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A Low-carbon roadmap for Belgium

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

Industry sector – lime document

This document is based on content development by the consultant team as well as expert workshops that were held on the 13-05-2013, 18-05-2011 and 15-06-2011

vito
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Content – Industry sector - lime

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Executive summary for the lime sector

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Construction of different future production trajectories

- 3 trajectories for lime production in Belgium have been defined, they vary **from +27 to -5% by 2050**
  - The high demand trajectory is based on a **recovery of 2008 production level**(for Lime and decarbonated dolomite, 2010 levels for sintered dolomite) explained by new markets development (sewage water cleaning, fossil electricity, channel dredging and infrastructures)
  - The intermediary trajectory is based on **0 growth**
  - The low demand trajectory assumes a **-5% evolution** on the 2050 horizon

Estimate of potential and cost for the GHG reduction opportunities

- **GHG emission reduction potential (at constant production) is important (-72% in level 3) but it's applicability mainly depends on CCS**
  - **Energy efficiency** can improve GHG emissions by 12%
  - **Lignite substitution by natural gas** has limited potential (-2%) for €30/tCO_2e
  - **Substitution by alternative fuels (biomass & waste)** has some potential (-5%)
  - **CCS is unavoidable** to significantly reduce GHG emissions (-54%) for ~55€/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

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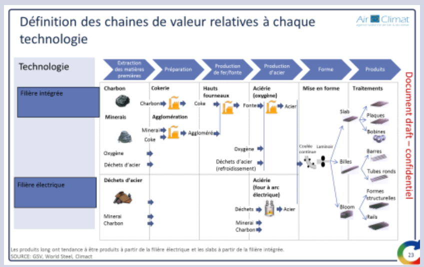
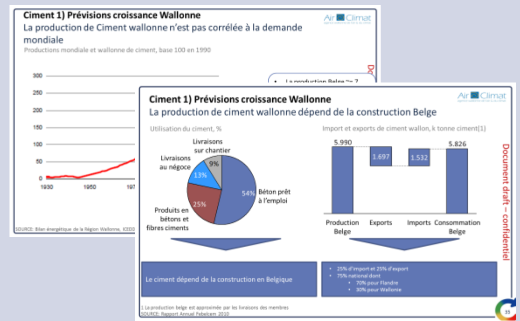
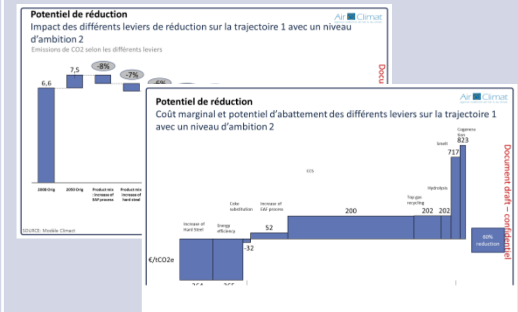
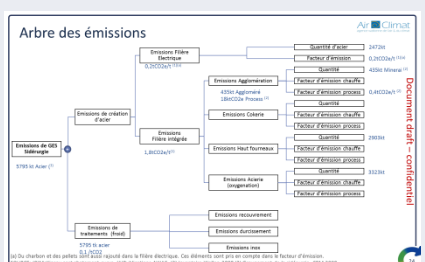
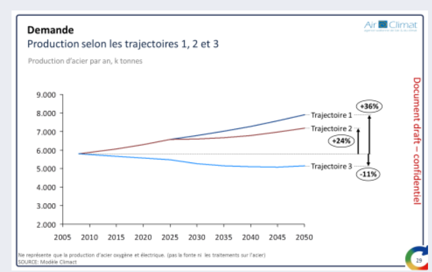
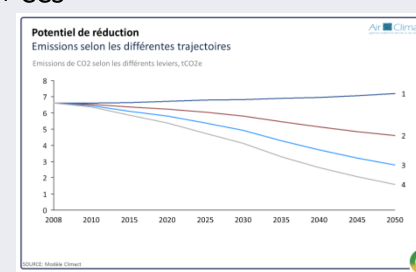
A detailed analysis is performed for each industrial sector, the methodology is detailed in the general industry document (and not repeated in each sector document)

	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

Lime production and energy efficiency are stable

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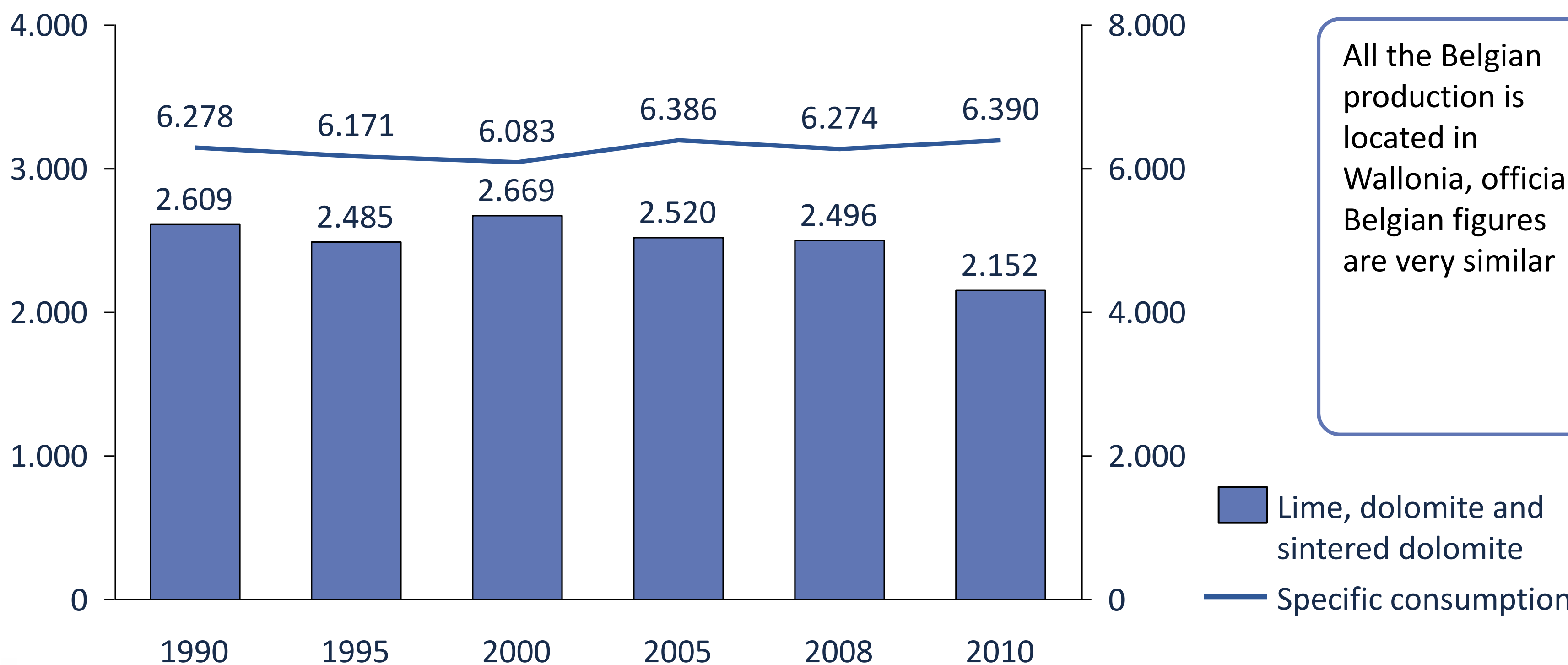
Walloon lime production and specific consumption evolution
(kt, Gj/kt)



All the Belgian production is located in Wallonia, official Belgian figures are very similar

NOTE: For confidentiality reasons, only aggregated data is shown here (the analysis is performed segmenting the different lime types)
SOURCE: Walloon energy balance, NIR for 2010 belgian production (Walloon balance figure for 2010 is 2070)

