A Low-carbon roadmap for Belgium

Study realised for the FPS Health, Food Chain Safety and Environment

Industry sector – glass document

This document is based on content development by the consultant team as well as expert workshops that were held on the 19-05-2011, and 20-06-2011 for the Wallonia scope

This document has then been reviewed in 2013 for the Belgian scope

Content – Industry sector - glass

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Executive summary for the glass sector

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Construction of different future production trajectories

- 3 trajectories for glass production have been defined, they show **a strong variation from ~+95% to ~-15% by 2050**
  - The high demand trajectory assumes a high growth in the flat glass, fibre glass and other glass sectors and a stability of the hollow glass sector. It also assumes the recovery of several flat glass ovens and the creation of a new hollow glass installation by 2015
  - The intermediary trajectory assumes 0 growth
  - The low demand trajectory assumes a 50% decrease of the hollow glass sector and a 10% decrease of the other sectors

Estimate of potential and cost for the GHG reduction opportunities

- **The Glass GHG emission reduction potential (at constant production) is significant (~ 63% in level 3),**
  - **Energy efficiency** can still by improved and bring up to ~11% reductions
  - Within **process improvements**, **cullet** increase can bring 4% reduction for a 2€/tCO_2e gain and **oxycombustion** 11%
  - **Fuel substitution by gas and biomass** also has potential (~6% and 3%)
  - **CCS is unavoidable** to significantly reduce GHG emissions (28% in level 3, 0% in level 2) for ~€ 50/tCO_2e

NOTES Reduction potentials are for an ambition levels 3, expressed as a % of the 2010 GHG emission level except where explicitly mentioned otherwise.
The reduction in each step represents the additional reduction percentage after all the previous levers have been applied.
This is why : (1) The reductions of the actions add up to the total reduction of the sector (levers are applied in the sequential order represented here)
(2) Level 4 ambition can therefore be smaller in cases where more potential has been achieved with the previous levers
There is a double counting between the biomass potentials mentioned here and in the supply section, it is removed in the OPE²RA model

Reference list

- FIV/VGI (Fédération de l’industrie du verre, verbond van de glasindustrie) data
- Syndical federation of the French glass industry, Annual report, 2007.
- European Commission, Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Glass Manufacturing Industry, December 2001 & July 2009.
- Beerkens, Energy Balances, 2006.

Content – Industry sector - glass

A detailed analysis is performed for each industrial sector, the methodology is detailed in the general industry document (and not repeated in each sector document)

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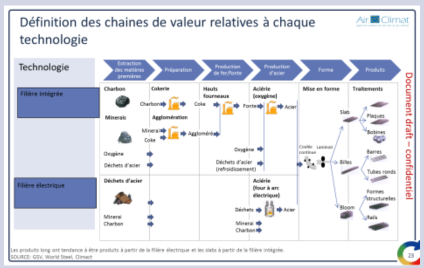
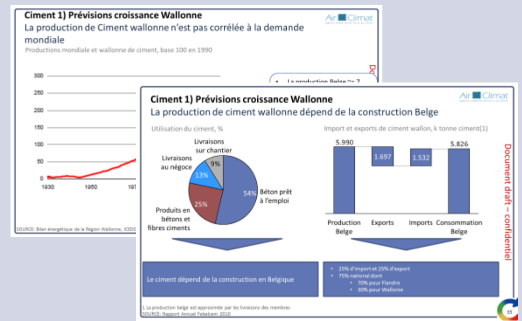
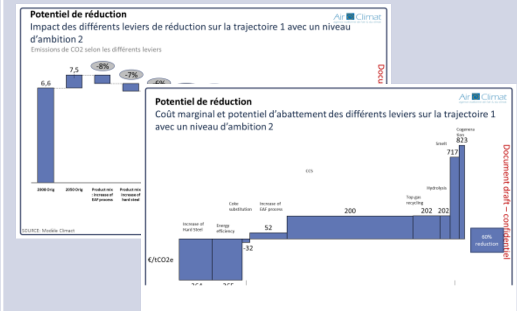
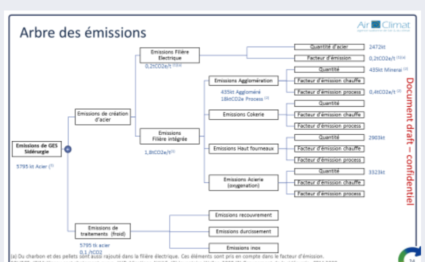
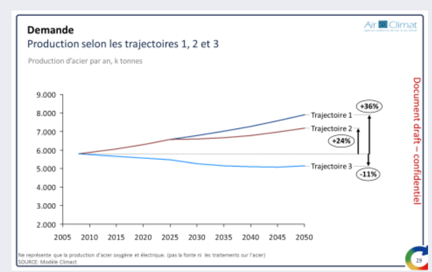
	Understanding the industry	Modelling demand trajectories	Modelling trajectories with intensity levels + CCS
Analyses	Definition of the value chain	Analyses of growth and competitiveness	Potential of CO_2 reduction incl. costs
Results	Modelling the emissions tree	Demand trajectories	Trajectories with different intensity levels + CCS

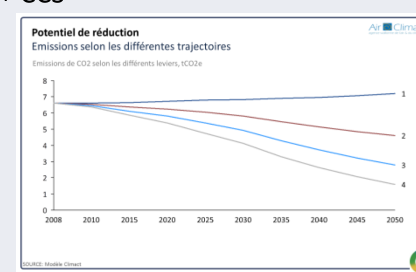








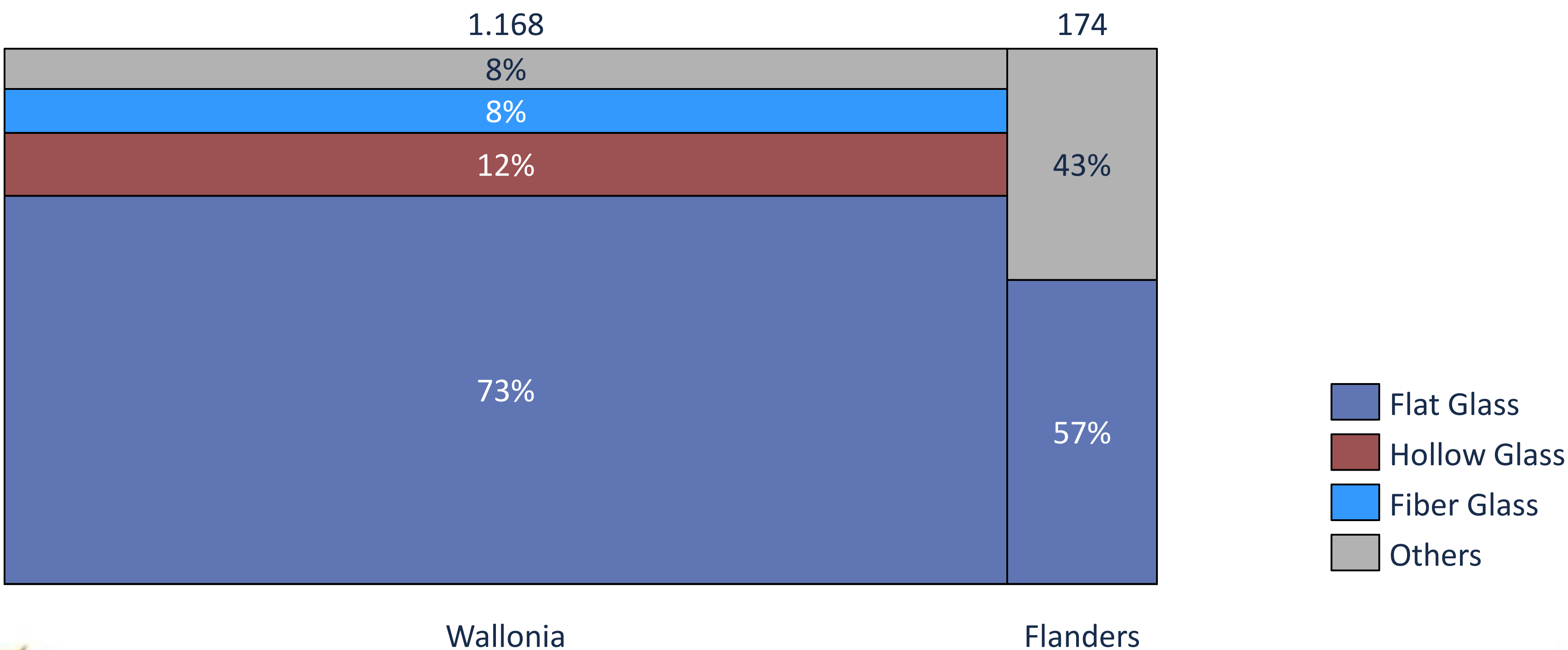




SOURCE: Climact

Most of the Glass production is in Wallonia, so most results of the Wallonia low Carbon growth analysis can be reused in this analysis

Glass production per region
(Ktons commercialized glass)



SOURCE: Flanders data from 2010 FIV statistics, Wallonia data from 2010 Wallonia energy balance

Consumption profiles differ significantly per sub-industry

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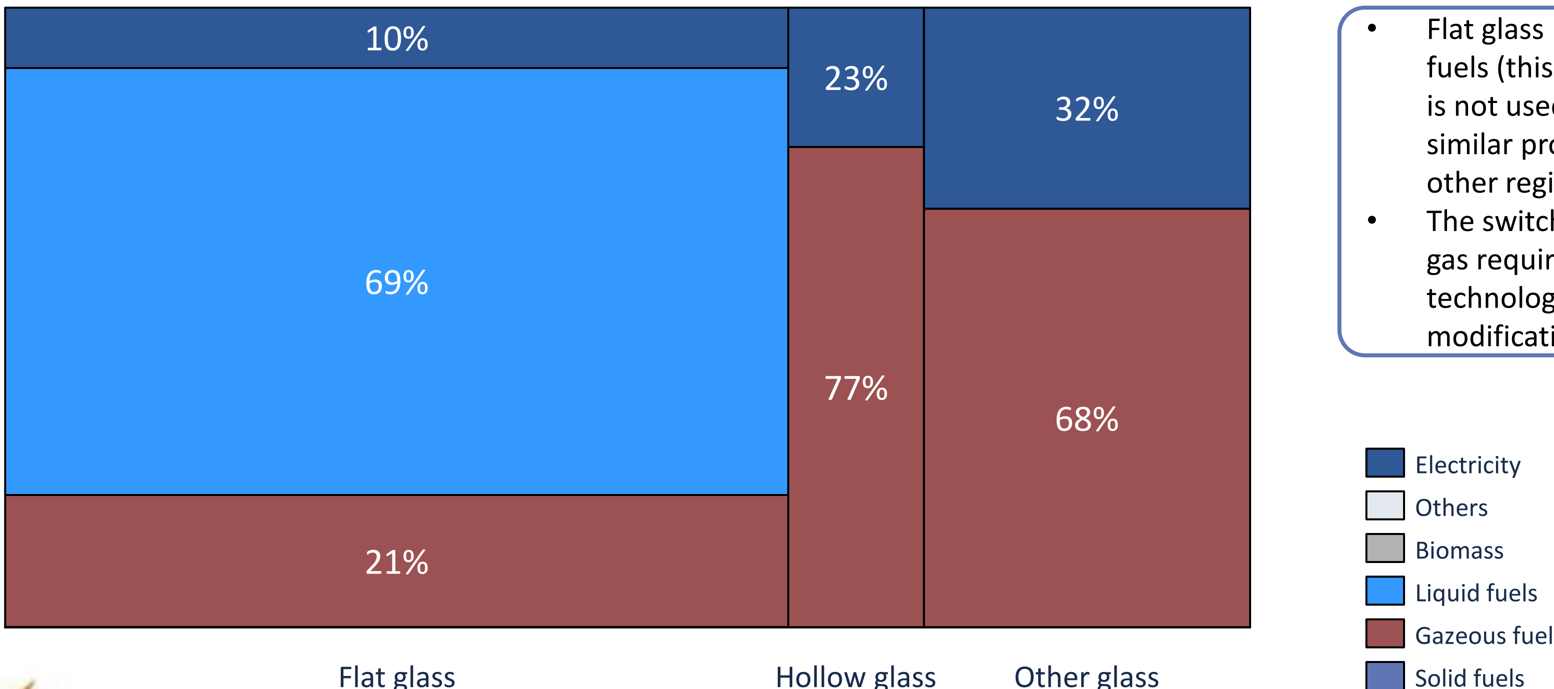
Energy sources distribution per sub-industry, 2010, % in Belgium

