimistic interpretation of best-practice policies: renovation of most buildings by 2050 (e.g. FR, Wallonia)
3%/year by 2030, **87%** is renovated by 2050 (i)

Level 3. Building codes for renovation and binding targets for MS:
3,4%/year by 2030, **96%** is renovated by 2050(i)

Note: (i) if not demolished

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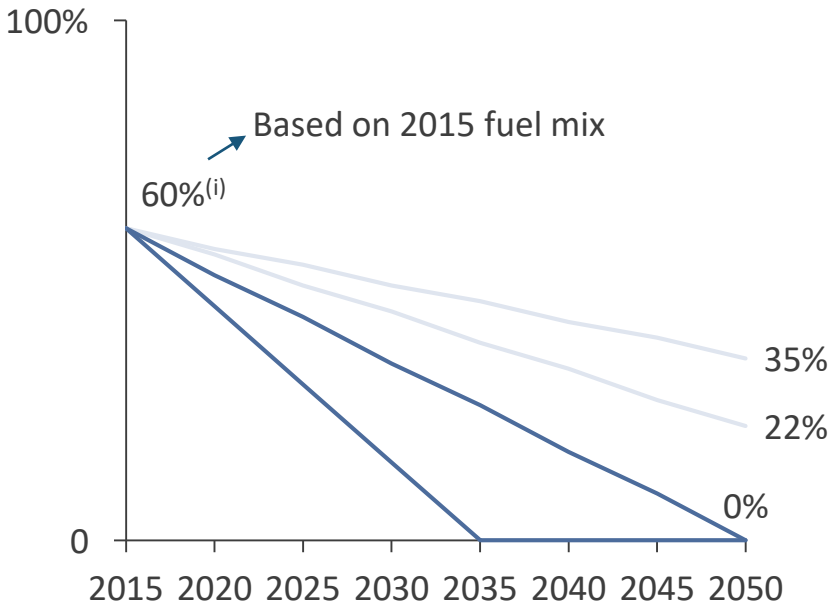
- Buildings efficiency
- **Decarbonizing heat**
- Mix of technologies
- Appliances

Full heat decarbonization by between 2050 and 2035 is realistic, many cities/localities have already pledge to reach 100% RES heat

Share of fossil-fuel heating in EU residential buildings for the four ambition levels
[% of energy used for heating]



Note: (i) 71% in service buildings

Source: Ecofys, 2016. EU pathways to decarbonized heating sector

Rationale for the levels:

Level 0. Trend toward **decarbonized heat by 2100**
There remain supports to fossil-fueled heating systems, low fossil-fuel prices

Level 1. Trend toward **decarbonized heat by 2070**

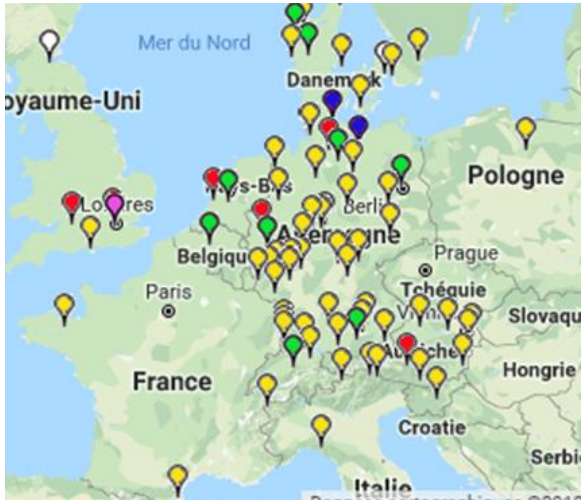
Level 2. Ambitious policies are adopted and deliver DK targets 100% RES heat by 2050
Many cities/localities have already pledge to reach 100% RES heat (see next slide)

Level 3. Best-practice policies are adopted and deliver **e.g.** 100% RES heat by 2030 targeted by Upper Austria. 2035 is considered to account for a minim 15-year lifetime of heating systems

The means to provide the decarbonized heat is defined by other levers (see following slides)

Dozens of territories and institutions in the EU have shifted or are committed to shifting within the next few decades to 100% renewable energy in at least one sector(i)

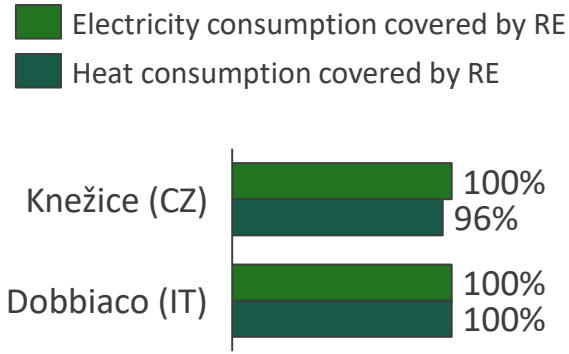
Pledges logged on GO100%.org(1)