Lime energy consumption related GHG emissions are stable

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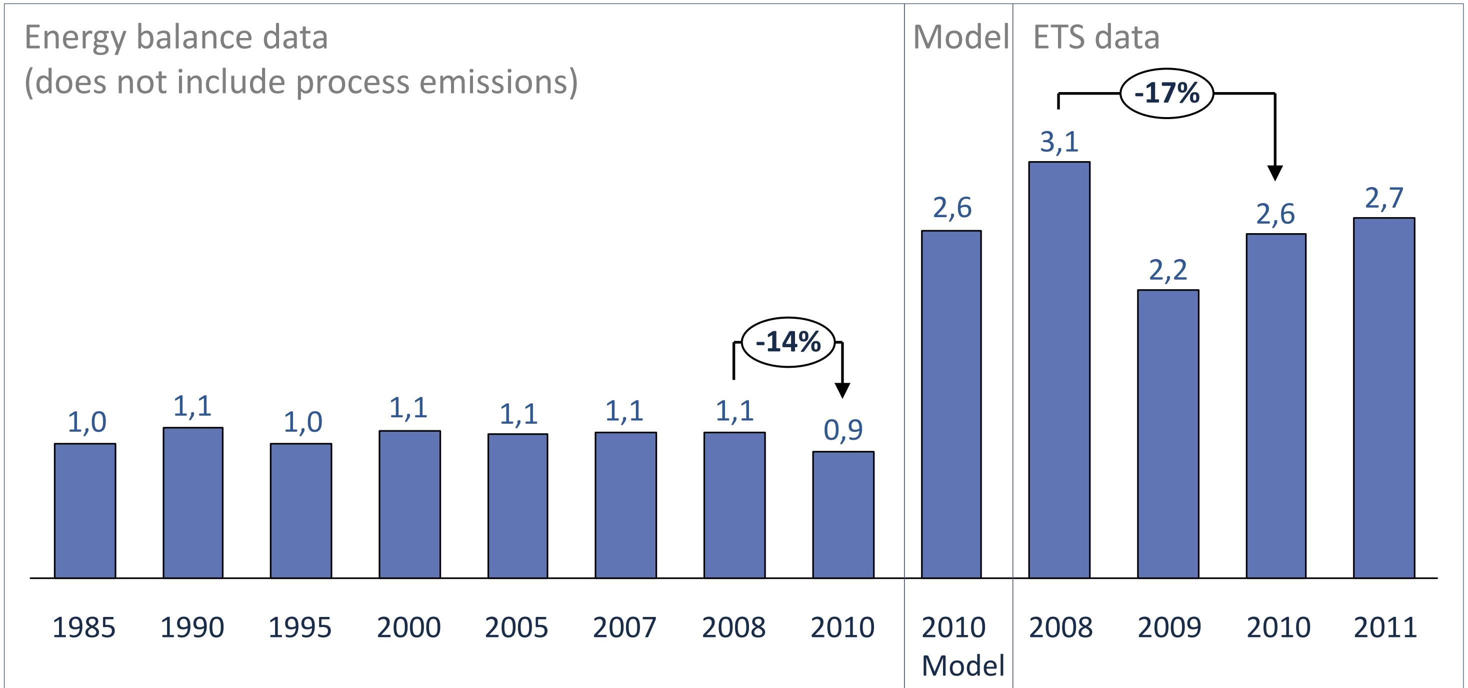
GHG emissions linked to final energy consumption in the Walloon non-metallic minerals ($MtCO_2e$)



Process emissions are twice the size of the combustion emissions

NOTE: Consumed energy only represents a portion of the emissions (process emissions must also be added)
There is a scope difference between the datasets; the Energy balance data covers the whole value chain, whereas the ETS scope starts at the materials placed in the ovens (and allocates the previous steps to a “quarries” segmentation).

SOURCE: CITL, 2010 Walloon energy balance

Lime consumes mainly solid and gaseous fuels

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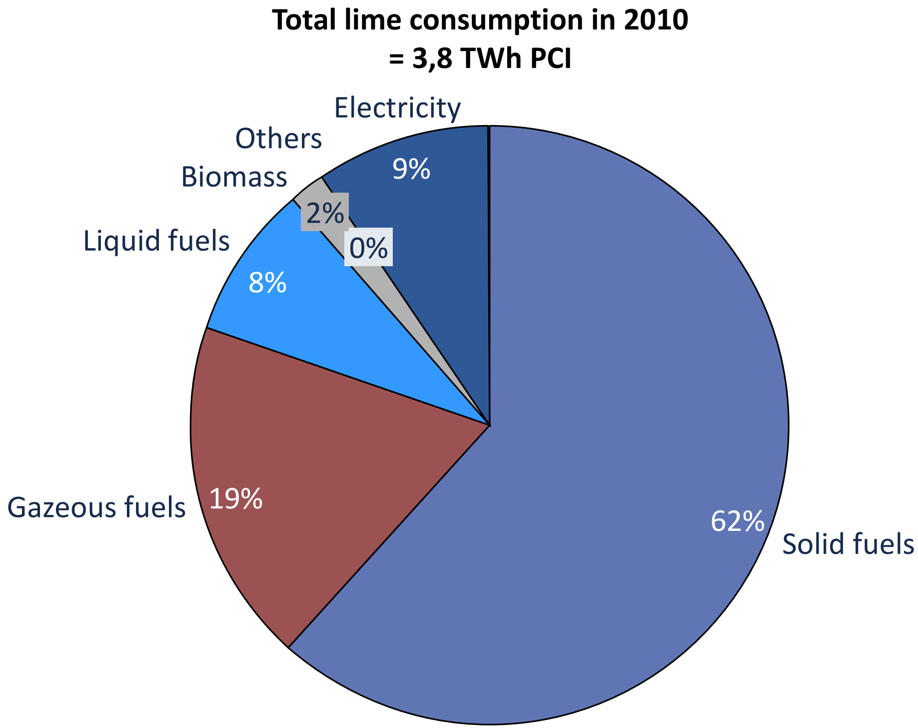
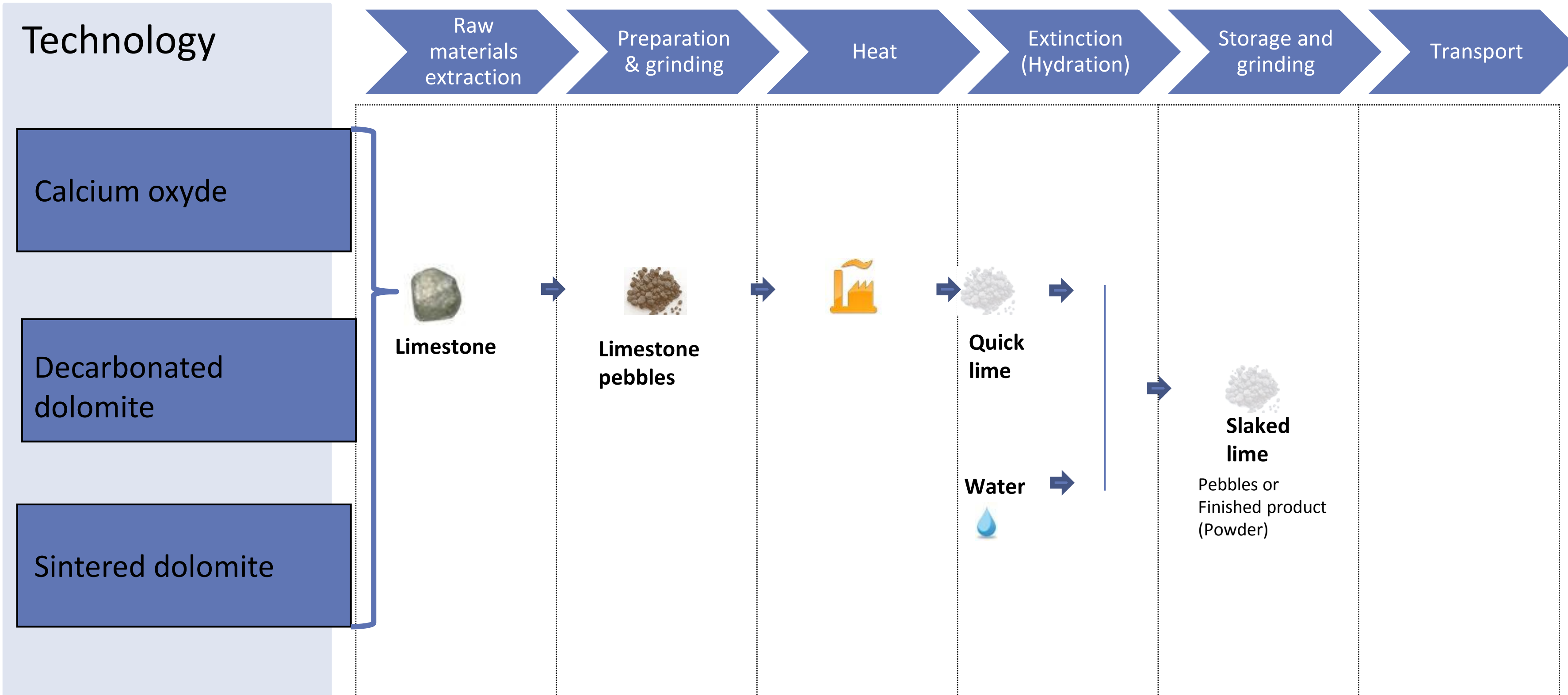
Energy sources distribution
(%)



- There is very limited biomass use in lime
- Solid fuels are made of lignite(71%), coal/'hard coal' and petrol coke
- Gaseous fuels are made of natural gas
- Liquid fuels are made of light fuels