Total consumption glass industry in 2010
= 4,0 TWh PCI

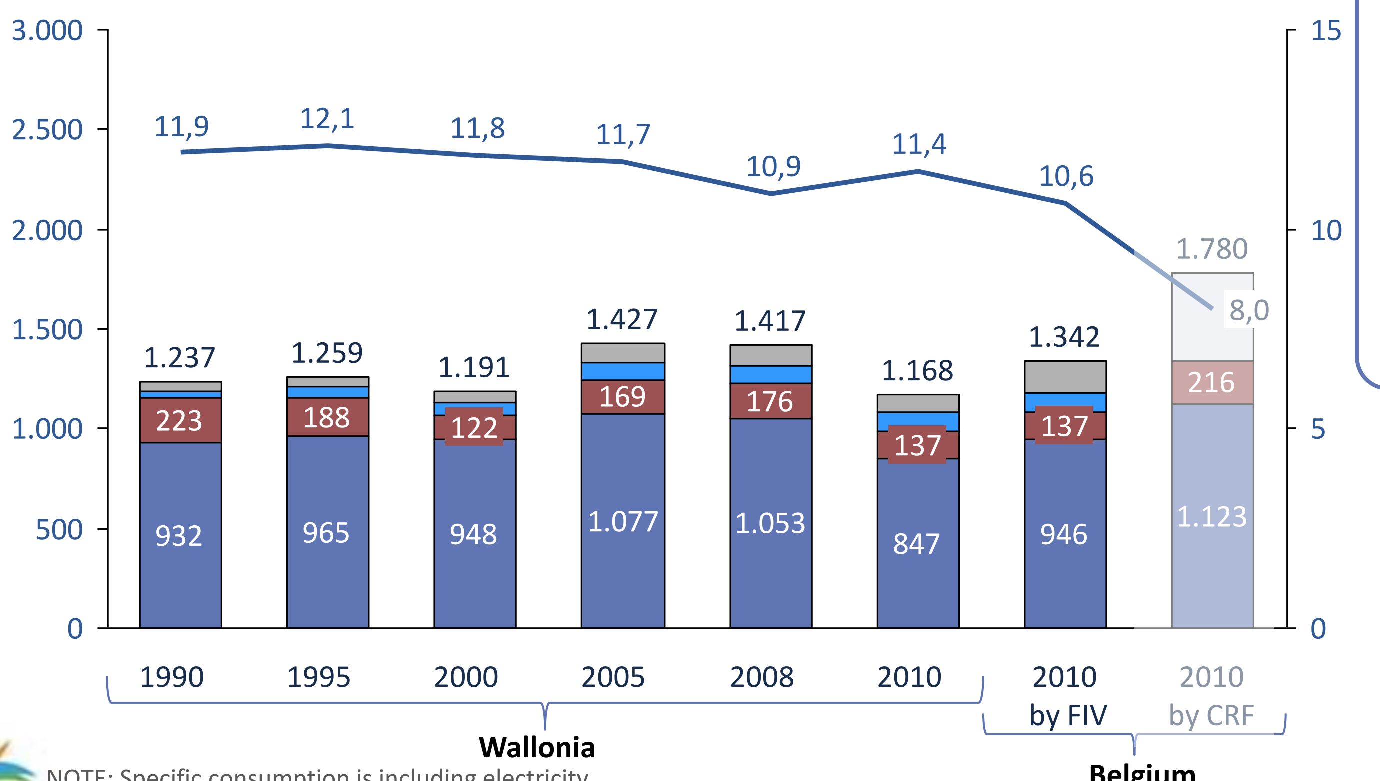


- Flat glass uses heavy fuels (this fuel type is not used on similar products in other regions)
- The switch to natural gas requires a flame technology modification

SOURCE: FIV 2010 data

Glass production and energy efficiency are stable

Evolution of the commercialized production of the glass sector, (Ktons),
Specific consumption, (Gj/ commercialized tons)



- One of the Belgian specificities is to have more flat than hollow glass. It is typically the opposite abroad
- FIV production figures are being used for this analysis (not the CRF)
- The specific consumption tends to increase when production decreases

NOTE: Specific consumption is including electricity
SOURCE: 2010 Walloon energy balance, Sector consultation

In France, emissions per ton of glass have been significantly reduced since the 1960's

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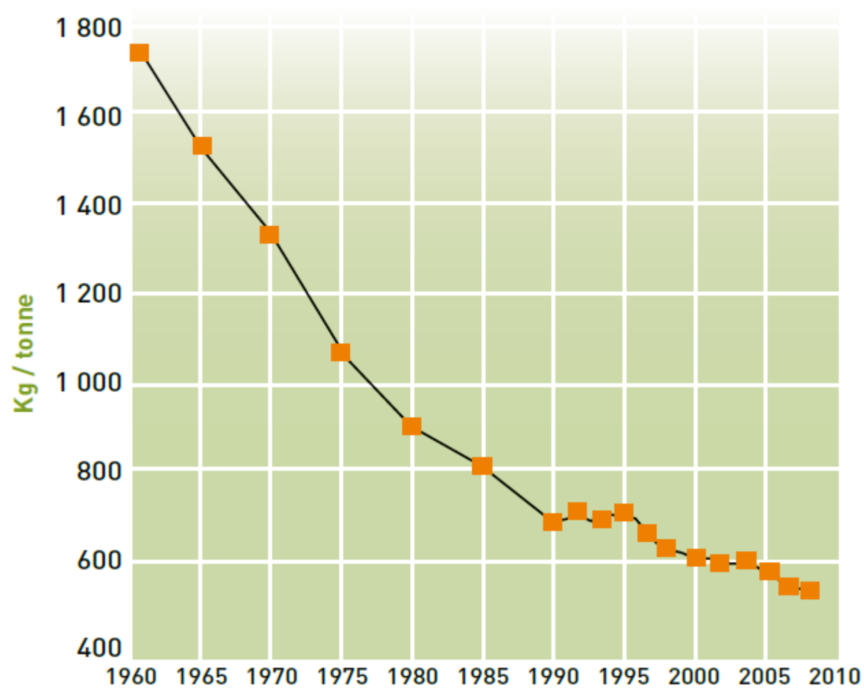
Specific emissions
(kg CO_2/ton of glass)



Main levers used

- Switch to float technology
- Cullet recycling
- Glass colour sorting
- Oven conception
- Combustion control

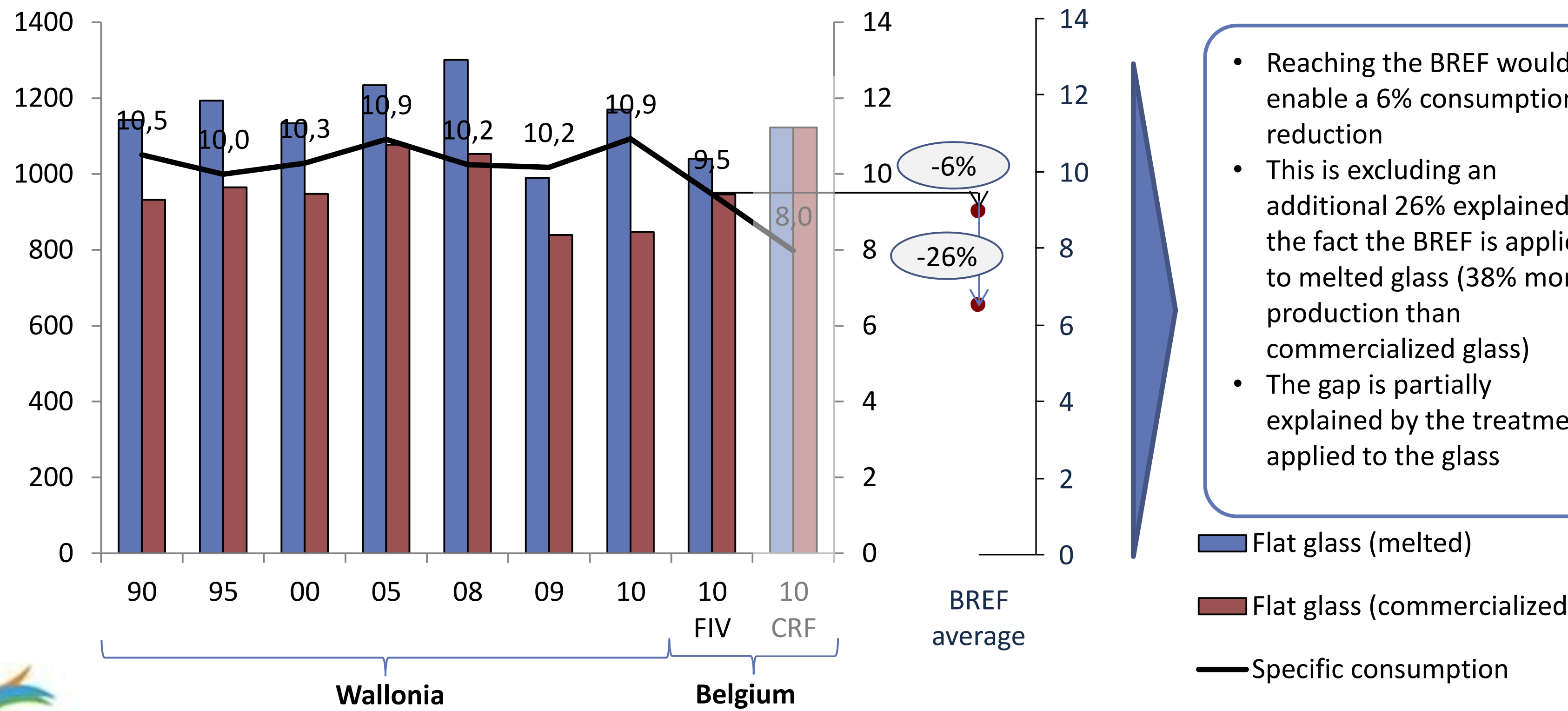
Gap with the previous analysis

- Energy mix
- Wallonia-France differences
  - A higher proportion of hollow glass in France
  - No electricity emissions in France (nuclear power park)

SOURCE: (1)French Glass federation

Flat glass production and energy efficiency are stable

Flat glass sector production evolution in Wallonia and Belgium, (Ktons),
Specific consumption, (Gj/commercialized tons)



- Reaching the BREF would enable a 6% consumption reduction
- This is excluding an additional 26% explained by the fact the BREF is applied to melted glass (38% more production than commercialized glass)
- The gap is partially explained by the treatments applied to the glass

SOURCE: 2010 Wallonia energy balance, FIV statistics, BREF

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Hollow glass production is decreasing while energy efficiency is stable

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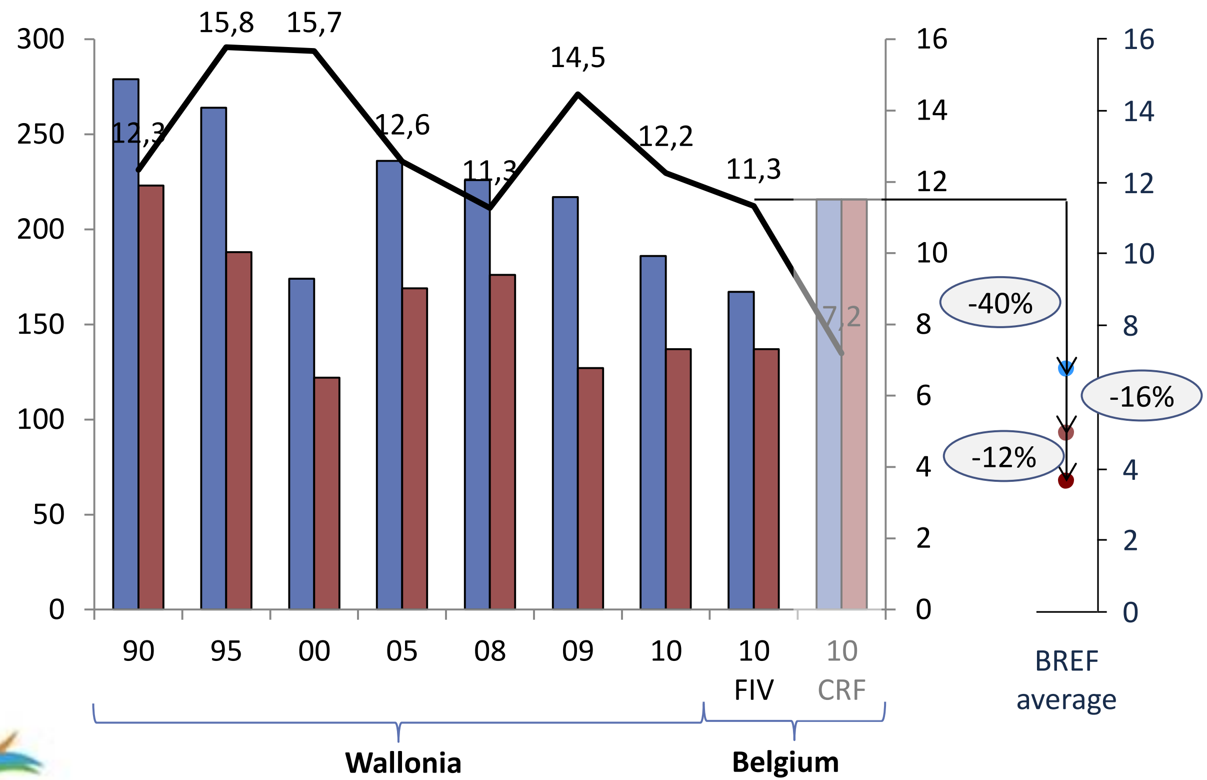
Hollow glass production evolution in Wallonia and Belgium, (Ktons),
Specific consumption, (Gj/commercialized tons)



- Reaching the BREF would enable a 40% consumption reduction
- This is excluding :
  - An additional 16% explained by the fact the BREF is applied to melted glass (which is 36% more than the commercialized glass)
  - An additional 12% explained by the product mix differences between the region and Europe (more cups and less bottles)

SOURCE: 2010 Wallonia energy balance, FIV statistics, BREF

The production of other glass types is increasing and their specific consumption is stabilizing