- EU:
  86 pledges logged on the platform
- Worldwide:
  - 59 Countries,
  - 72 Cities,
  - 63 Regions/States,
  - 9 Utilities,
  - 21 NonProfit/Educational/Public Institutions,

  Totaling
  more than 1.8 billion people

100% RES champions(2)



Note: (i) e.g. electricity, transportation, heating/cooling

Source: (1) http://www.go100percent.org/cms/index.php?id=19 (2) http://www.go100re.net/wp-content/uploads/2014/11/RES-Poster_A1.pdf

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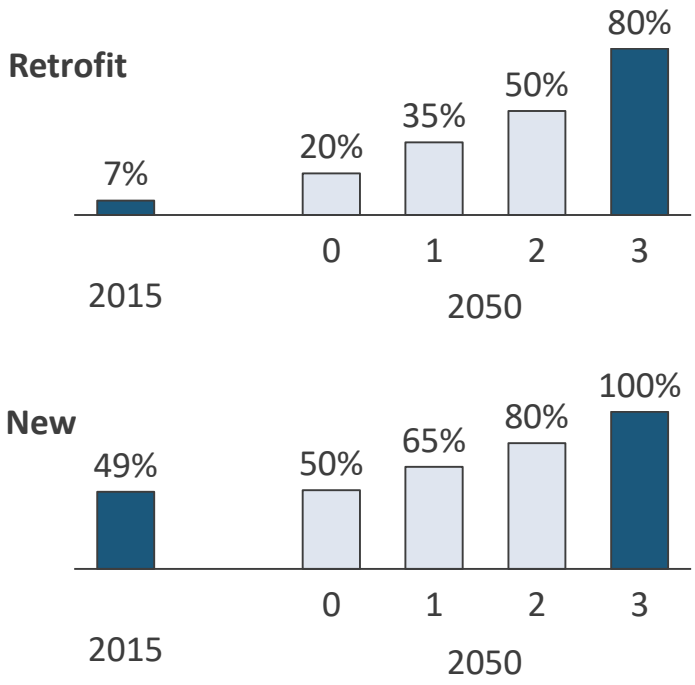
Heat pumps could provide up to 65% of the heat load in retrofitted systems and 100% in new buildings

Share of heat pumps in the heating energy
[% w.r.t. RES-based single heating systems]



Rationale for the levels (based on Ecofys 2013[(1)(i)]):

Level 0. Current policy implementation

Level 1. Moderate heat pump ambition scenario
defined as intermediate between 1 and 3

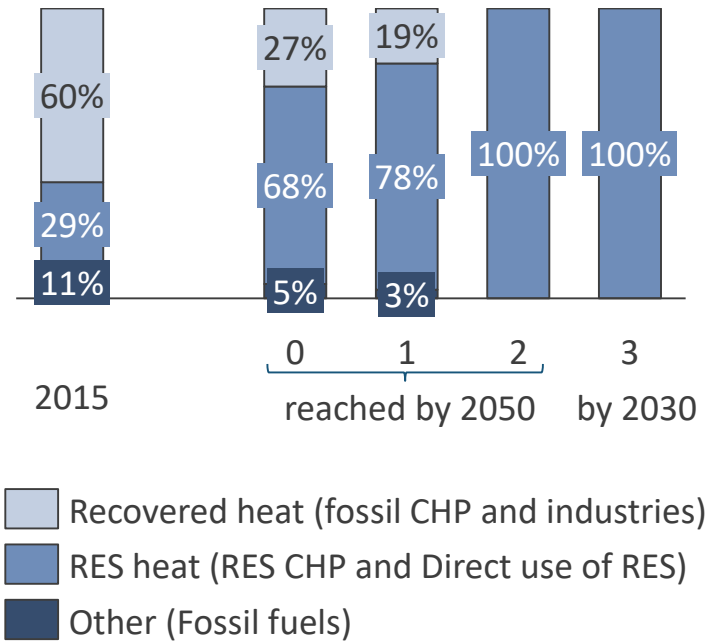
Level 2. Ambitious heat pump scenario
In terms of shares in new sales, this corresponds to 50% in new installations and 30% in retrofits

Level 3. Very ambitious heat pump scenario
In terms of shares in new sales, this corresponds to 65% in new installations and 50% in retrofits (i.e. 100% of sales in individual heating systems)

Note: This leads so similar ambitions (in terms of number of systems) than the ones suggested by Ecofys[(1)], when combined with the maximum ambition for RES-based SHS (65%)
Source: (1) Ecofys, 2013. Heat Pump Implementation Scenarios until 2030

The carbon intensity of heat districts is derived from the heat decarbonization lever

Heat district by type of heating energy
[% of heat provided by HD]