SOURCE: 2010 Walloon energy balance

Supply chain definition for the various technologies



SOURCE: Preliminary Climact analysis

Lime has numerous applications

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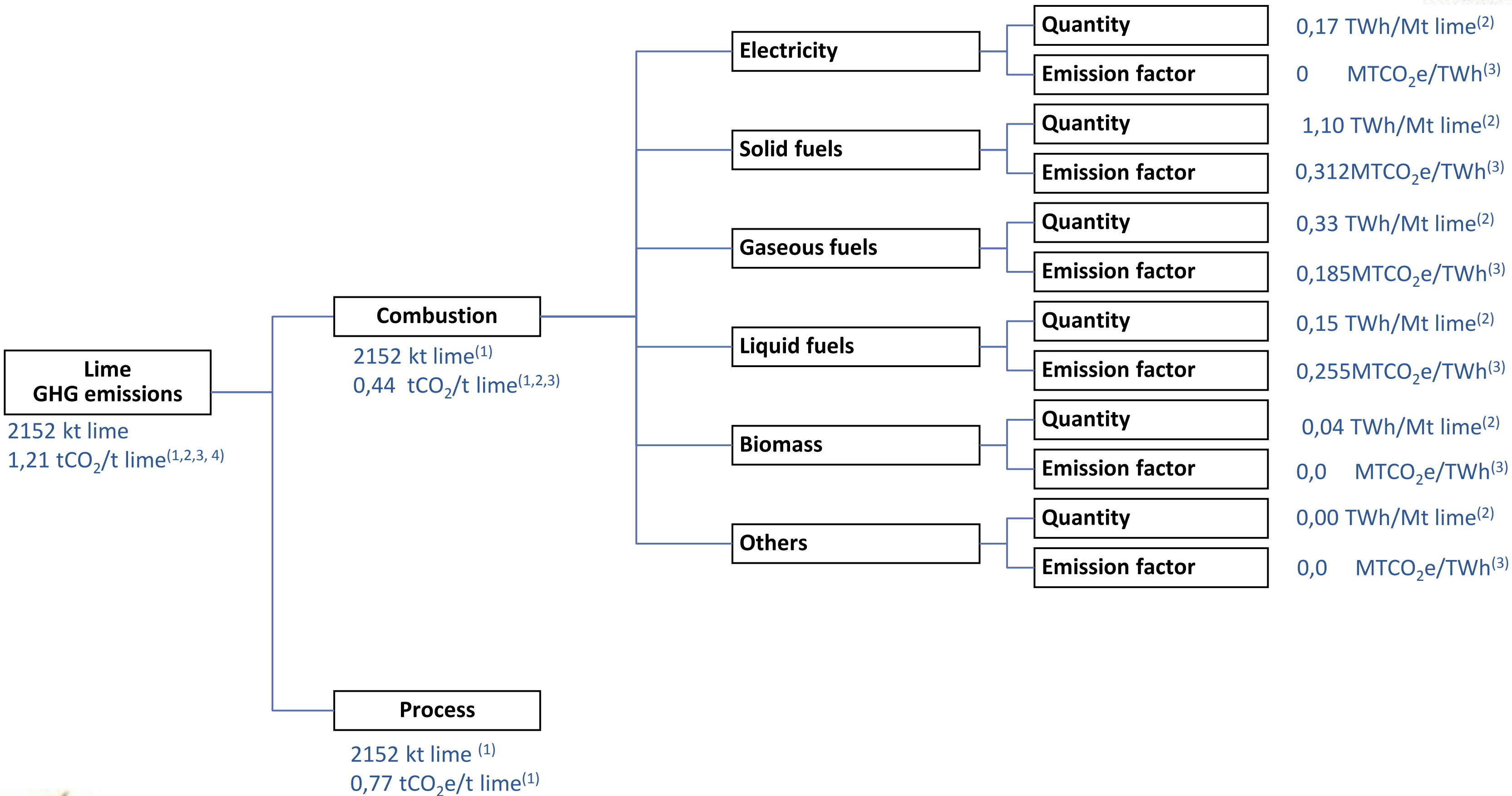
	Quick lime		Slaked lime
	Quick lime	**Quick lime powder**	
Applications	• Steel flows • Combustion gas desulphurisation (FGD) • Various environmental applications. • Production of glass fibres, aluminium, pulp and paper, uranium, gold, copper ...	• Environmental treatments • Concrete production, • Soil stabilization • Neutralizing agent in agricultural applications	**Examples**: • Water and waste treatment • Soil stabilization • Agricultural applications • Asphalt modification • Combustion gas desulfurization • Construction products (mortar, plaster, whitewash and stucco)
Differences	• Less diluted chemically • All sizes • Use of lime extinguishers		• More diluted chemically • Specific size required • No lime extinguishers

SOURCE: Graymont

Modelled emission tree



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NOTE : For confidentiality reasons, the different lime types are aggregated in this slide

SOURCE: (1) 2010 National Inventory Report CRF 1,4 (2) 2010 Walloon energy balance (3) Carmeuse and Lhoist (4) Climact analysis

Content – Industry sector - lime

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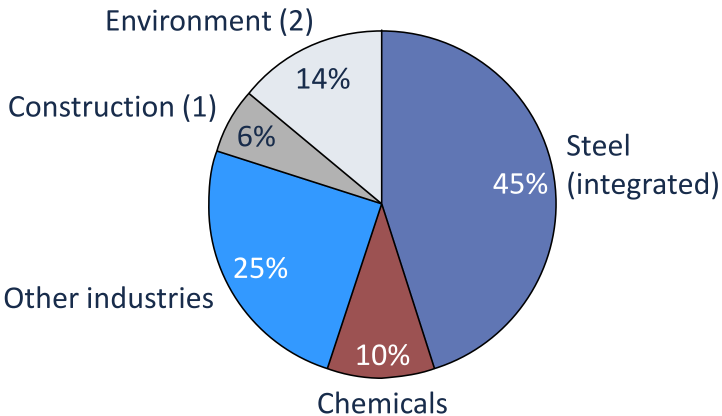
Belgium growth forecasts

Belgium lime production depends on various sectors, of which the integrated steel sector

Lime uses
(illustrative %)



Lime depends mostly on the industrial sectors (of which ~half for the integrated steel),
The rest is varied.

Sector trends

- Growth is mainly expected in environment and construction sectors
- Two trends support a geographic markets opening:

On higher added value products	On lower added value products
In the last 2 years, a trend towards more technical and higher added value products has been observed. This trend is expected to continue and to support market internationalisation and substitution of other products (e.g. cement)	Additional competition on lower added value products is expected from several European periphery ovens which currently work at sub-capacity

NOTE: Includes construction sector and construction industry, (2) Includes sewage water cleaning, fossil electricity, channel dredging and infrastructures)
SOURCE: Interview experts, Fediex 2010 report on the extraction industry

Belgium growth forecasts

Several parameters have been taken into account to assess the future demand

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Growth forecast parameters

Expected growth forecast definition	• The lime production has historically been very stable before 2008. The 2008-2010 drop is explained by the closure of Walloon oxygen steel plants. • The future production will be more linked to external event than to the site production capacity. Furthermore, the sector but has a historical capacity to develop new markets (e.g. sewage water cleaning, fossil electricity production, channel dredging and infrastructures) • GDP: 1,6% (1) • Federal planning bureau using Primes non-metallic minerals : 1,3% (05-20) 1,4% (20-30) (2) • GEM E3 projections on other non-metallic minerals: 0,9%(6) • 2030 projections: 1,9% (10-20), 0% (20-30) • PMDE Wallonia (10-20): Lime: 0% (3) • Construction market: 0%(4)
Probability to create new infrastructures	• Competitive sector sensitive to carbon leakage (2nd most impacted actor by CO_2 price) • No new installations expected on medium term. Potential new quarries are identified but can be blocked because of environmental permits restrictions
Competitiveness	• Belgium has enough Limestone in its quarries to support medium to long term production. • Delocalisation tendency (driven by high labour costs and limited by the export costs)
Imports and exports proportion	• 10% export, 0% imports • Import rate could increase because of the European periphery ovens working at sub-capacity
Indicators to correlate to the Walloon production	• Belgian GDP (Glass, paper and chemical sectors) (previously 50% to the oxygen steel sector)
Product mix expected modifications	• Same product mix is expected in the future

SOURCE: (1)Belgian Federal Plan Bureau 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 for the park (6) GEM-E3 projection, physical production output (kton) (used in TUMATIM study)

Belgium growth forecasts

3 trajectories influencing energy demand are modelled

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Possible growth scenarios

- Development of new markets to recover 2008 production levels

Possible closure scenarios

- If no free allocation of quotas (scenario not modelled because excluded)

Trajectory 1

Development of new markets to recover 2008 production level(for lime and decarbonated dolomite, 2010 levels for sintered dolomite) because of new markets development (sewage water cleaning, fossil electricity, channel dredging and infrastructures)

- 3,9% CAGR on 2010-2015
- Then +5% on the 2050 horizon 2050 (0,1% CAGR)

Trajectory 2

Lime production maintained at its current level

- +0% on the 2050 horizon

Trajectory 3

- -5% on the 2050 horizon 2050 (0,1% CAGR)