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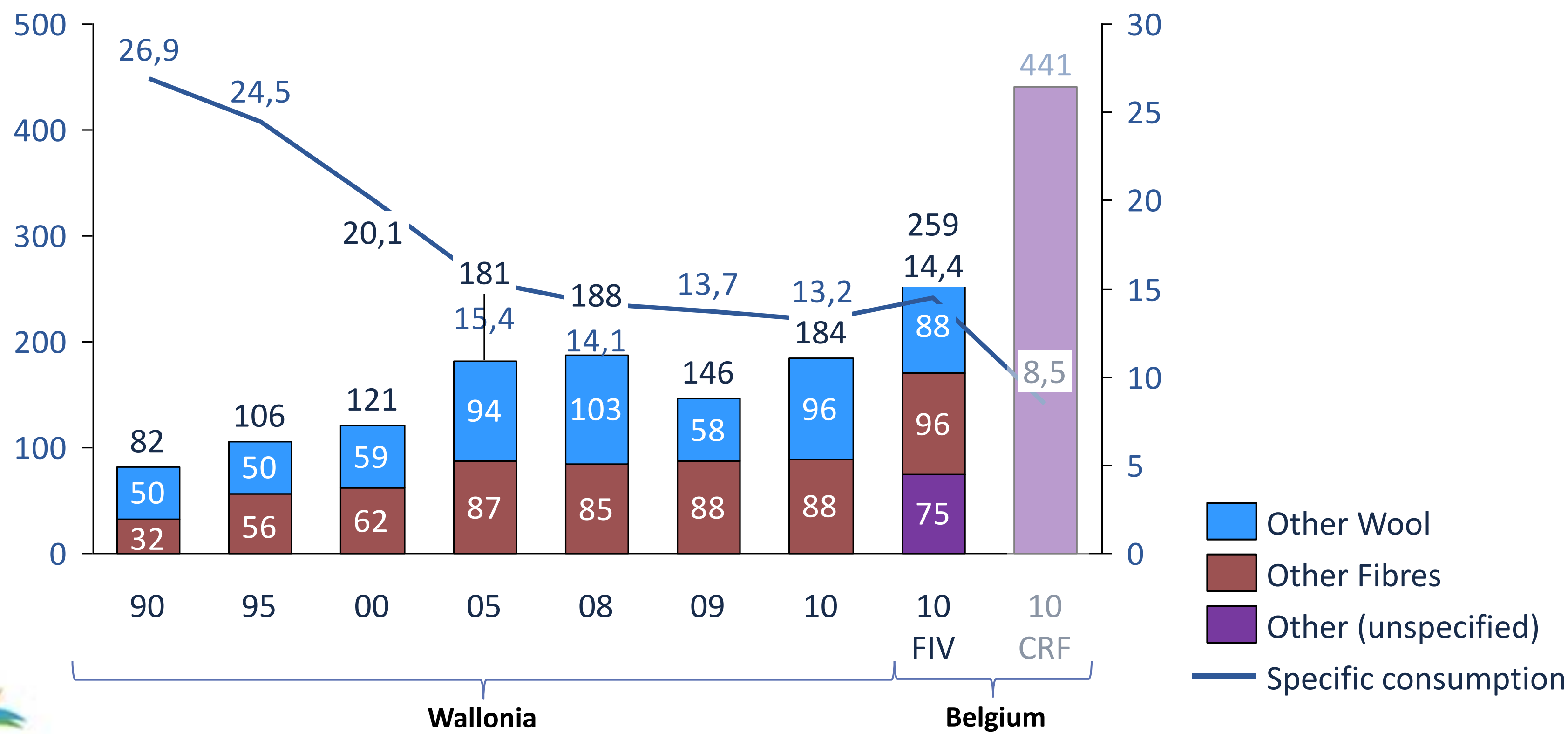
Other glass consumption evolution in Wallonia and Belgium, (Ktons commercialized),
Specific consumption, (Gj/commercialized tons)



SOURCE: 2010 Wallonia energy balance, FIV statistics

Energy consumption emissions for glass production are slowly decreasing

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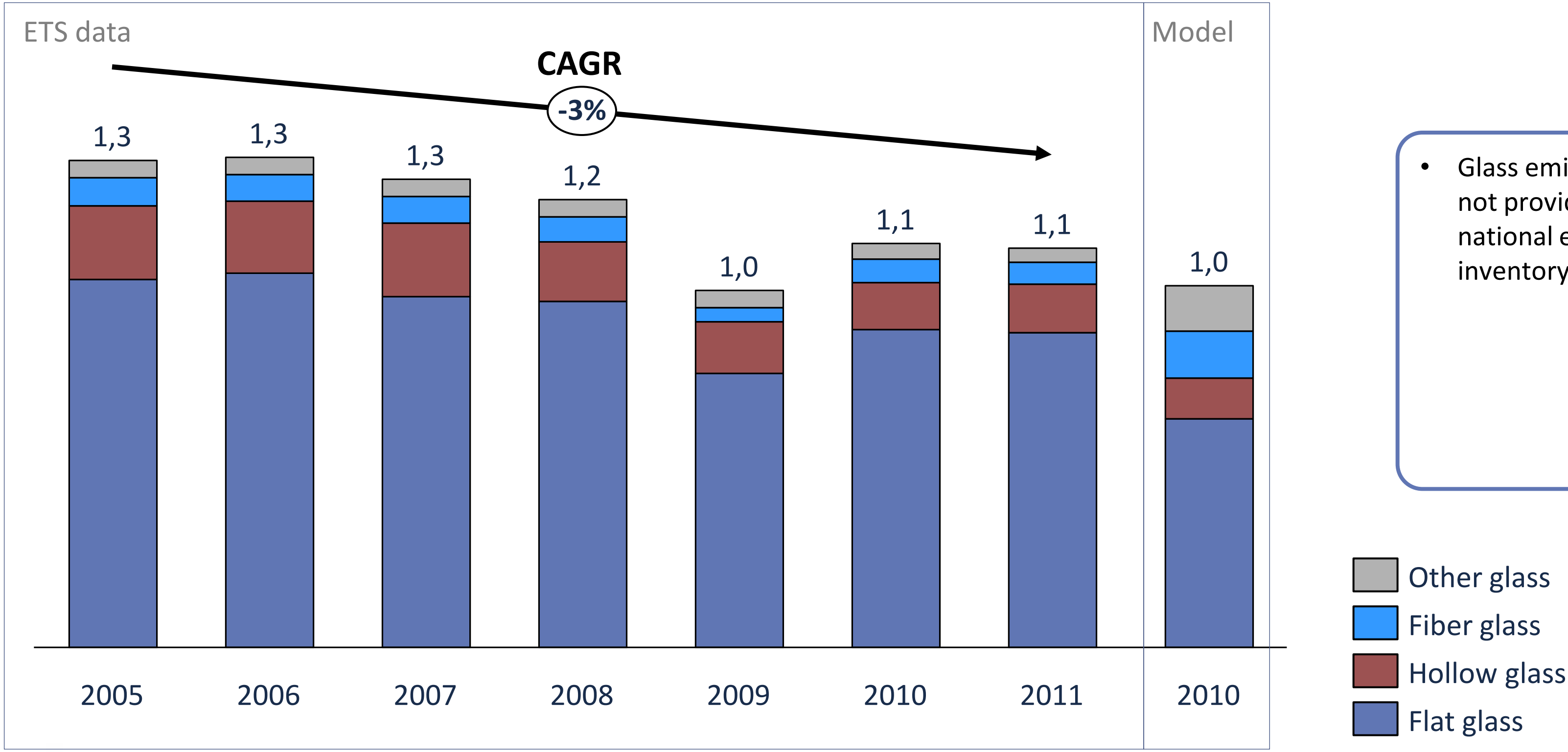
Emissions linked to the final energy consumption in the Belgian glass sector, ($MtCO_2e$)



- Glass emissions are not provided in the national emissions inventory

NOTES: Energy consumption only represents a portion of the emissions, process emissions must be added.
ETS data only includes CO_2, electricity related emissions are allocated to the energy production sector.

SOURCE: CITL, Climact model

Most large glass installations are in Wallonia, so most results of the Wallonia low Carbon growth analysis can be reused in this analysis

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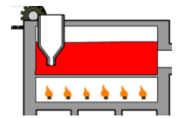
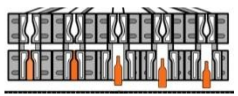
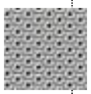
Belgian ETS installations

Region	Installations	Emissions per year (tCO_2e)				Type	Products
		2008	2009	2010	2011		
Wallonia	3B-Fibreglass Battice	68.399	39.499	61.296	59.919	Others (fibres)	Glass fiber
	AGC Flat Glass Europe Moustier	601.861	460.576	556.905	551.237	Flat	
	AGC Flat Glass Europe Roux	60.077	48.820	57.574	62.181	Flat	
	Durobor Soignies	32.197	31.639	26.711	25.069	Hollow	Drinking glasses, verrines
	Gerresheimer Momignies	20.373	15.851	16.986	18.692	Hollow	Laboratory, upscale flasks
	Knauf Insulation Visé	46.082	47.674	42.747	39.877	Others (wool)	Glass wool
	MD Verre Vidrala Ghlin	60.094	55.449	40.924	48.126	Hollow	Bottles
	Saint Gobain Glass Auvelais	169.064	125.138	135.628	132.837	Flat	
Flanders	AGC Flat Glass Europe Mol Plant	112.290	110.535	117.129	111.910	Flat	
	Emgo	49.263	38.826	43.008	38.777	Hollow	Incandescent light bulbs
	Pittsburgh Corning Europe	27.505	27.170	25.174	25.804	Other	Cellular glass
Grand Total		1.247.205	1.001.177	1.124.182	1.114.429	/	

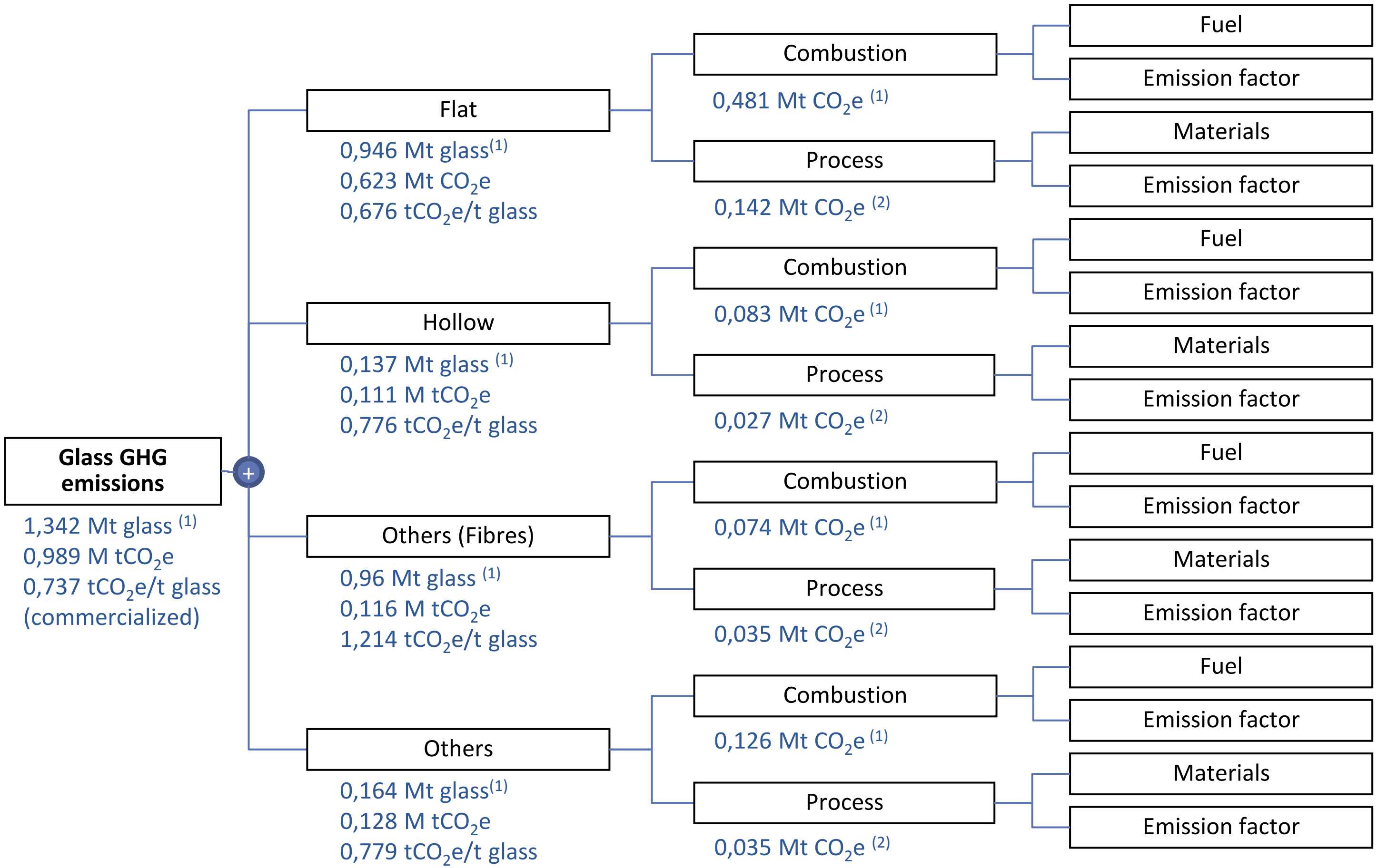
SOURCE: CITL

Glass supply chain definition for each technology

Technology	Raw materials extraction	Furnaces	Forming	Products
Flat	**Vitrifier** (e.g. White sand) **Melter** (e.g. soda) **Stabiliser** (e.g. limestone) **Recycled** (recycled, cullet,…)	**Materials fusion**  1500°c	**Float** cullet →  Cast onto a bath if tin in fusion cullet ←	**Glass panes**
Hollow	Idem (different proportions)	Idem	**In moulds** cullet →  cullet ←	**Bottles** **Verrines** **Glasses** **Special glasses** (labo) **Luxury glasses** (perfumes)
Others (fibres)	Idem	Idem	**Fibers creation**  Glass threads are coiled → Sticks	**Fiber glass**
Others (wool)	(recycling can reach 90%)		→ Adding binders, drying	**Wool glass**