Impact of non-RES heat on GHG emissions:

- Emissions from recovered heat are accounted in the power and industry models
- Emissions from fossil fuels are derived based on a mix similar to the one of individual heating systems

The rationale follows the one of heat decarbonization lever:

Level 0. Trend toward decarbonized heat by 2100

Level 1. Trend toward decarbonized heat by 2070

Level 2. Heat districts decarbonized by 2050

Level 3. Heat districts decarbonized by 2030

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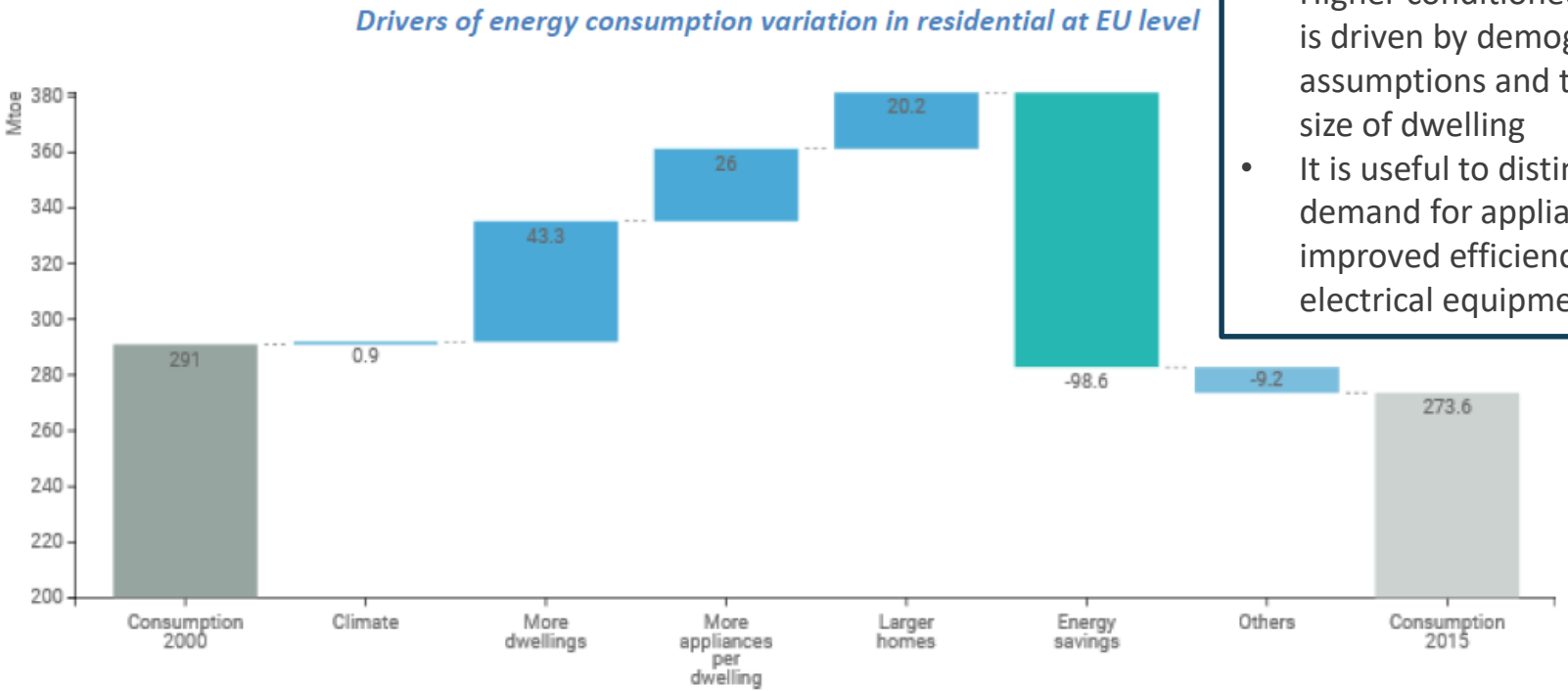
- Buildings efficiency
- Decarbonizing heat
- Mix of technologies
- **Appliances**

Most of energy savings are offset by a growing demand as shown in this slide for historical consumption (2000 to 2015)