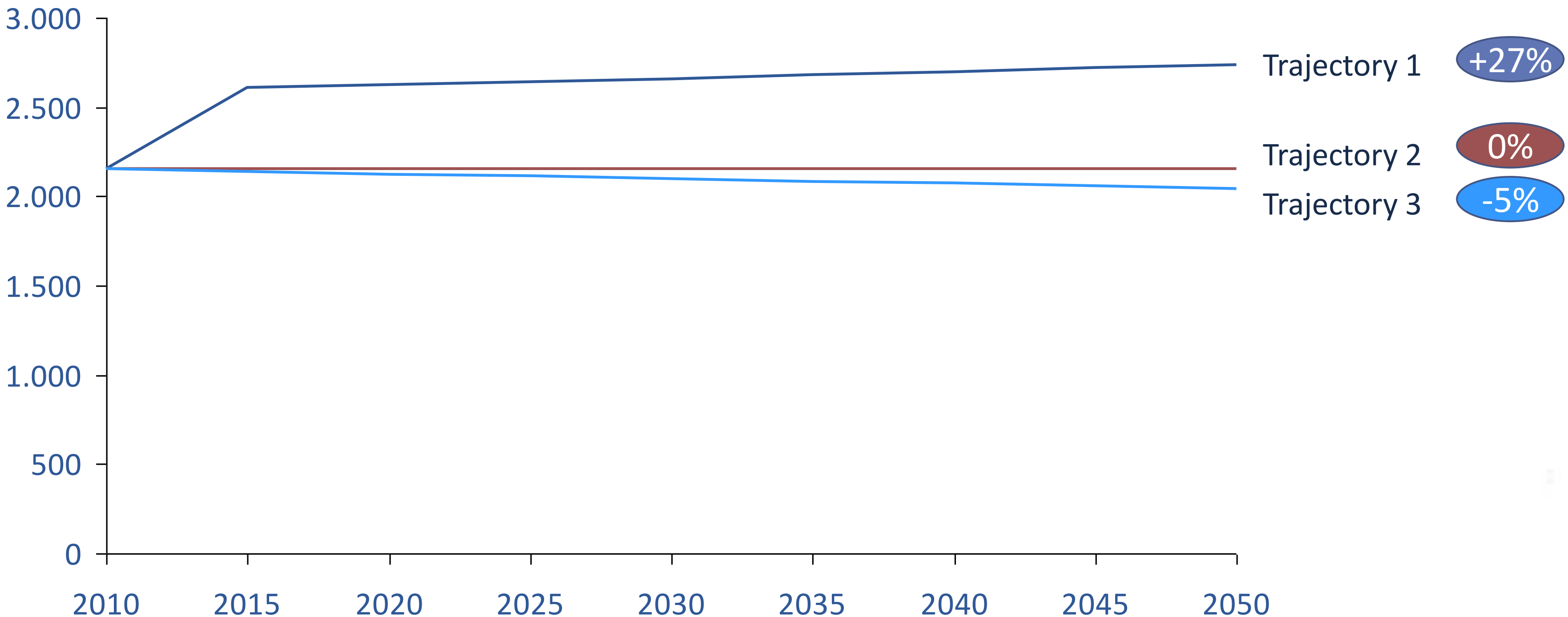
SOURCE: Climact analysis

Belgium growth forecasts

Production along trajectories 1, 2 and 3

Lime production per year
(k tons)

Delta 10-50,%



SOURCE: Climact Model

Reduction potential

Reduction levers are additional and applied in the following order

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Methodology

Product mix	Energy efficiency	Process improvements	Alternative fuels	End of pipe
• Increase the proportion of products that require less CO_2	• Reduce mechanical and thermal losses • Recover thermal losses (e.g. CHP)	• Modify the way products are made	• Increase the proportion of fuels which emit less CO_2	• Capture the CO_2 emitted by the production

Examples

Product mix	Energy efficiency	Process improvements	Alternative fuels	End of pipe
Lower decarbonatation	Kiln type	Product dilution	Biomass	CCS
	CHP	Batch → continuous	Lignite → Natural gas	
	Recycled dust		Waste	

Product mix

Product specifications can be better tailored to client needs, however this will not significantly impact the sector emissions

- Several applications require less decarbonatation in the end product (e.g. road stabilisation)
- This could lead to emission reductions of ~0.1% and will probably lead to a sorting of the products depending on the decarbonatation intensity

SOURCE: Consultation

Reduction potential: energy efficiency (1/2)

The BREF potential is 32-40% more efficient than current Belgian sector

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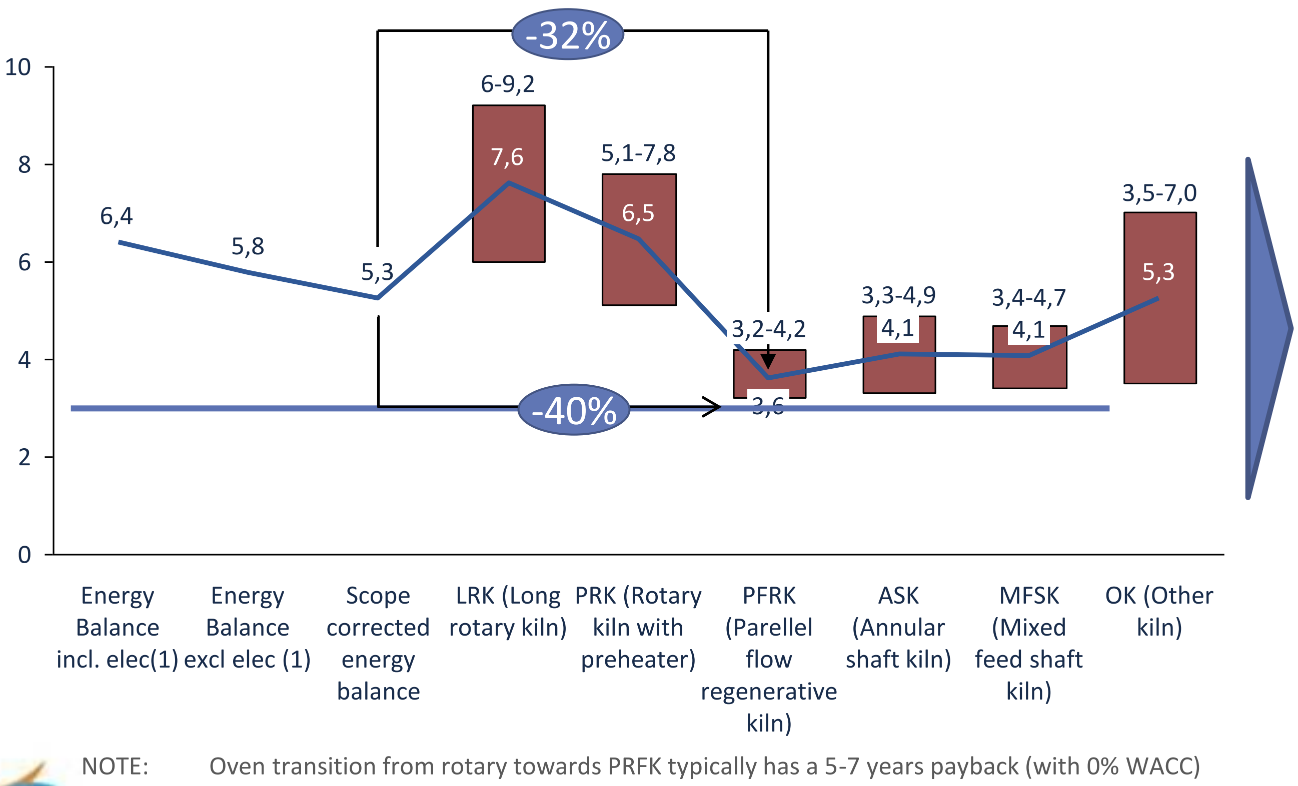
Thermal energy consumption
(Gj/t lime in 2010)



- BREF potential is maximum 40% more efficient (5,3→ 3,2) (2)
- A conservative calculation assesses that a switch from the current ovens to PRFK ovens (straight) enables 32% energy gains (5,3→3,6)
- There are obstacles to this switch:
  - Reduction of the amount of raw materials that can be valued (straight ovens do not accept fine particle sizes)
  - Product quality differences are an incentive to only switch part of the production to straight ovens
- These obstacles are balanced by the technological improvements expected by 2050

NOTE: Oven transition from rotary towards PRFK typically has a 5-7 years payback (with 0% WACC)
(2) The federation considers this maximum potential not feasible technically

SOURCE: BREF for all data except, (1) 2008 Walloon energy balance, 2010 National Inventory Report CRF v1.4

Reduction potential: energy efficiency (2/2)

Improve the energy efficiency

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Level 1

- **Minimum effort** (following current regulation)
- **Switching a small part of the production to more efficient ovens**
- **(-8% energy by halving level 2 ambition)**

Level 2

- **Moderate effort** easily reached according to most experts
- **Switching part of the production to straight PRFK ovens**
- **(-16% energy by halving level 3 ambition)**

Level 3

- **Significant effort** requiring cultural change and/or important financial investments
- **Reaching the average potential for straight PRFK ovens**
- **(-32% energy by going from 5,3 to 3,6 Gj/ton lime)**

Level 4

- **Maximum effort** to reach results close to technical and physical constraints
- **Reaching the BREF maximum potential for straight PRFK ovens**

(-40% energy by going from 5,3 to 3,2 Gj/ton lime[(1)])

NOTE: (1) The federation considers this ambition level not feasible technically

SOURCE: Lime consultation, Climact analysis

Reduction potential: alternative fuels (1/2)

Alternative fuel potential is strong, and 15% has been achieved in the past

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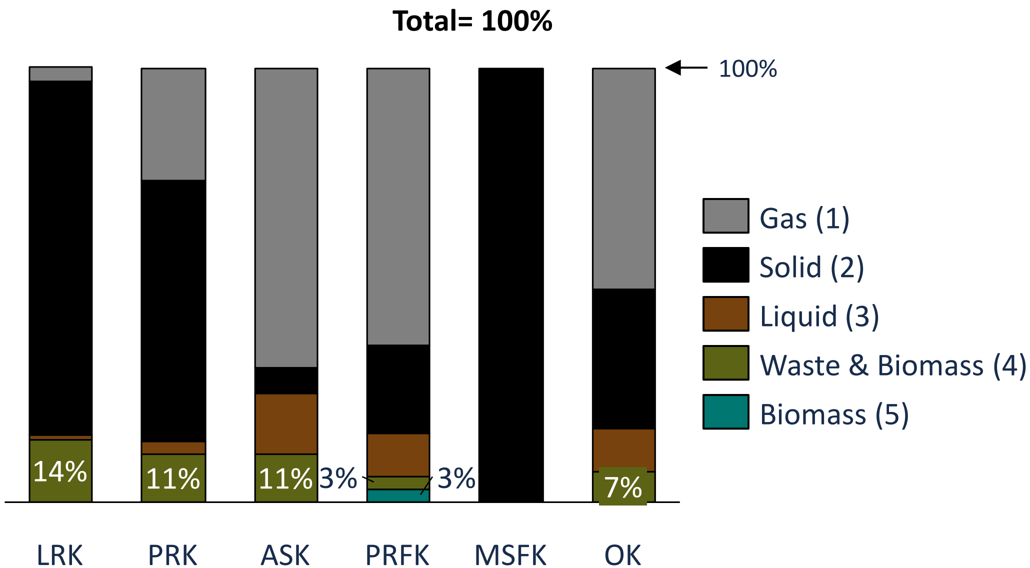
Proportion of fuels used in the different types of lime kilns
(% in ovens in 2003)