SOURCE: Climact high level analysis, FIV

Emission tree



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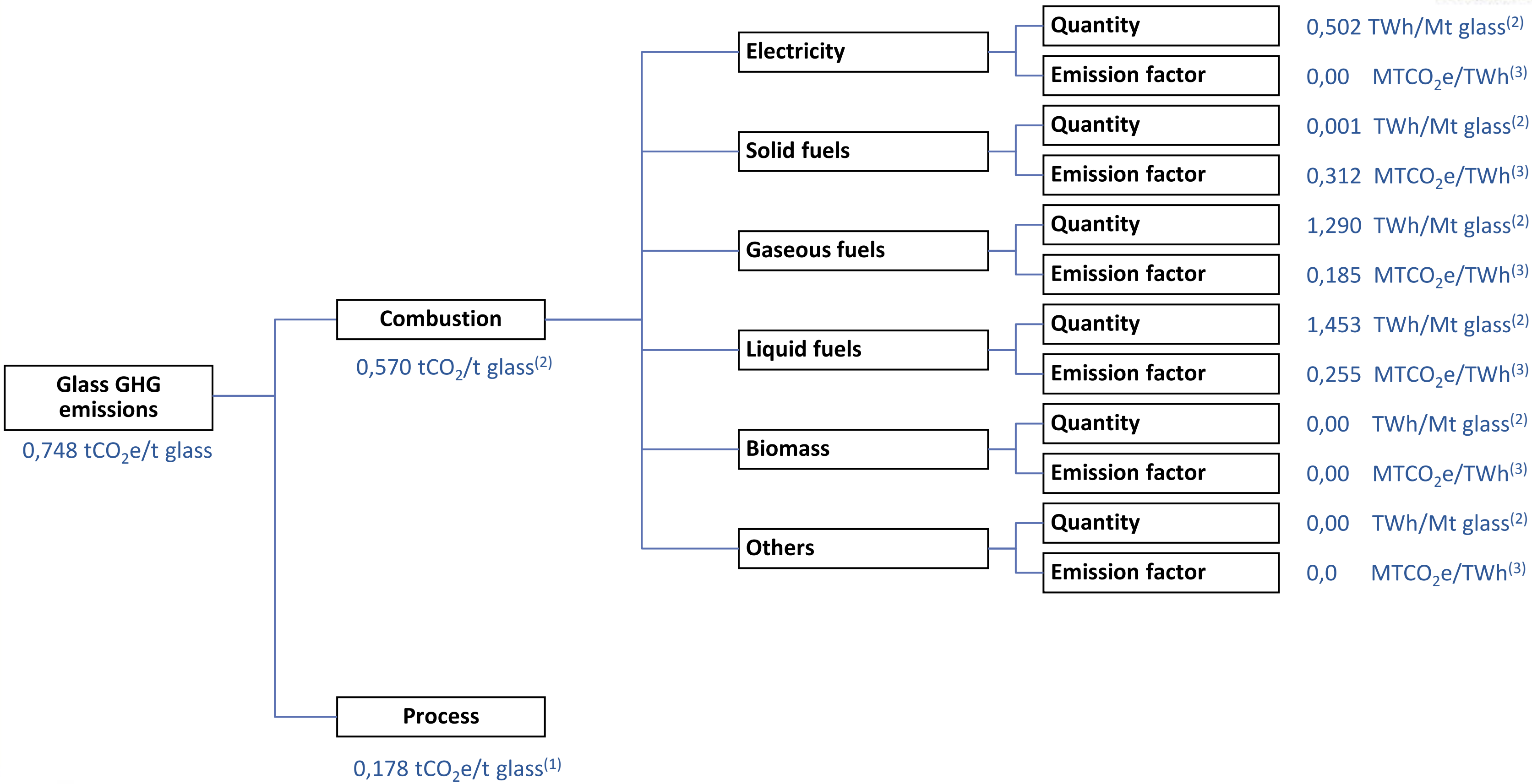
SOURCE: (1) FIV data, commercialized (2) 2010 Belgium GHG emission inventory

Emission tree (energy mix)



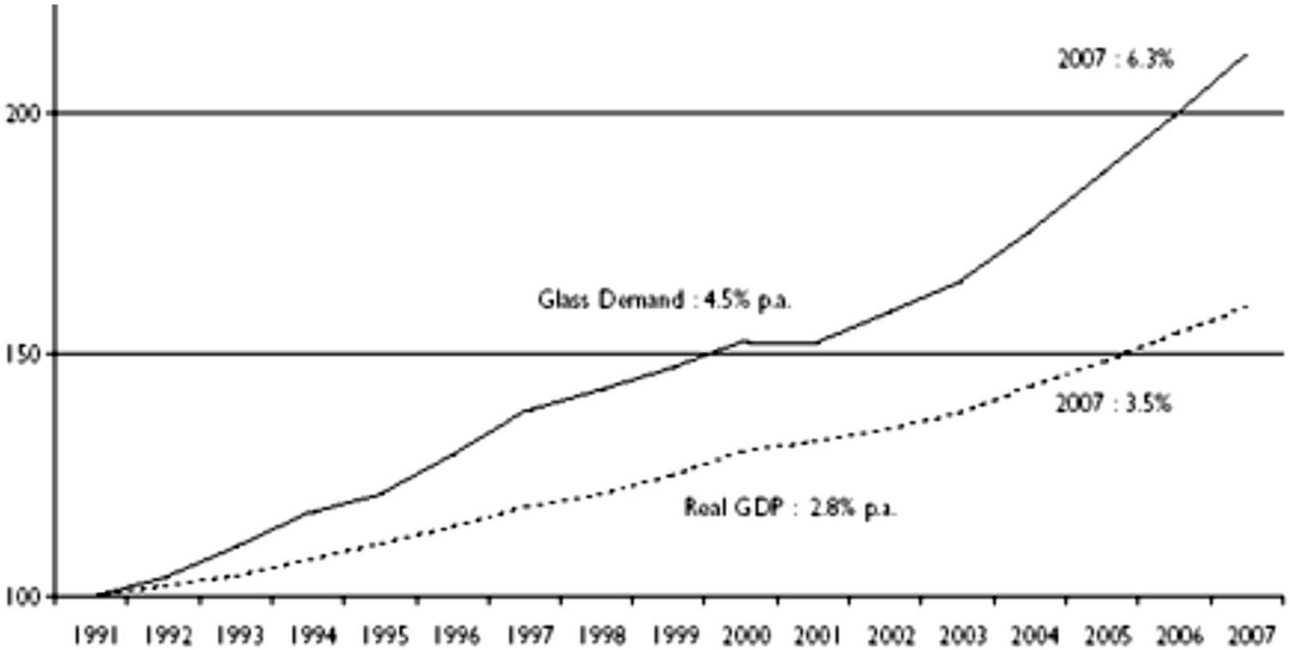
NOTE: Simplifying assumption that the average energy mix is used for all the fuel types
SOURCE: (1) Belgium 2010 GHG inventory (2,3) Climact analysis

Content – Industry sector - glass

Growth forecasts: World

World glass demand is highly growing since more than 30 years

Flat glass world demand
(Index 1991 =100)



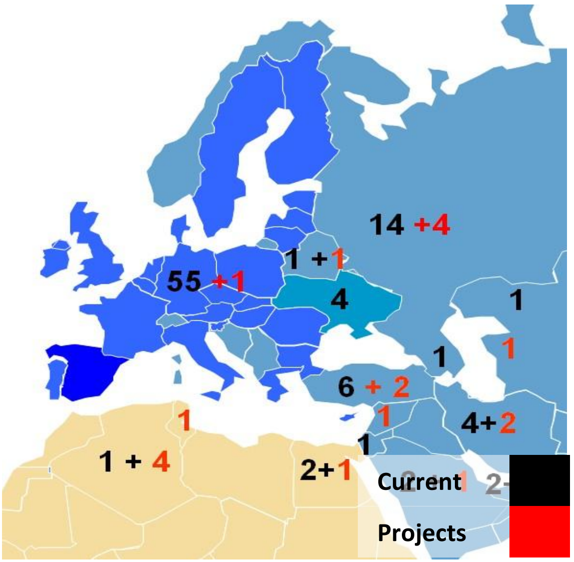
- For more than 30 years, flat glass demand has increased by above 4,5% per year [(1)]
- In 2007, the growth rate reached 6,3%

SOURCE: FIV presentation, (1) Expert interviews

Growth forecasts: Europe

At the continent scale, growth is mainly around EU27, but not further because of transport costs

Current flat glass production lines and projects on the 2015 horizon



Flat glass production lines

	Current	New in 2009	Projects on the 2015 horizon
EU27	59	0	1 (Germany)
Neighbouring countries (Eastern Europe, North Africa and middle east)	39	5	18

Regular historical growth of 2% for the European flat glass market
Hypothesis that growth is maintained until 2010
Growth mainly in the European periphery with European imports
Sector recognized as sensible to carbon leaks

SOURCE: FIV presentation, (1) Expert interview (2)Plan Pour la Maîtrise Durable de l'Energie

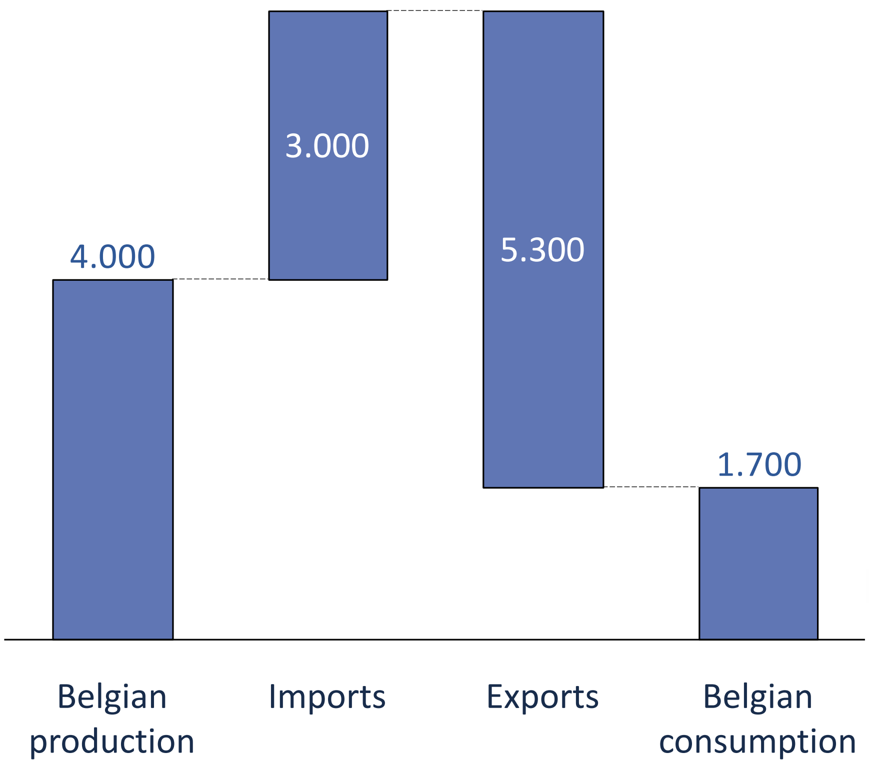
Growth forecasts: Belgium

Glass demand has been assessed at Belgian level

Details on the Belgian growth

- Historical growth explained by the opening of one oven
- Hollow glass remains uncertain
  - After the crisis, production had fallen by ~50%, recovery has been lower
- Fiber sector has a firm historical growth, even if it is currently slowing. (This growth is historically stronger but more irregular in reinforcement fibres than in insulating fibres)
- Above 80% of the glass is for exports

Daily flows (tons)



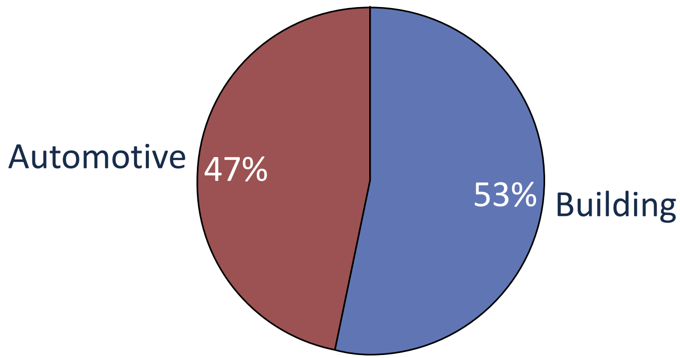
SOURCE: (1) Expert interview (2)Plan Pour la Maîtrise Durable de l'Energie

Growth forecasts: Belgium

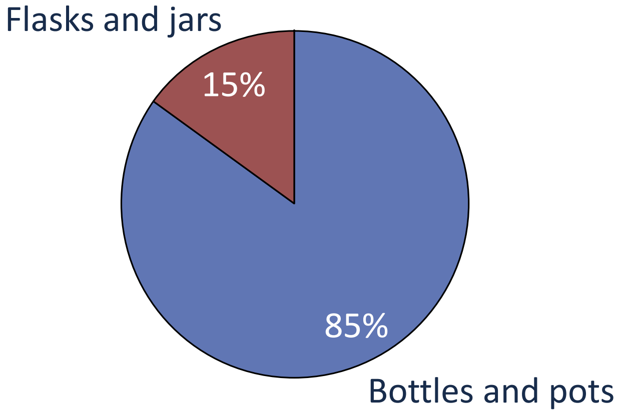
Glass production can be correlated to production indicators

Illustrative percentages

Flat glass uses in France[1]
(%)



Hollow glass uses
(%)



- More export & less automotive in Belgium
- Demand correlated to European building sector

- Little export
- Demand correlated to the Belgian GDP

SOURCE: (1) French glass federation (no Belgian data was available)