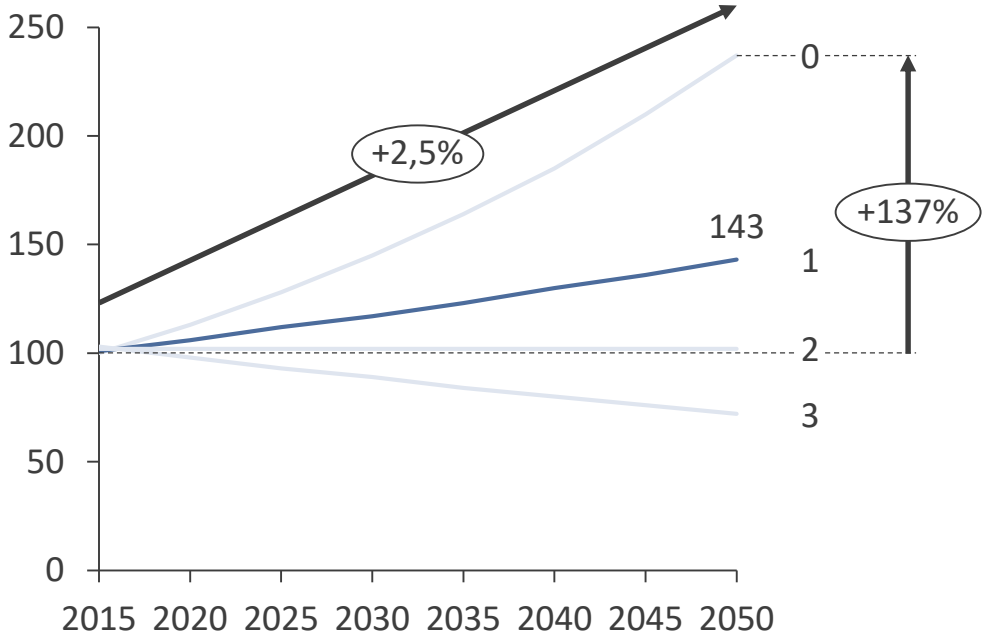
- Higher conditioned space area is driven by demographic assumptions and the average size of dwelling
- It is useful to distinguish higher demand for appliances from improved efficiency of electrical equipment

Drivers in the EU CTI model:	Number of households	Appliance utilization Growth rate	Floor area requirement	energy efficiency of heating and appliances (a.o.)

Source: www.odyssee-mure.eu

In the BaU demand for appliances is projected to increase by 137%

Evolution of electricity-dependent services of households with constant efficiency [% w.r.t. demand in 2015]



Source: (1) CE - 2013 - EU Energy, transport and GHG

Rationale for the levels:

Level 0. EU Reference scenario 2013(1)
The projection is obtained by removing the effect of energy efficiency and demographic evolutions from the projections for the electricity demand in households

Level 1. Growth limited to +1%/year

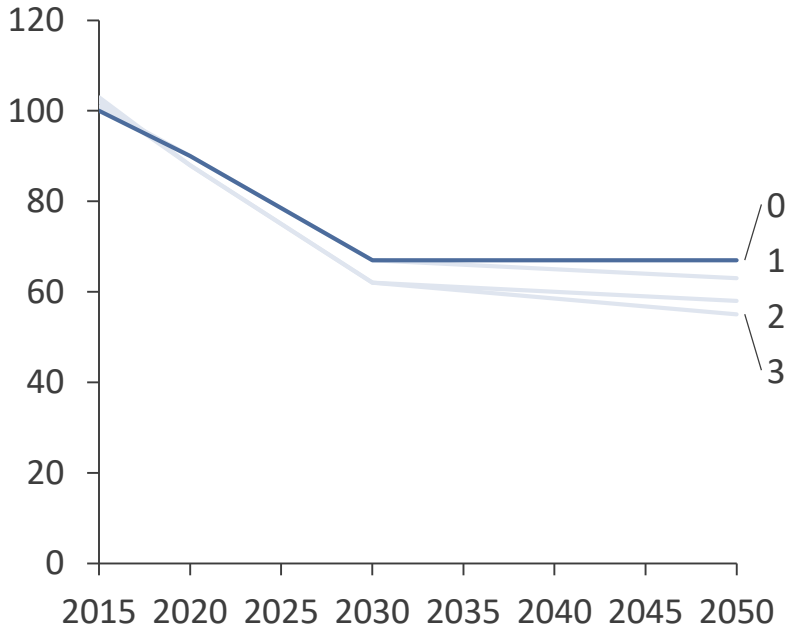
Level 2. Appliance utilization stabilized at today's level

Level 3. Reduction with -1%/year

The resulting electricity consumption for appliances results from the combination of this lever with the one defining energy efficiency improvement

Energy efficiency of electrical equipment is projected to increase up to 2030

Evolution of energy intensity of appliances
[% w.r.t. demand in 2015]



Rationale for the levels:

Level 0. EU Reference scenario 2013(1)
-2,0%/year up to 2020
-2,9%/year up to 2030
-0,1%/year up to 2050

Level 1.
Higher improvements on 2030-2050:
additional -0,5%/year

Level 2.
+ Higher improvements on 2020-2030:
additional -0,5%/year

Level 3.
+ Further improvements on 2030-2050:
additional -0,5%/year

Source: (1) CE - 2013 - EU Energy, transport and GHG