NOTE: The fact the biomass yield is higher in lime does not imply it should be used in lime as priority

(1) Natural coke, coke oven and converter gas, butane & propane gas
(2) Coal, petcoke, metallurgical coke, lignite, anthracite
(3) Heavy, medium and light fuel oil
(4) Waste wood, tires, plastic, waste liquid fuels, animal fat, meat bone meal
(5) Wood, woodchips, sawdust wastes from agriculture and forestry

SOURCE: BREF

Current alternative fuel use
Some oven types used already close to 15% alternative fuels in 2003 :

Lever application limitations :

Fuel specification restrictions
- In order not to affect product quality, the fuel utilisation conditions are very strict
- This technology is expected to have impacts in terms of emissions (particles, other atmospheric pollutants,…)

Technology availability
- The technology enabling to use a large portion of alternative fuels is still being developed

Fuel availability and cost
- The available potential is unknown
- There are costs for the transport and processing and drying

Reduction potential: alternative fuels (2/2)

Portion of alternative fuels in 2050

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Level 1	Level 2	Level 3	Level 4
• **Minimum effort** (following current regulation)	• **Moderate effort** easily reached according to most experts	• **Significant effort** requiring cultural change and/or important financial investments	• **Maximum effort** to reach results close to technical and physical constraints
• **Biomass/waste is too expensive or biomass is inaccessible**	• **Constant use of substitutes**	• **Strong increase (more could reduce the product quality)**	• **Even stronger biomass/waste mix**
(0% of alternative fuels in the mix)	**(2 % of alternative fuels in the mix)**	**(20% of alternative fuels in the mix)**	**(60% of alternative fuels in the mix)**

NOTE: Major supply would be required to support the ambitious levels (e.g. 1 oven would requires 2000hc of wood)
Simplifying assumption : the waste price is assumed aligned on the biomass prices

SOURCE: Lime consultation, Climact analysis

Reduction potential: Lignite to gas (1/2)

Lignite to gas potential

Use of Maerz kilns

- Maerz kilns are of the most efficient available technology (PRFK)
- With the Maerz technology, kilns can alternatively be operated with either 100 % natural gas, or 100 % solid fuel (gaseous/solid fuel combination are more difficult)
- The use of these ovens currently supports a transition back to the use of lignite (gas being more expensive)
- However, some applications (~25% e.g. food related products) will always rely on gas
- Transition costs per ton differs between sites
    - Dunkerke: € 30/ton
    - Dusseldorf: € 90/ton

Use of Maerz kilns on the Aisemont site

Carmeuse has installed a solid fuel firing system on the existing 300 tpd natural gas fired Maerz lime kiln No. 4 in their Aisemont Plant

SOURCE: Maerz company website, internet research

Reduction potential: Lignite to gas (2/2)

Lignite to gas potential

Level 1	Level 2	Level 3	Level 4
• **Minimum effort** (following current regulation)	• **Moderate effort** easily reached according to most experts	• **Significant effort** requiring cultural change and/or important financial investments	• **Maximum effort** to reach results close to technical and physical constraints
• **80% lignite and 20% gas**	• **conversion of 33% of lignite**[1]	• **conversion of 66% of lignite** [1]	• **conversion of 100% of lignite** [1]

NOTE: (1) This transition would be favored by higher solid fuel or lower gas prices
Lignite corresponds to 70% of the solid fuels used in the lime industry

SOURCE: Lime consultation, Climact analysis

Reduction potential: CCS (2/3)

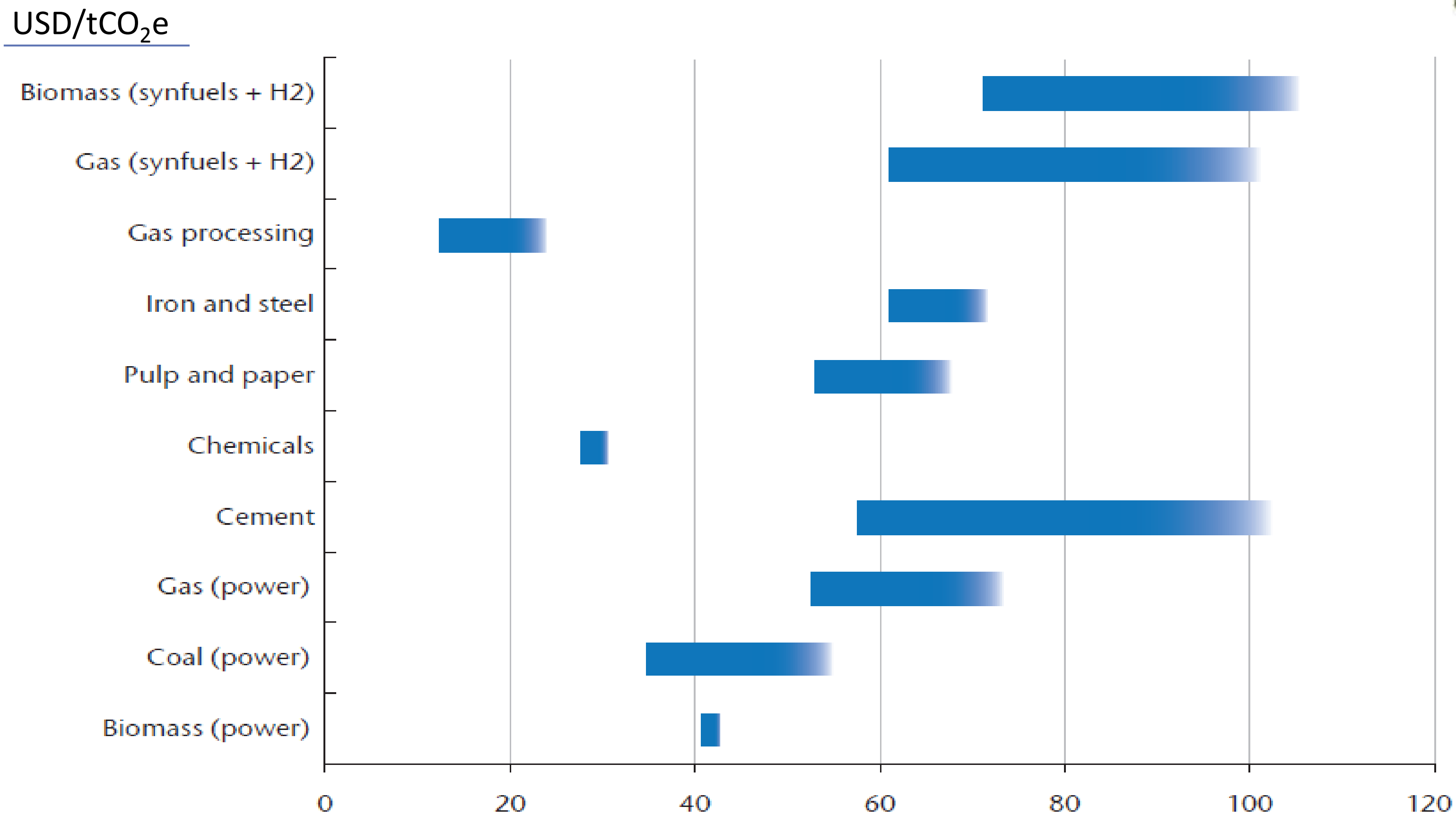
CCS potential is based on size of installations

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 (2/3)

Cost per industry



NOTE: Cement cost is used as an estimate for the lime sector (US$ 75/tCO_2e = € 57/tCO_2e)

SOURCE: IEA

Reduction potential: CCS (3/3)

CCS implementation by 2050

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Level 1	Level 2	Level 3	Level 4
• **Minimum effort** (following current regulation)	• **Moderate effort** easily reached according to most experts	• **Significant effort** requiring cultural change and/or important financial investments	• **Maximum effort** to reach results close to technical and physical constraints
• **No implementation** (0%, starting after 2025)	• **Only largest sites** (36 %, starting after 2025)	• **Only large and medium sites** (66%, starting after 2025)	• **All sites** (85%, starting after 2025)

NOTE: Costs are expected to increase on the smaller installation sizes. This refinement has not been included to simplify the model
SOURCE: Cement consultation, Climact analysis