Growth forecasts: Belgium

Summary of parameters influencing demand on the 2050 horizon

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Parameters	Flat	Hollow	Others
Specification of the expected growth type (CAGR)	• European population towards 2050: 1% • GNP: 1,6% (1) • Glass industry (2010-2050) : 0,96%(2) • Construction: 0% (4)		
	• 2030 projections: 1,5% until 2020 then 1,6% until 2030 (following 23% increase by 2015 with ovens back in production)(preliminary figures)	• 2030 projections: 0% (Following 25 % increase by 2015 with new oven) (preliminary figures)	• 2030 projections: 1,3% until 2020 and 1,4% until 2030 (preliminary figures)
	PMDE (10-20) (3) • Flat: 2%	PMDE (10-20) (3) • Hollow: 0%	PMDE (10-20) (3) • Fibres: 2,5%
New infrastructure creation probability	• 14 out of the 60 ovens are currently exceptionally on hold. It is assumed these will go back in production before 2015	• Uncertain sector stability • an additional oven will be added in 2013 (+25% vs the 4 ovens currently in use).	• /
Indicator to which the Belgian production can be correlated	• European buildings (5)	• European GDP(5)	• European GDP
Product mix expected modifications	• Portion function of automotive currently in decline (6)		

SOURCES: (1) Federal plan bureau long term tendency (2) GEM-E3 projection, physical production output (kton) (used in TUMATIM study),
(3)Plan pour la Maîtrise Durable de l'Energie,
(4) Climact analysis: hypothesis of 1% annual growth of the park,
(5) FIV, (6) French glass federation

Growth forecasts: Belgium

3 trajectories influencing the future energy demand will be modelled

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Possible growth scenarios

GDP: 1,6% [1]
GEM 3E: 0,96% [2]
Walloon 2030 (10-20/20-30) [3]

- Flat: 1,5/1,6%
- Hollow: 0%
- Others: 1,3/1,4%

Walloon construction: 0% [4]
European construction: TBD

Possible closure scenarios

- Uncertain hollow glass stability, -50% possible in 2050
- Growth concentrated in the European periphery
- If no free quota allocation after 2020 (scenario not modelled because excluded)

	CAGR	
	2010-2020	2020-2050
Trajectory 1	• Flat: 1,5% (+23% in 2015) • Hollow: 0% (+25% in 2015) • Others: 1,3%	• Flat: 1,6% • Hollow: 0% • Others: 1,4%
Trajectory 2	• 0%	• 0%
Trajectory 3	• -10% in 2050 (continuous decrease)	• Flat and others: -10% in 2050 (continuous decrease) • Hollow: -50% in 2050

SOURCES: (1) Federal plan bureau Belgian Long term tendency, (2) Belgian Federal plan bureau, (3)Plan pour la Maîtrise Durable de l'Energie, (4) Climact analysis: hypothesis of 1% annual growth of the park

Belgium Growth forecast

Production along trajectories 1, 2 and 3

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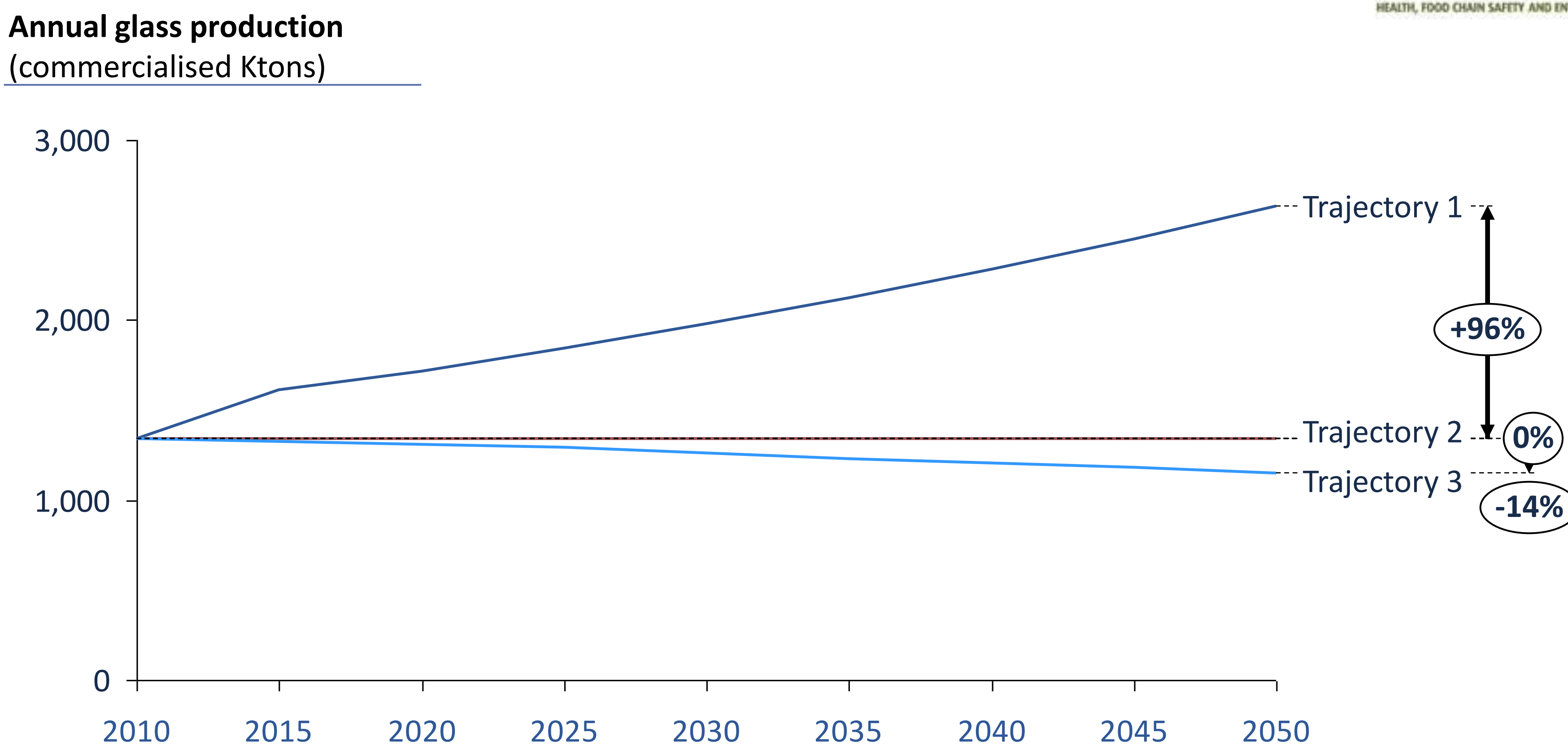
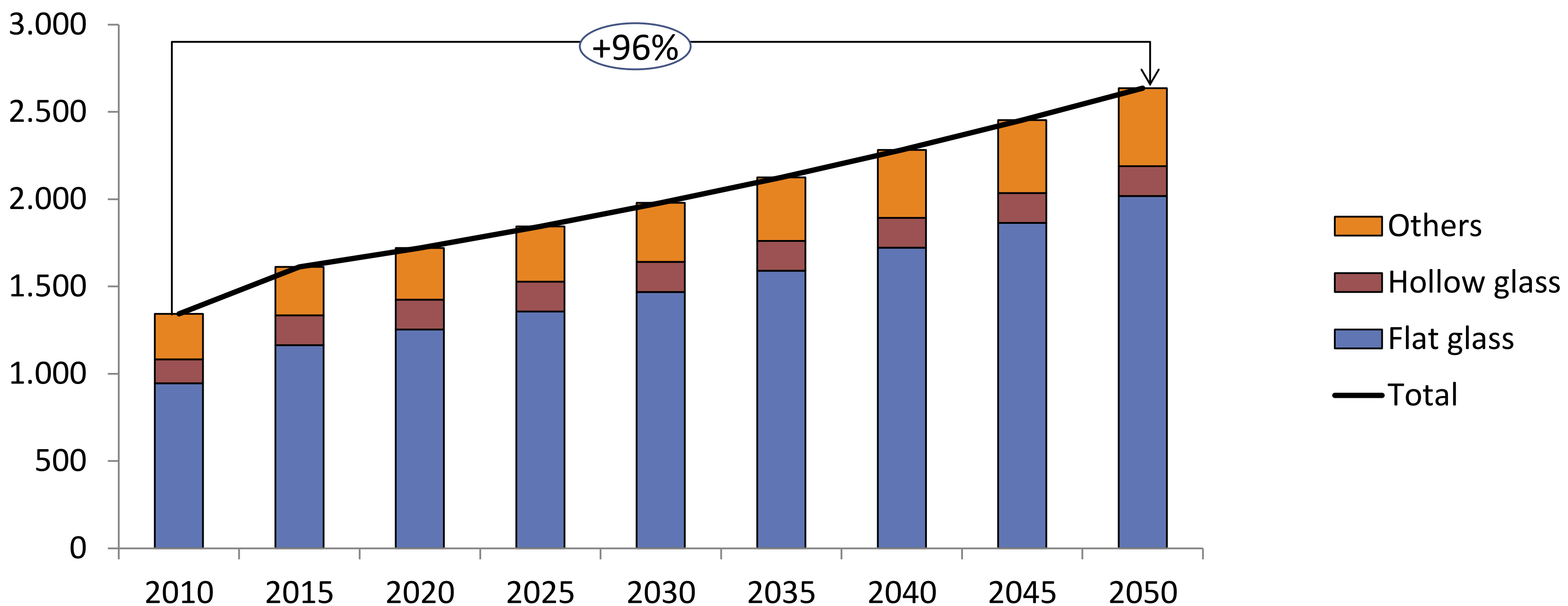


SOURCE: OPE²RA model

Belgium Growth forecast

Production along trajectory 1

Annual glass production
(commercialised Ktons)

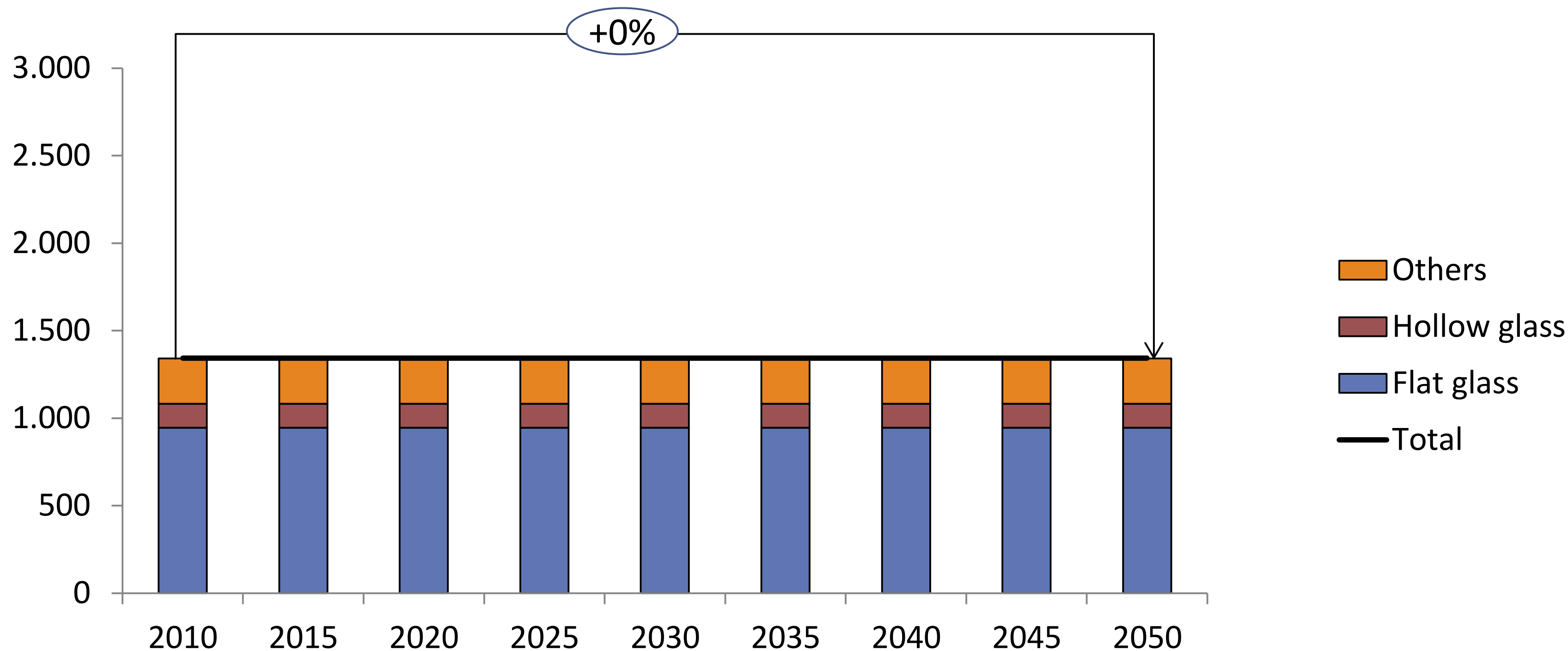


SOURCE: OPE²RA model

Belgium Growth forecast

Production along trajectory 2

Annual glass production
(commercialised Ktons)