Additional information on the levers

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Lever type	Lever description	Description
Behavioural	Environmental management system, consumption monitoring	Impact expected to be minor
Product mix	Decrease decarbonatation	See specific slide
Energy efficiency	Kiln type	See specific slide
	CHP	Impact expected to be minor Only applicable to long rotating ovens; these ovens will disappear in case of transition towards more efficient ovens (which are not long rotating) Furthermore, potential is limited by the 'exit' temperature which is of only 100°C
	Recycled dust	Impact expected to be minor Historically reached potential will get lower if ovens have a higher utilisation in the future
Process improvements	Switch from batch to continuous process	Improvement potential already reached
	Particles and sludge recovery	Impact expected to be minor
	Thermolysis	Breakthrough technology (not expected to be implemented by 2050) Consists in using waste combustion gases as fuel for the ovens. Implementation downside include: lots of smokes, remaining solid waste and technological cost.
Alternative fuels	Biomass	See specific slide
	Lignite to natural gas	See specific slide
End of pipe	CCS	See specific slide

SOURCE: (1) Interview

Reduction potential

Reduction potential per technology and category, by 2050

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Lime levers

Lever type	Improvement lever	2050 Potential (%)per ambition level				Cost	Description	Applicability		
		1	2	3	4			Lime	Decarbonated dolomite	Sintered dolomite
Energy efficiency	Increased kiln efficiency, Switch ➔ PFRK	8%	16%	32%	40%	Hyp: cost= fuel gain	Reaching the average potential for straight PRFK ovens in level 3	✓	✓	✓
Alternative fuels	More alternative fuels (incl .waste)	0% Biomass/ waste	2% Biomass/ waste	20% Biomass/ waste	60% Biomass/ waste	Fuel costs	Not applied in this section Currently 2% biomass No capex	✓	✓	✓
	Switch Lignite ➔ Natural gas	Switch to 80% lignite	33% of lignite to gas	66% of lignite to gas	100% of lignite to gas	30€/tCO_2	Cost includes fuel costs and capex	✓	✓	✓
End of pipe	CCS	0%[3]	36%[3]	66%[3]	85%[3]	57€ /tCO_2[3]	As of 2025 1tCO_2e=3MWh	✓	✓	✓

SOURCE: (1) BREF, (2) IEA cement roadmap , (3) IEA CCS roadmap with Climact analysis

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Reduction potential

Emissions along the different trajectories and reduction ambition levels

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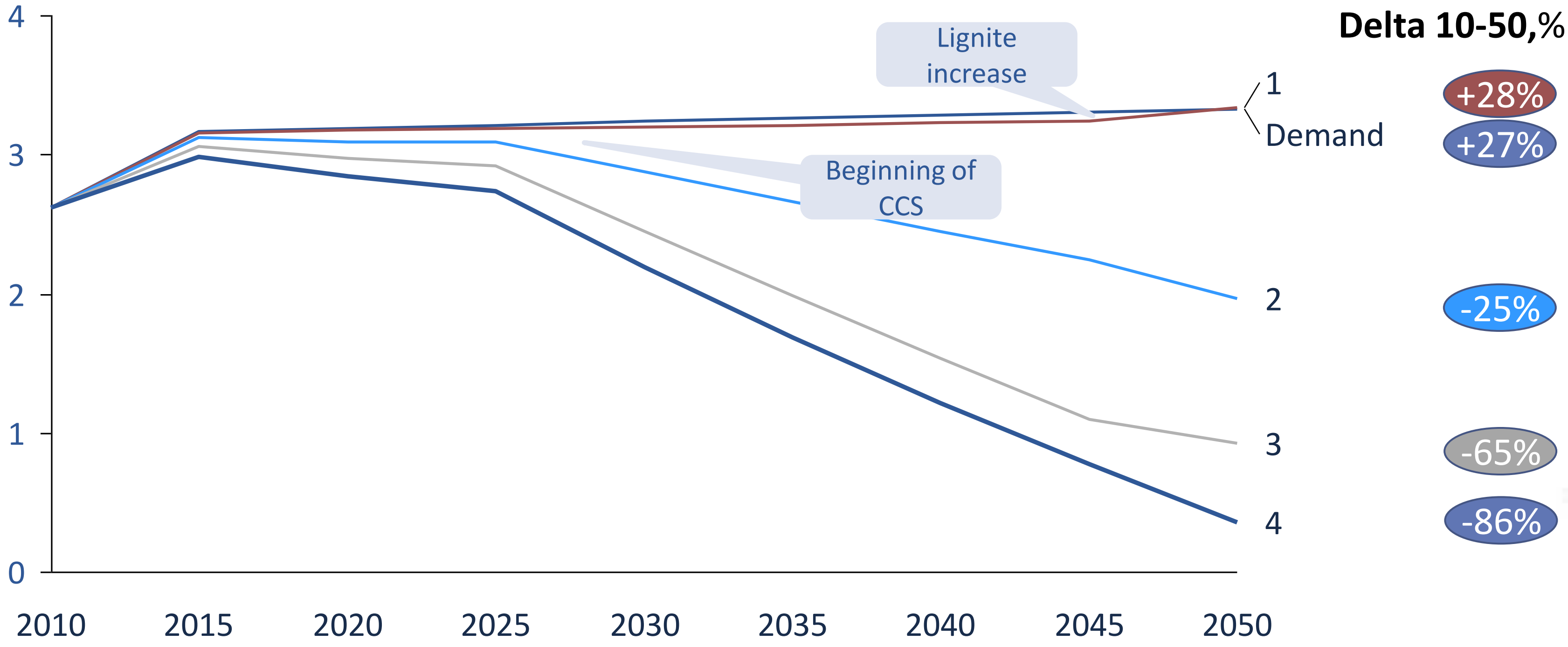
Trajectory 1 (high growth) GHG emissions for different ambition levels
($MtonCO_2e$)



NOTE: Including biomass potential
SOURCE: OPE²RA model

Reduction potential

Emissions along the different trajectories and reduction ambition levels

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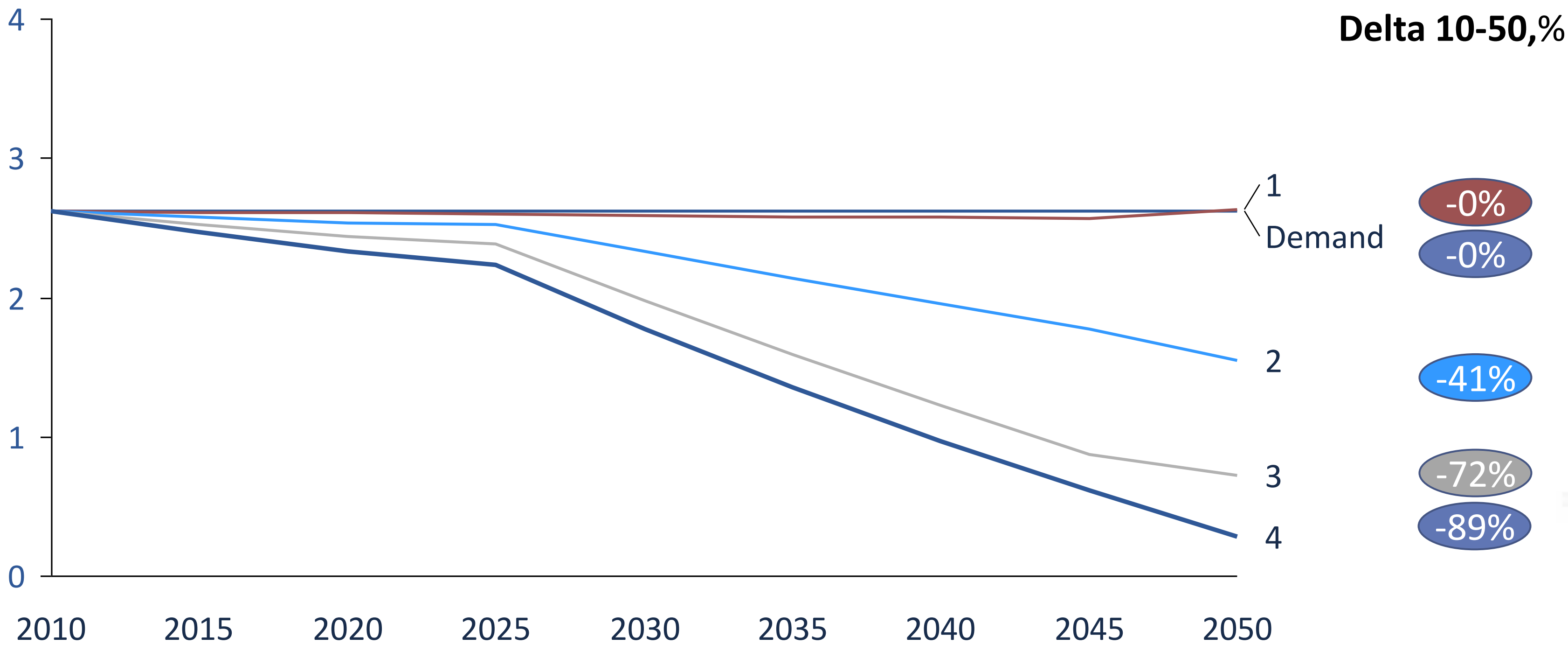
Trajectory 2 (medium growth) GHG emissions for different ambition levels
($MtonCO_2e$)