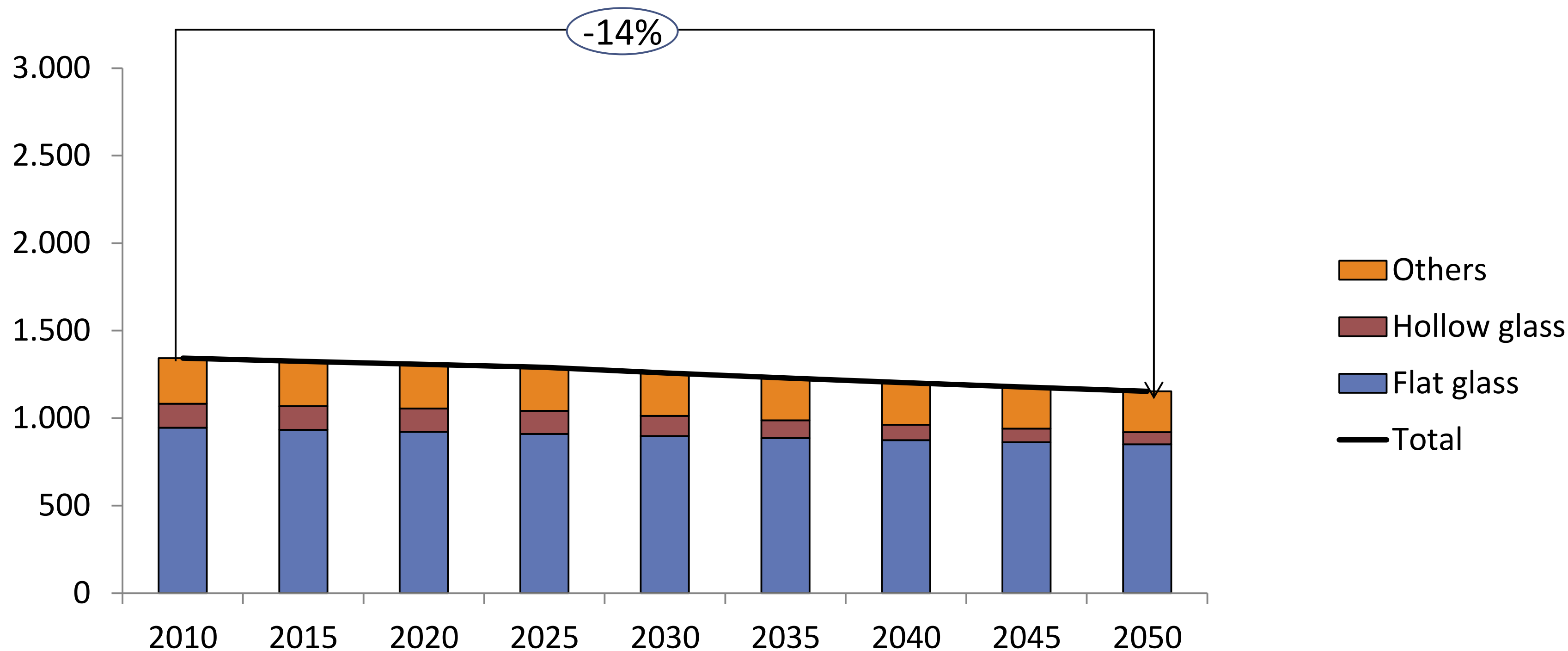


SOURCE: OPE²RA model

Belgium Growth forecast

Production along trajectory 3

Annual glass production
(commercialised Ktons)



SOURCE: OPE²RA model

Reduction potential

Reduction levers can be applied in the following order for the glass industry

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Methodology

Product mix
- Increase the proportion of products which require less CO_2

Plastic substitutes

Energy efficiency
- Reduce mechanical and thermal losses
- Recover thermal losses (e.g. CHP)

Heat losses

CHP

Process improvements
- Improve how the products are made

Cullet increase

Particles capture (fusion)

Electro-static precipitator (ESP)

Oxyfuels

Reduce chromium

Alternative fuels
- Increase the proportion of fuels which emit less CO_2

Fuel to gas switch

Biomass

End of pipe
- Capture the CO_2 which has been emitted for production

CCS

NOTE: Levers which reduce the CO_2 emissions of production but generate more CO_2 emission in the life cycle are not modelled (e.g. single layer windows and current plastic substitutes)

Reduction potential

Detail per lever

Lever group	Levers	Applicability
Product mix	Substitutes	Substitution of glass by plastic is not modelled
Energy efficiency	Heat losses reduction and better heat recuperation	Hypothesis of 15% potential everywhere in level 3 obtained through a weighted average: • Flat: -25% vs BREF on 946 kt • Hollow: -40% vs BREF on 137 kt • Others: hypothesis -40% on 259 kt Insulation is not easily applicable because the ovens will heat and the glass could pass through the joints Preheating of the air injected in the ovens is not applied everywhere yet in the hollow glass
	CHP and heat recuperation	No potential in 2050, because of energy efficiency. Modelling (cross industry) available
Process improvements	Increasing the cullet proportion	+10% in level 3 (+2,5% energy efficiency and -10% process emission) Profitable lever Cullet access difficulties: • During the 2009 crisis; cullet has been artificially created (also called conjuntural cullet) to maintain the ovens working • The region must develop an efficient glass collection and sorting system for glass issues by the construction and demolition sectors
	Oxyfuels	Using more pure oxygen for the combustion 24% emission reduction for flat and hollow (level 3). Potential already reached for the others. To refine the analysis, we should know the amount of oxygen required (oxygen production also creates GHG emissions). The additional oxygen production is currently not modelled.
Alternative fuels	Replacing fuel by gas	Level 2: 100% in 2050, Level 3: 100% in 2030, Level 4: 100% in 2020 In all cases, gas requires 5% additional kwh
	More biomass	Biomass potential is limited by supply, it is therefore modelled in another section of the tool Across all the sectors at once to avoid double counting In case of modelling: 20% potential for hollow and others (not flat) E.g. champagne bottles using vine wood by Saint-Gobain
End of pipe	CCS	See specific slide

SOURCE: (1) Expert interviews (2)Plan Pour la Maîtrise Durable de l'Energie

Reduction potential: CCS (1/2)

CCS potential is based on size of installations

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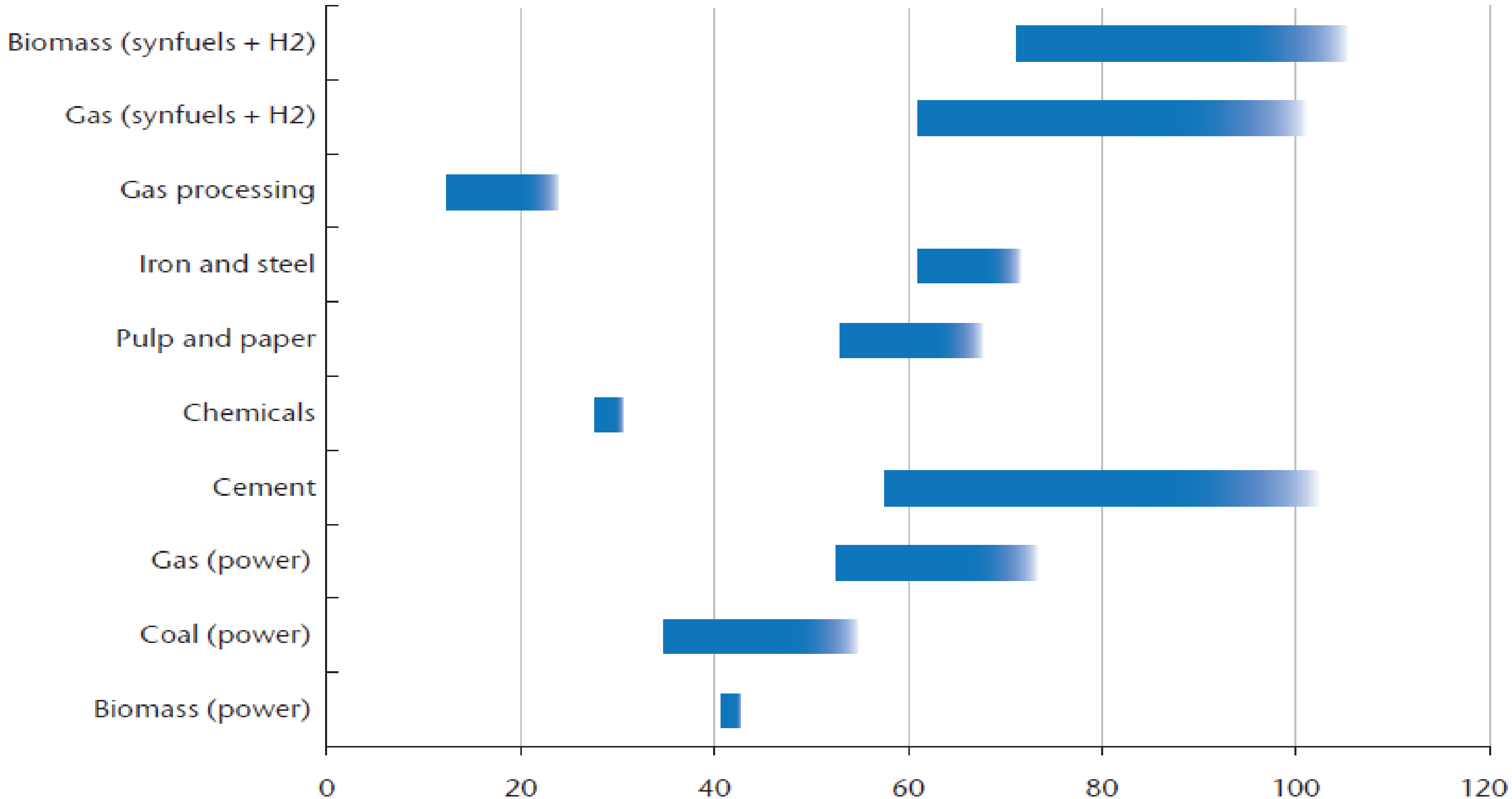
Industry	ton CO_2eq by production site category			Total	Level 1	Level 2	Level 3	Level 4
	<0,3 M	0,3-1 M	>1 M					
Iron & steel	1.291.469	787.034	4.386.583	6.465.086	0%	68%	80%	85%
Non ferrous metals	349.098	-	-	349.098	0%	0%	0%	85%
Chemical	1.777.925	1.185.959	3.088.691	6.052.575	0%	51%	71%	85%
Refineries	54.765	521.974	5.784.870	6.361.609	0%	85%	85%	85%
Lime	613.101	943.472	1.146.381	2.702.954	0%	36%	66%	85%
Glass	537.388	551.237	-	1.059.785	0%	0%	43%	85%
Cement	200.364	1.482.774	2.230.139	4.059.277	0%	51%	81%	85%
Food	981.850	-	-	981.850	0%	0%	0%	85%
Pulp & paper	768.785	-	-	768.785	0%	0%	0%	85%
Bricks & ceramics	567.888	-	-	567.888	0%	0%	0%	85%
Total	6.729.570	5.309.780	18.498.687	30.538.037	0%	59%	73%	85%
Coverage level 1	/	/	/					
Coverage level 2	/	/						
Coverage level 3	/							
Coverage level 4								

SOURCE: ETS registry (Belgium), analyse VITO&Climact

Reduction potential: CCS (2/2)

Industry costs

USD/tCO_2e



SOURCE: IEA

Reduction potential

Reduction potential and applicability per ambition for the levers, on the 2050 horizon

Glass levers

Lever type	Improvement levers	Potential (%) in 2050				Cost	Description	Applicability		
		1	2	3	4			Flat	Hollow	Others
Product mix	Substitutes	/	/	/	/	/	Not applicable			
Energy efficiency	Reduce heat losses and better recovery	8%	50% of level 3	-15%	120% of level 3	Cost = energy gain	Based on the BREF (aligned to the other industries)	✓	✓	✓
	Cogeneration	N/A	N/A	N/A	N/A	-€20/tCO_2	No potential in 2050, following energy efficiency			
Process improvements	Increase cullet proportion	0%	50% of level 3	+10% cullet	120% of level 3	~-2€/tCO_2	For each 10% additional cullet, 2-3% energy efficiency and 10% less process emissions (1)	✓	✓	✓
	Increase Oxyfuels	0%	50% of level 3	24%(1)	120% of level 3	Hypothesis 0	Use of pure oxygen instead of ambient air for the combustion	✓	✓	✓
Alternative fuels	Switch Fuel to Gas	0%	100% en 2050	100% en 2030	100% en 2020	Fuel cost	Requires a technology change (capex) which is not modelled Is slightly less efficient(+5% kwh gas)	✓		
	Increase biomass	0%	50% of level 3	20% de biomass	120% of level 3 (not modelled)	Fuel cost	Not applied in this section Else 20% potential in hollow and others (none in flat) (this is +6% on the whole glass industry)		✓	✓
End of pipe	CCS	0%	0%	43%	85%	€50/tCO_2	As of 2025 Capture 1tCO_2e requires 3MWh	✓	✓	✓

SOURCE: (1) BREF and glass sector consultation

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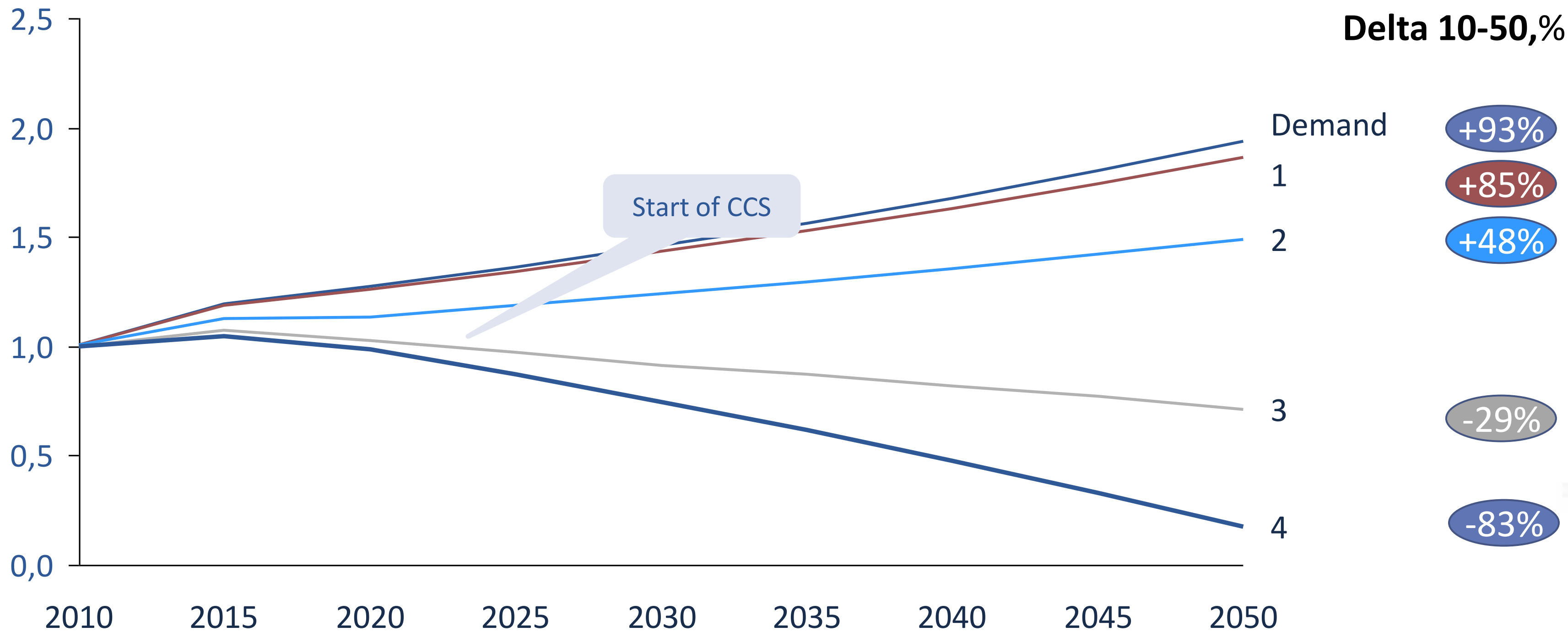
Reduction potential

Emissions along the different trajectories and reduction levels

Trajectory 1 (high growth) GHG emissions for different ambition levels
($MtonCO_2e$)



SOURCE: OPE²RA model

Reduction potential

Emissions along the different trajectories and reduction levels

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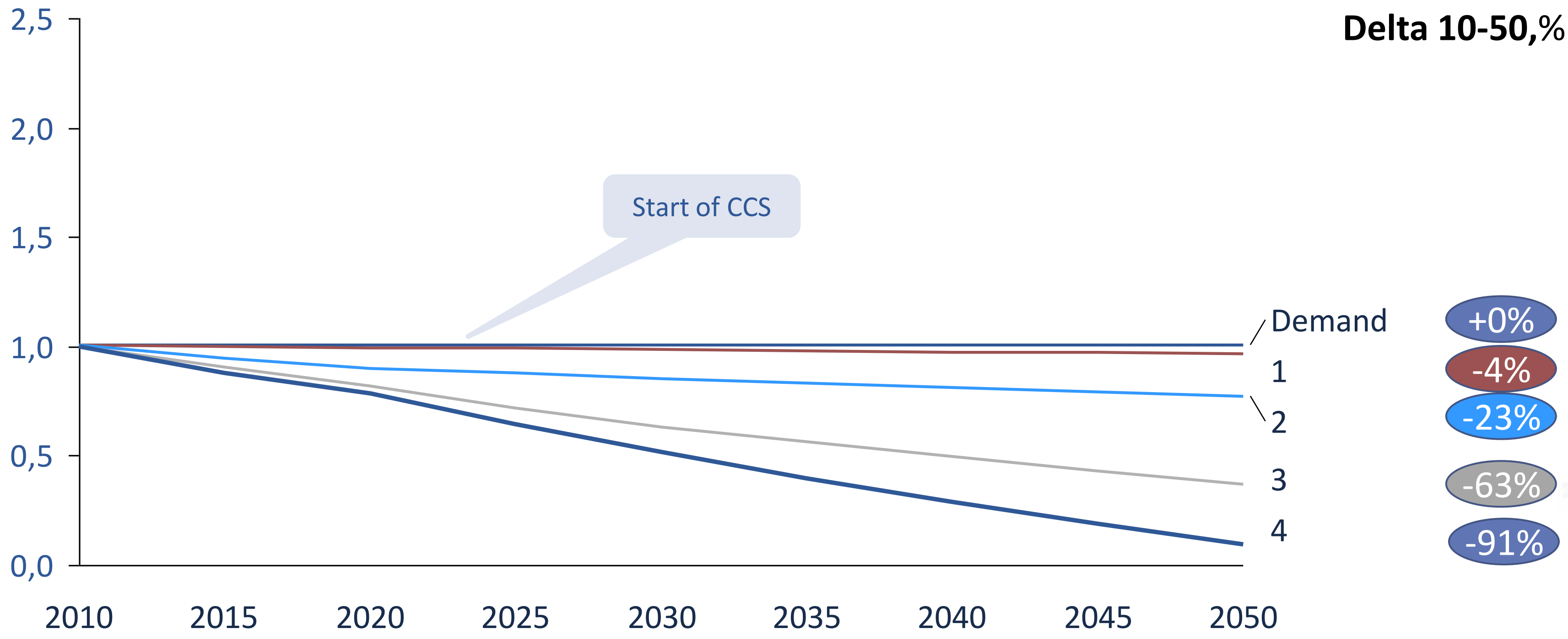
Trajectory 2 (middle growth) GHG emissions for different ambition levels
($MtonCO_2e$)



SOURCE: OPE²RA model

Reduction potential

Emissions along the different trajectories and reduction levels

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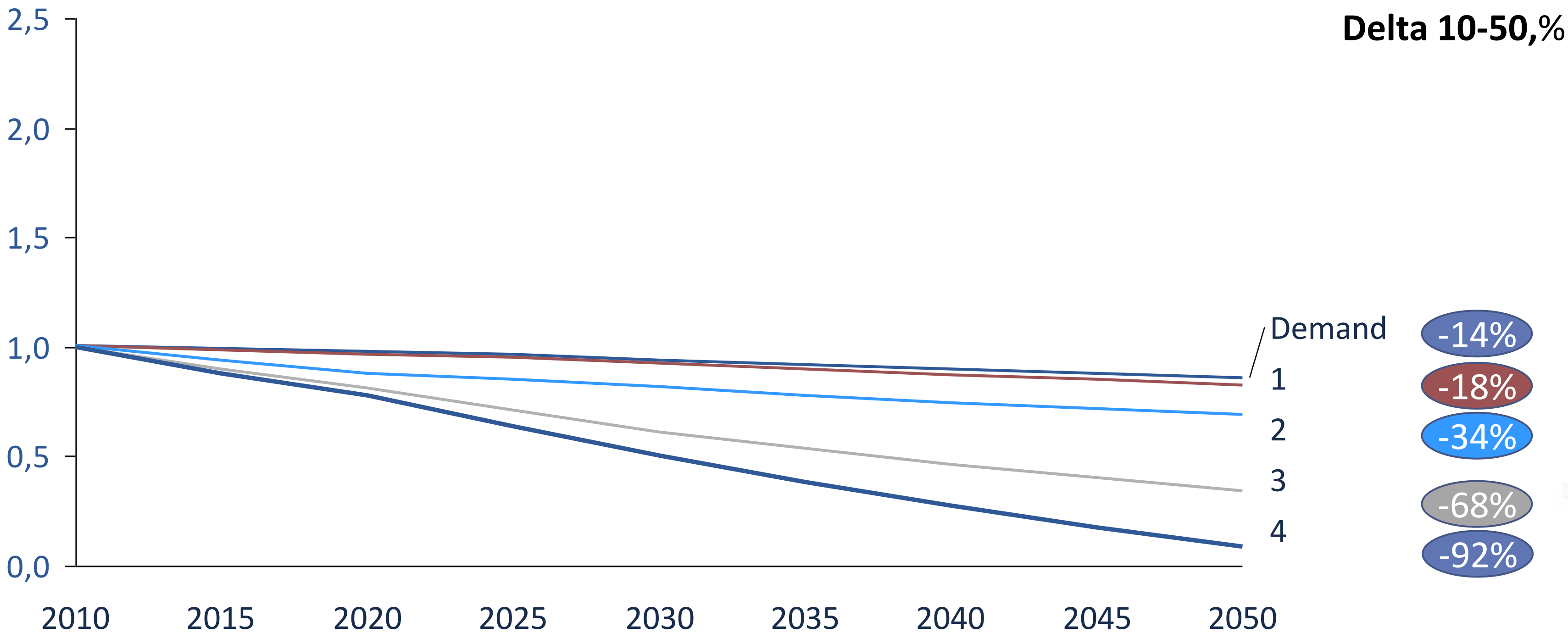
Trajectory 3 (low growth) GHG emissions for different ambition levels ($MtonCO_2e$)



SOURCE: OPE²RA model

Reduction potential

Only the maximal theoretical potential is in line with the European targets

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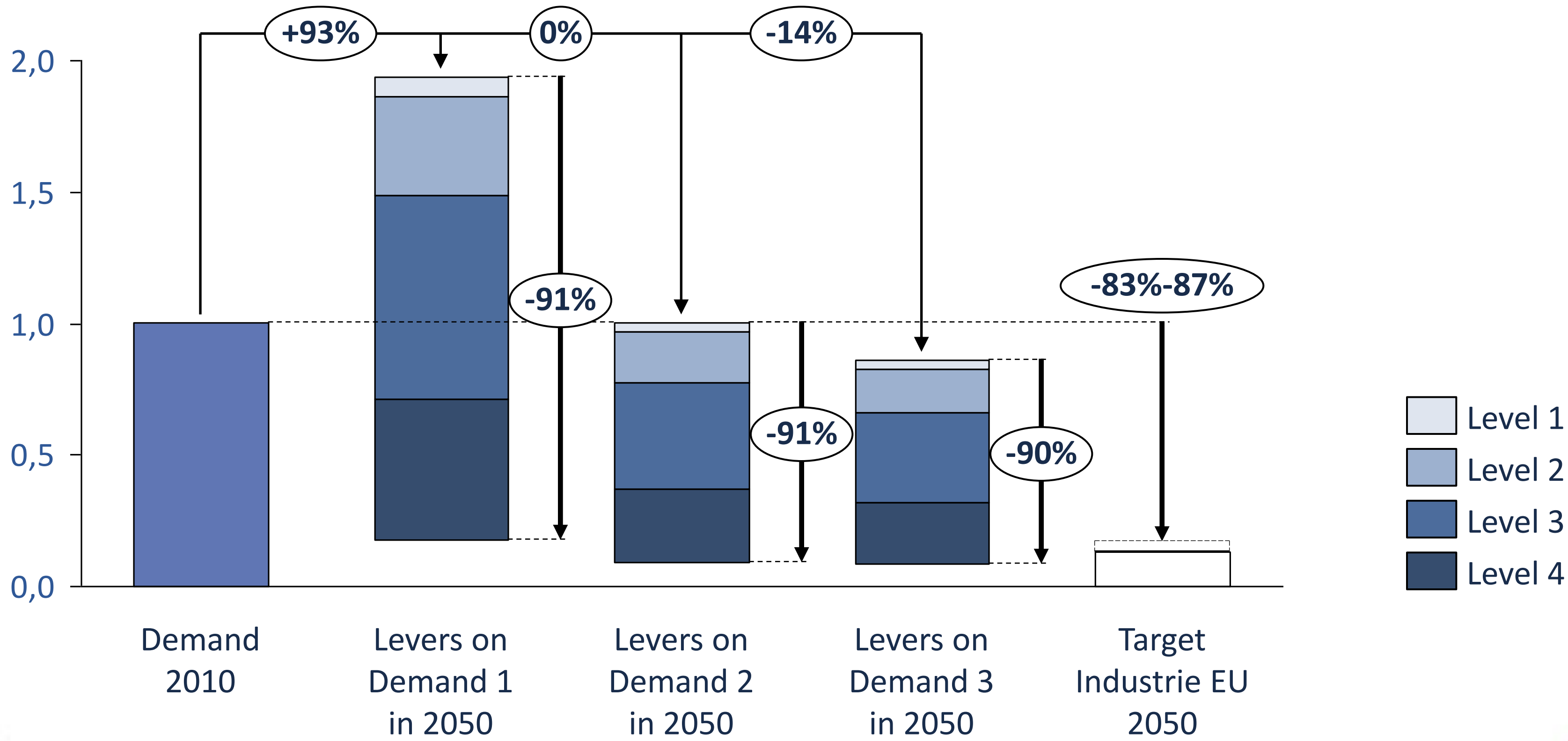
GHG emissions for different trajectories and ambition levels
(MtonCO_2e and % change in % of 2010 level)