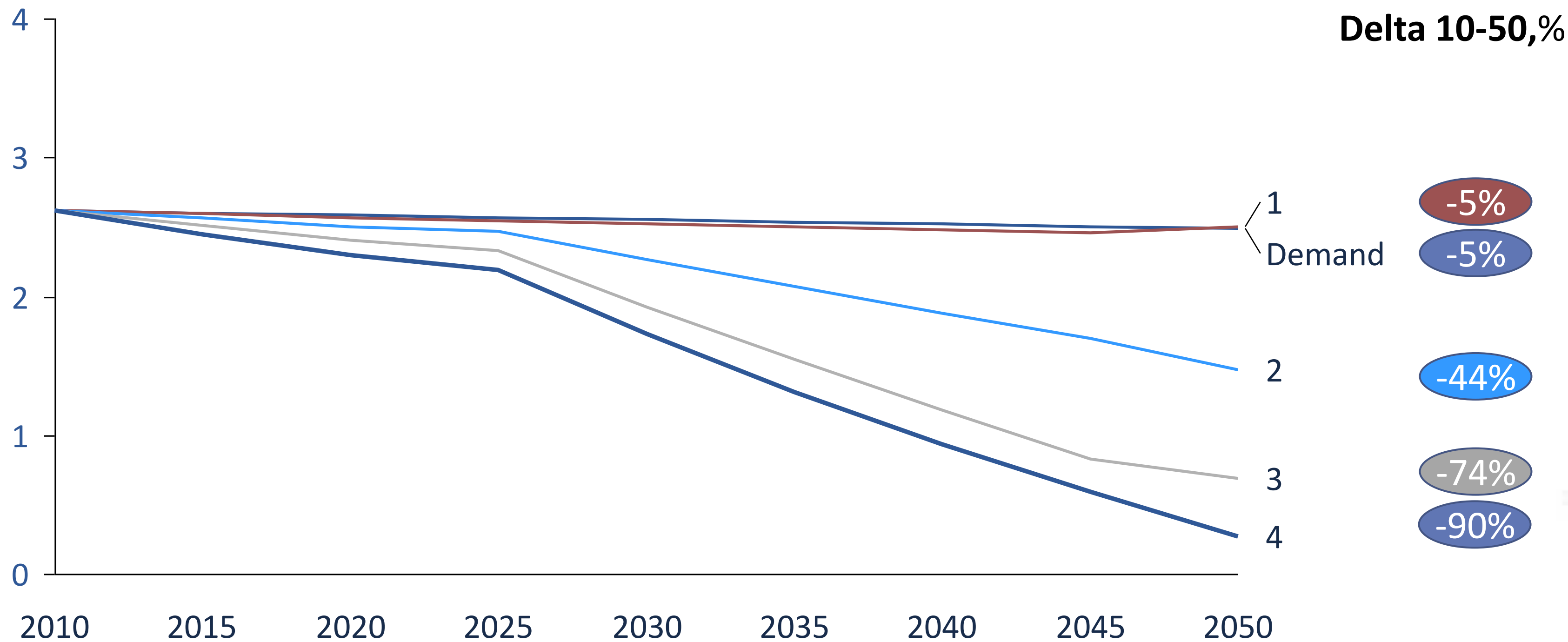


NOTE: Including biomass potential
SOURCE: OPE²RA model

Reduction potential

Emissions along the different trajectories and reduction ambition levels

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



NOTE: Including biomass potential
SOURCE: OPE²RA model

Reduction potential

Only ambition level 4 is in line with the industrial objectives of the European commission

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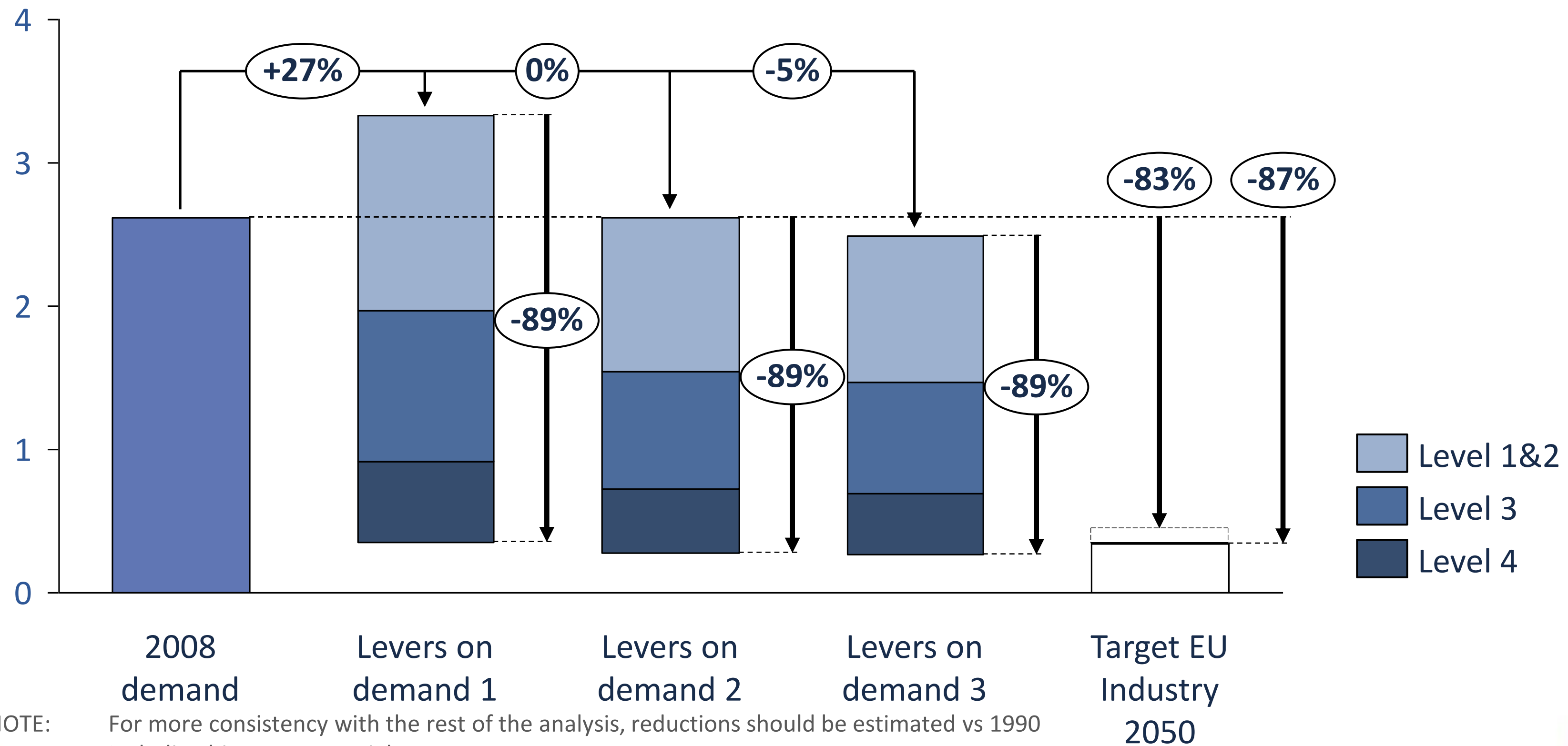
GHG emissions for different trajectories and ambition levels
(MtonCO_2e and % change in % of 2010 level)



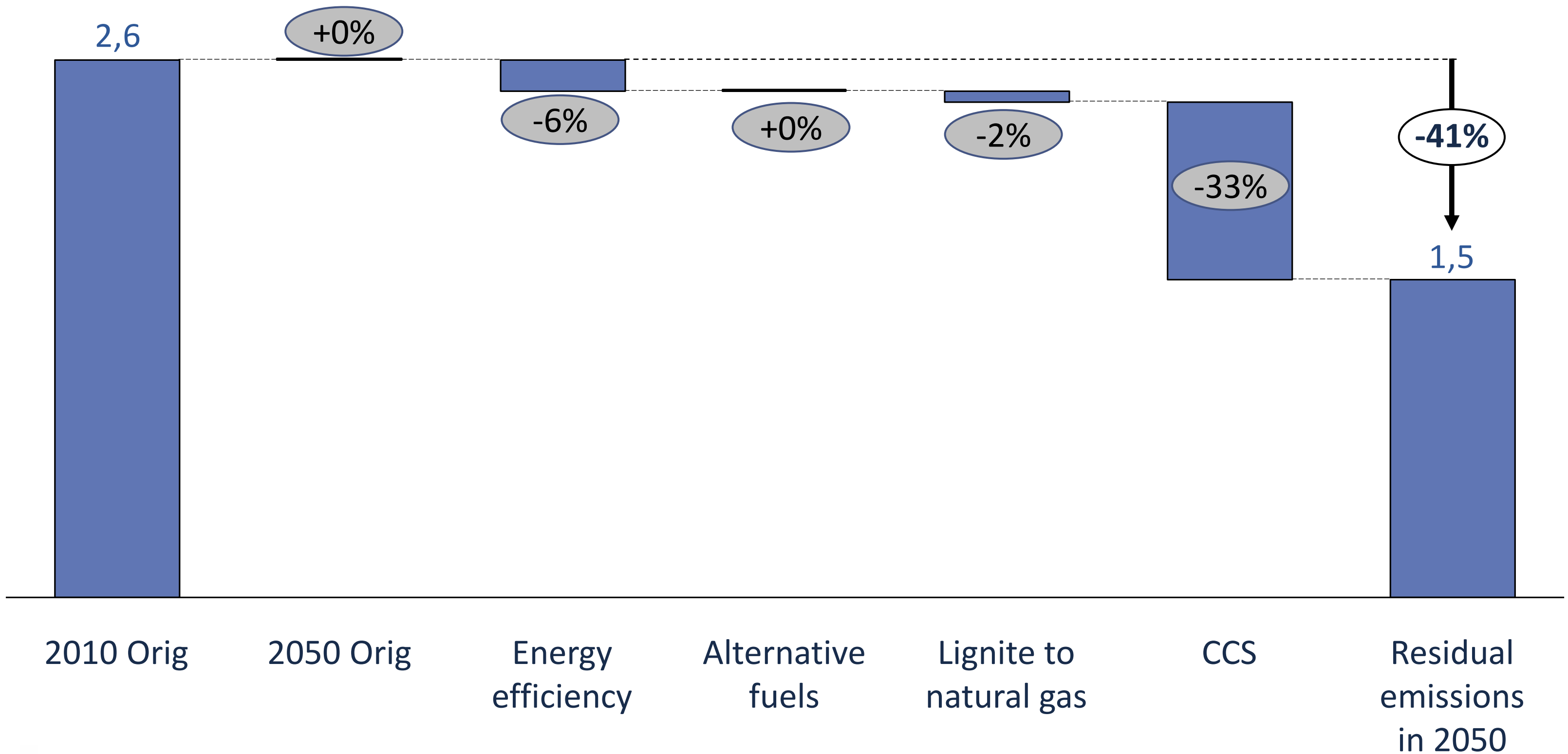
NOTE: For more consistency with the rest of the analysis, reductions should be estimated vs 1990
Including biomass potential