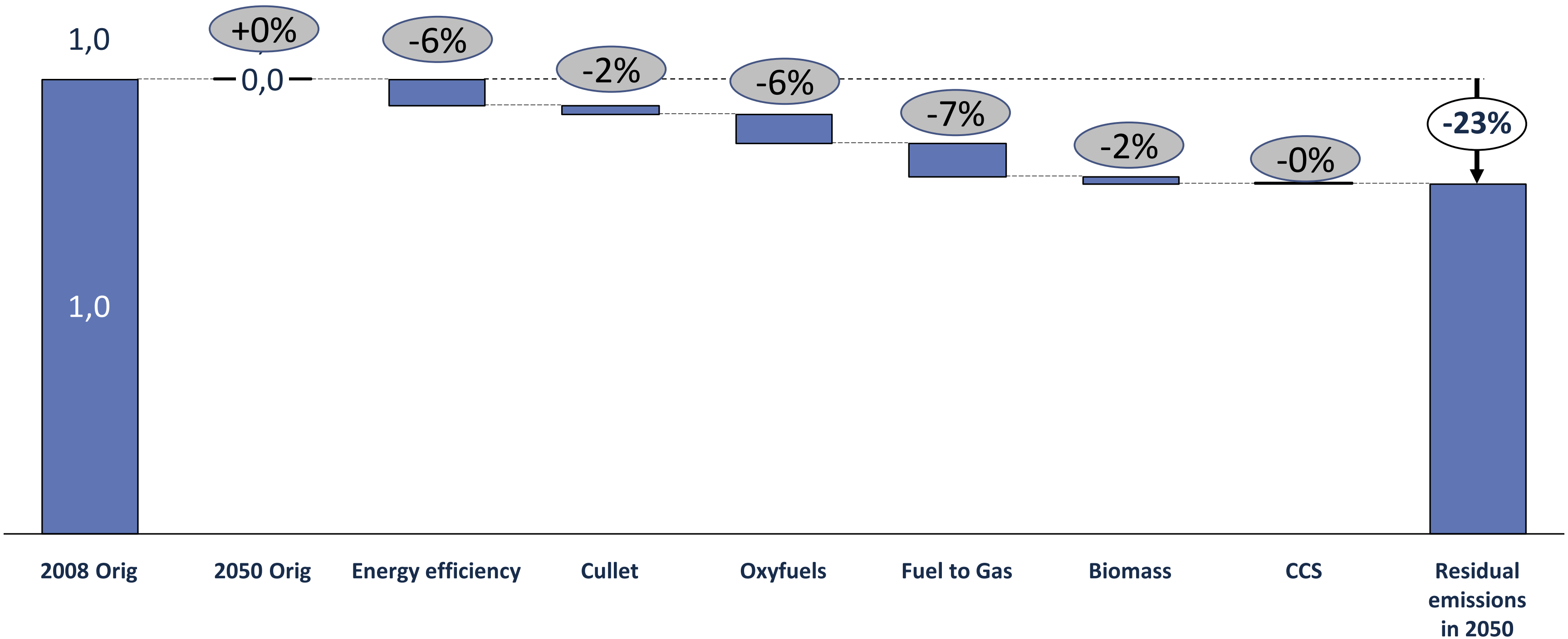
For more coherence with the rest of the analysis, the reductions should be assessed vs 1990

SOURCE: OPE²RA model

Reduction potential

Detail of the different reduction levers on trajectory 2 with ambition level 2

GHG emissions in 2050 using different levers
(% of 2010)

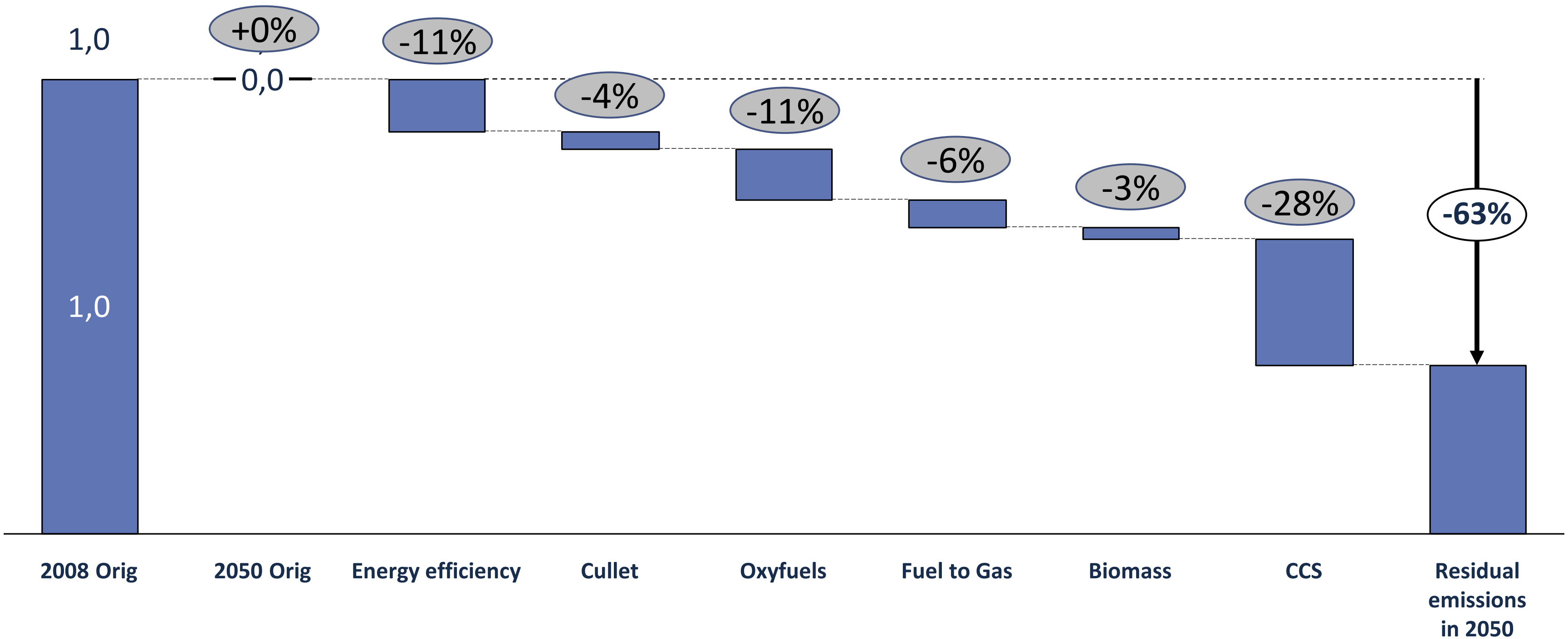


NOTE: Biomass potential is illustrated in this analysis and leads to a double counting which is removed in the model
SOURCE: OPE²RA model

Reduction potential

Detail of the different reduction levers on trajectory 2 with ambition level 3

GHG emissions in 2050 using different levers
(% of 2010)

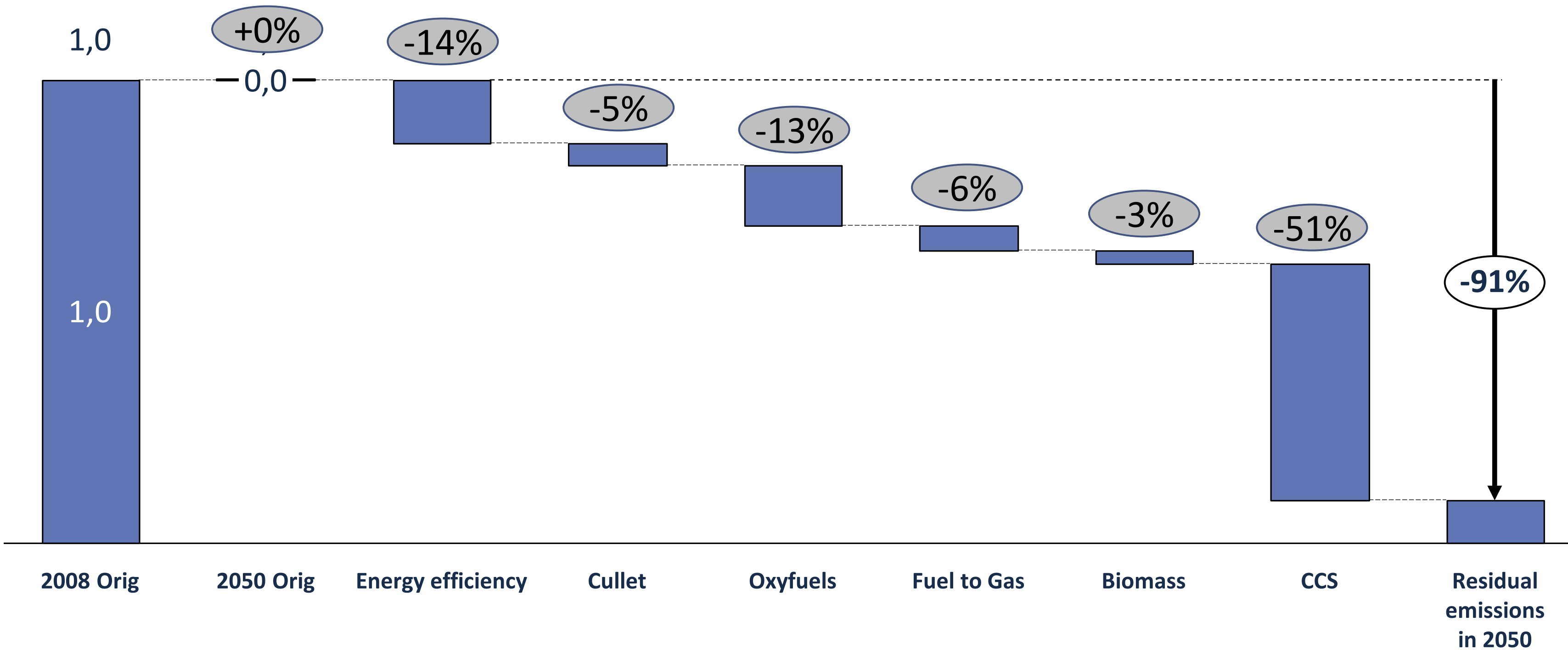


NOTE: Biomass potential is illustrated in this analysis and leads to a double counting which is removed in the model
SOURCE: OPE²RA model

Reduction potential

Detail of the different reduction levers on trajectory 2 with ambition level 4

GHG emissions in 2050 using different levers
(% of 2010)



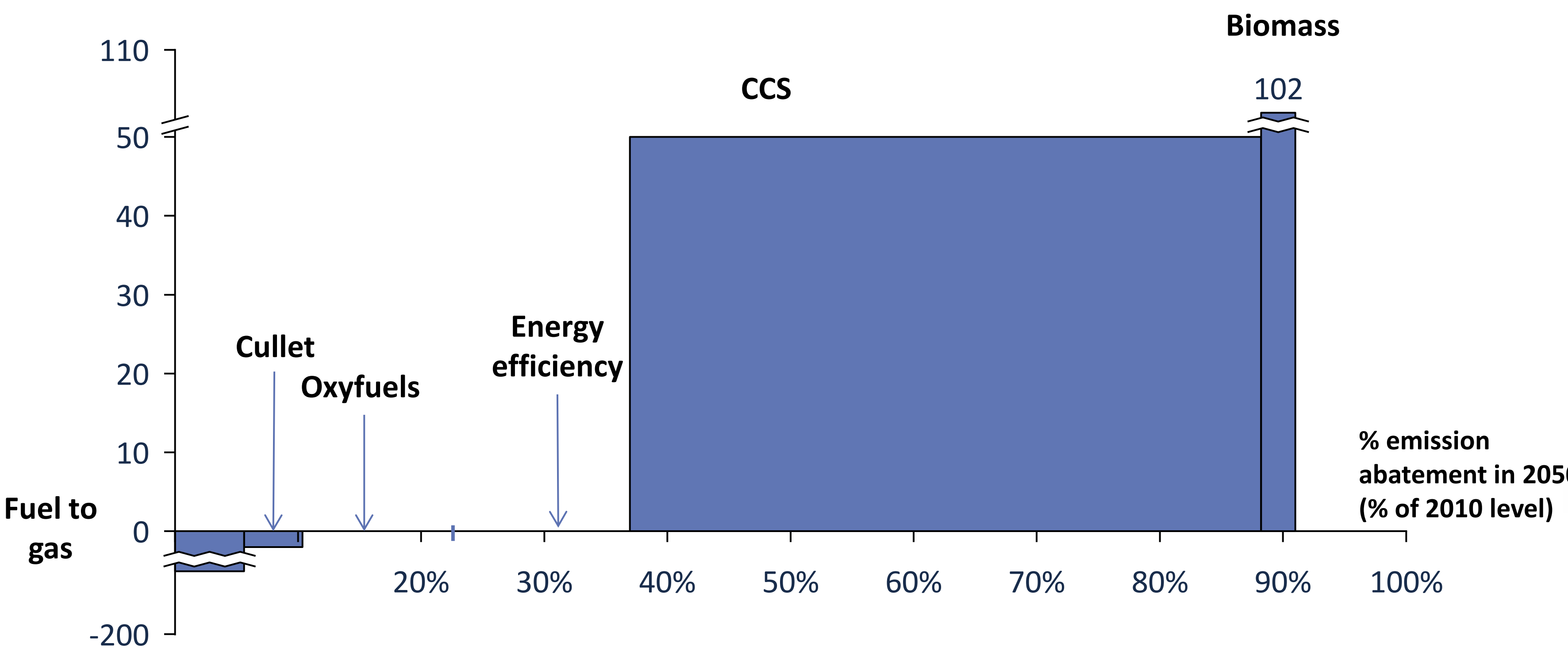
NOTE: Biomass potential is illustrated in this analysis and leads to a double counting which is removed in the model
SOURCE: OPE²RA model

Costs: glass

Marginal abatement costs of the different levers on trajectory 1 with a level 4 ambition

GHG abatement curve for the year 2050 (trajectory 2, ambition 4)

€/tCO_2e, % emission abatement in 2050 (% of 2010 level)



NOTE: Biomass potential is illustrated in this analysis and leads to a double counting which is removed in the model

SOURCE: OPE²RA model

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Technical details on the flat and hollow glass productions

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Energy distribution for the main industrial glass types

Type of glass	Flat glass	Container glass
Type of furnace	Float, regenerative cross-fired	Regenerative, end-fired
Pull rate	600 tonnes/day	260 tonnes/day
Cullet	25 %	83 %
Total energy consumption (GJ/tonne melted glass)	6.48 GJ/tonne melted glass	3.62 GJ/tonne melted glass
Water evaporation (batch humidity)	1 %	1.5 %
Endothermic reactions	6 %	2.4 %
Sensible heat glass melt (net)	33 %	44.2 %
Wall heat losses	15 %	18.3 %
Cooling and leakage heat losses	9 %	3.7 %
Flue-gas losses from bottom regenerator	32 %	27.6 %
Regenerator heat losses (structure)	4 %	2.3 %

SOURCE: BREF 2009 [97, Beerkens Energy Balances 2006]

Thank you.

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