SOURCE: OPE²RA model

Reduction potential

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

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



NOTE: Including biomass potential
SOURCE: OPE²RA model

Reduction potential

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

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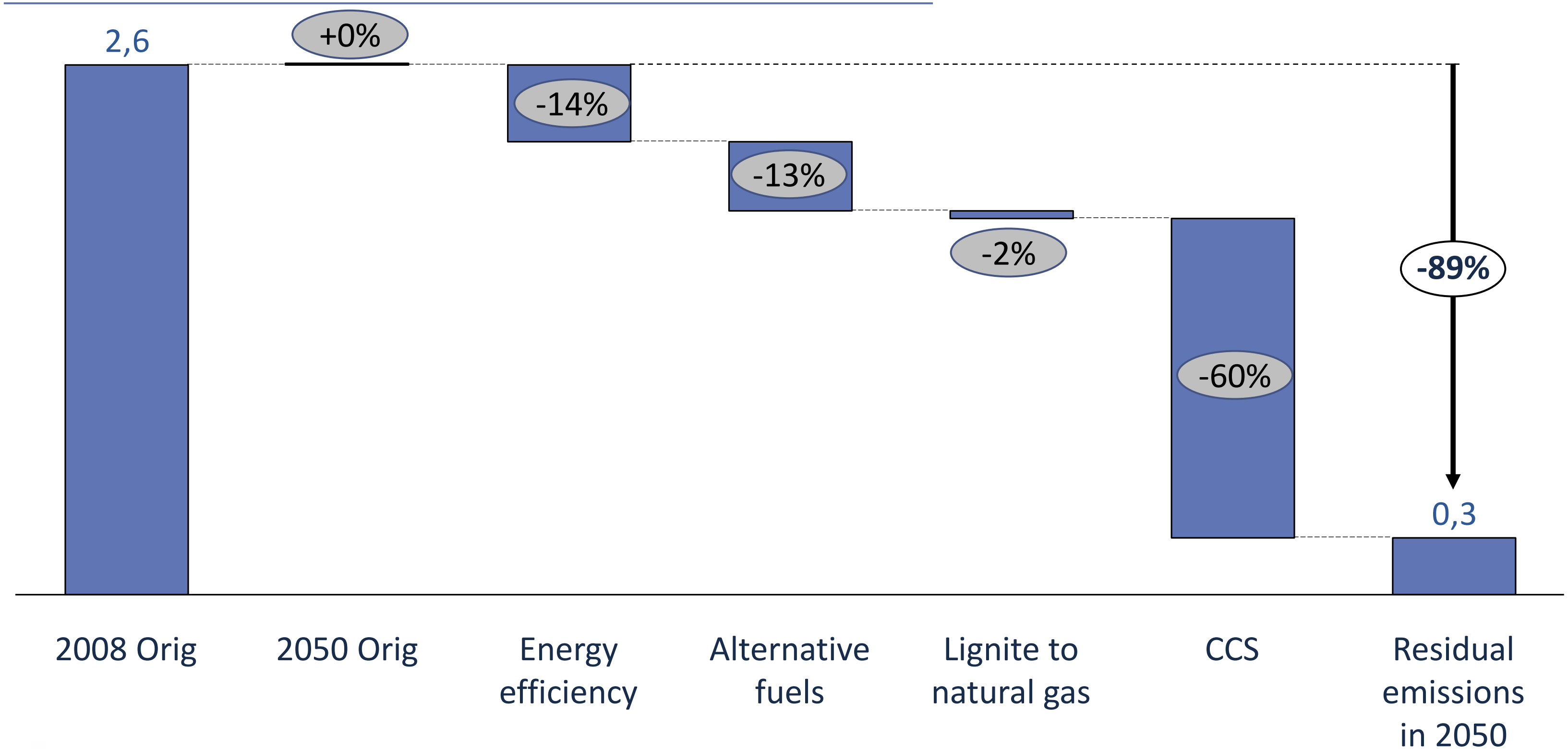
GHG emissions in 2050 using different levers
(% of 2010)



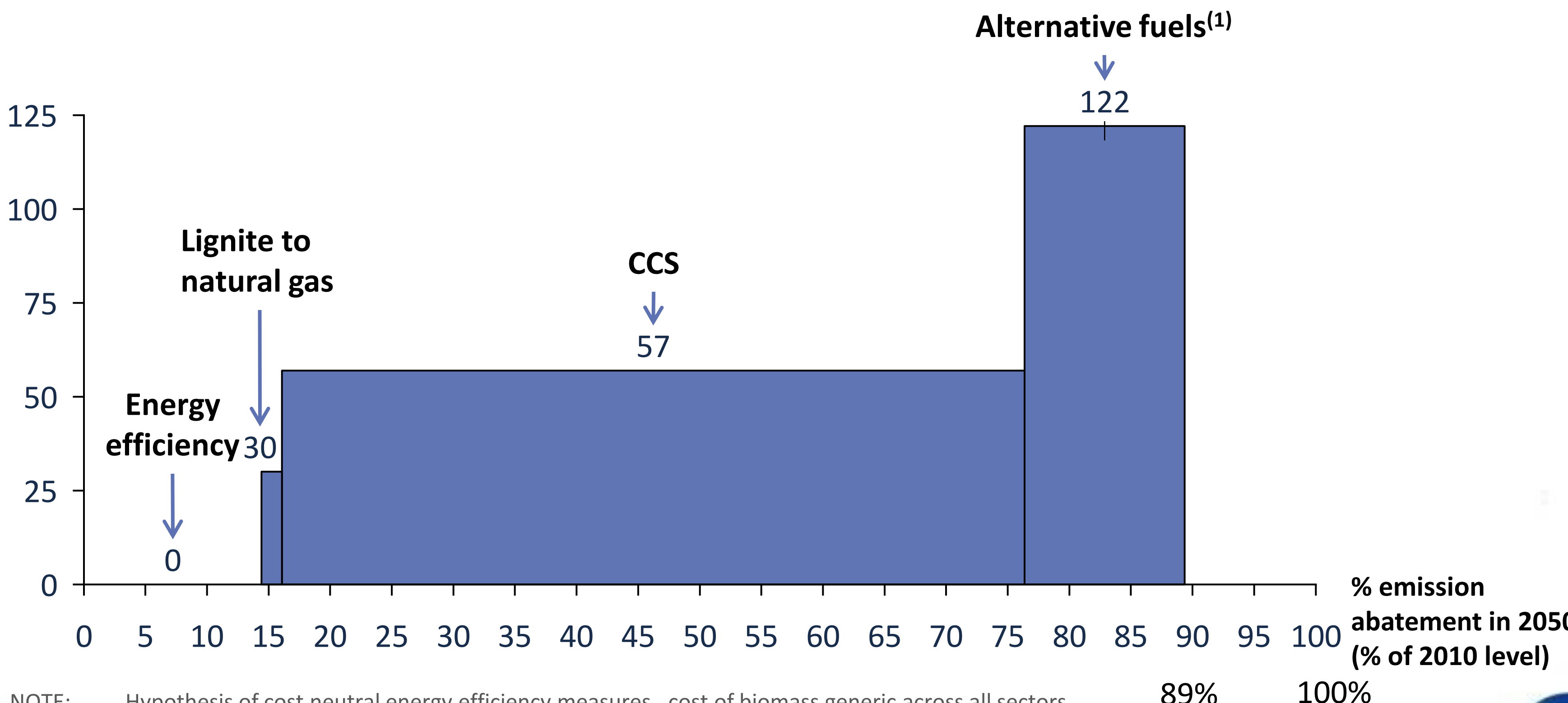
NOTE: Including biomass potential
SOURCE: OPE²RA model

Costs: Lime

Marginal cost and abatement potential of the different levers on trajectory 2 with ambition level 4 in 2050

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

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



NOTE: Hypothesis of cost neutral energy efficiency measures , cost of biomass generic across all sectors
(1) Alternative fuel cost is based on a cost of biomass only (not of waste; furthermore it was not visualized in the Wallonia exercise)

SOURCE: OPE²RA model

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Thank you.

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