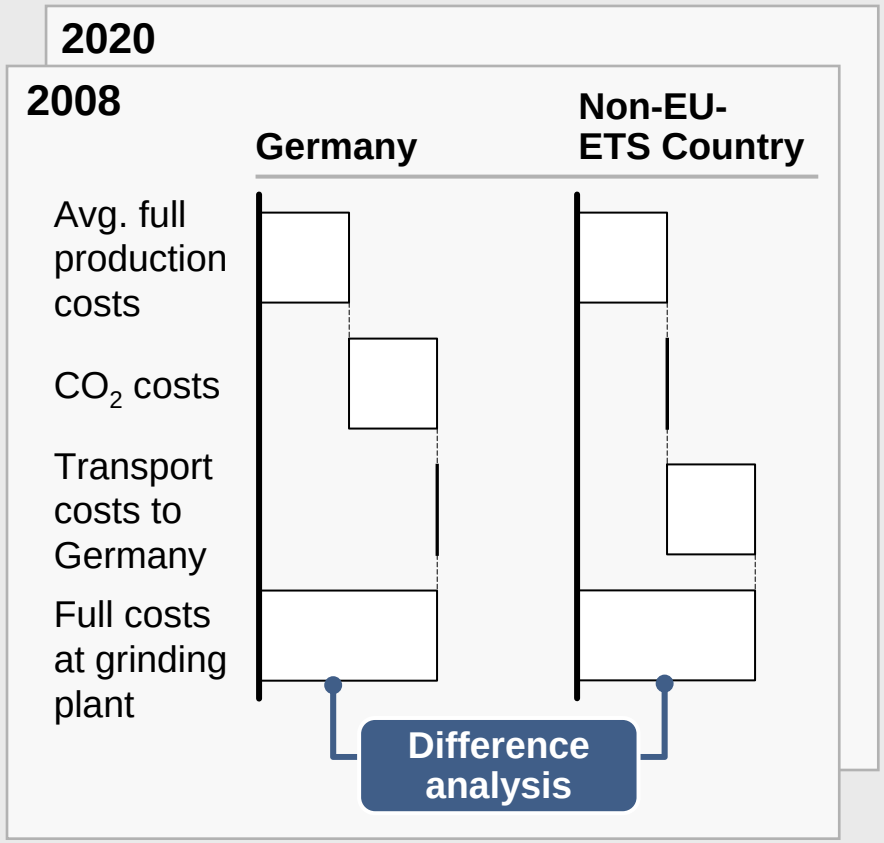
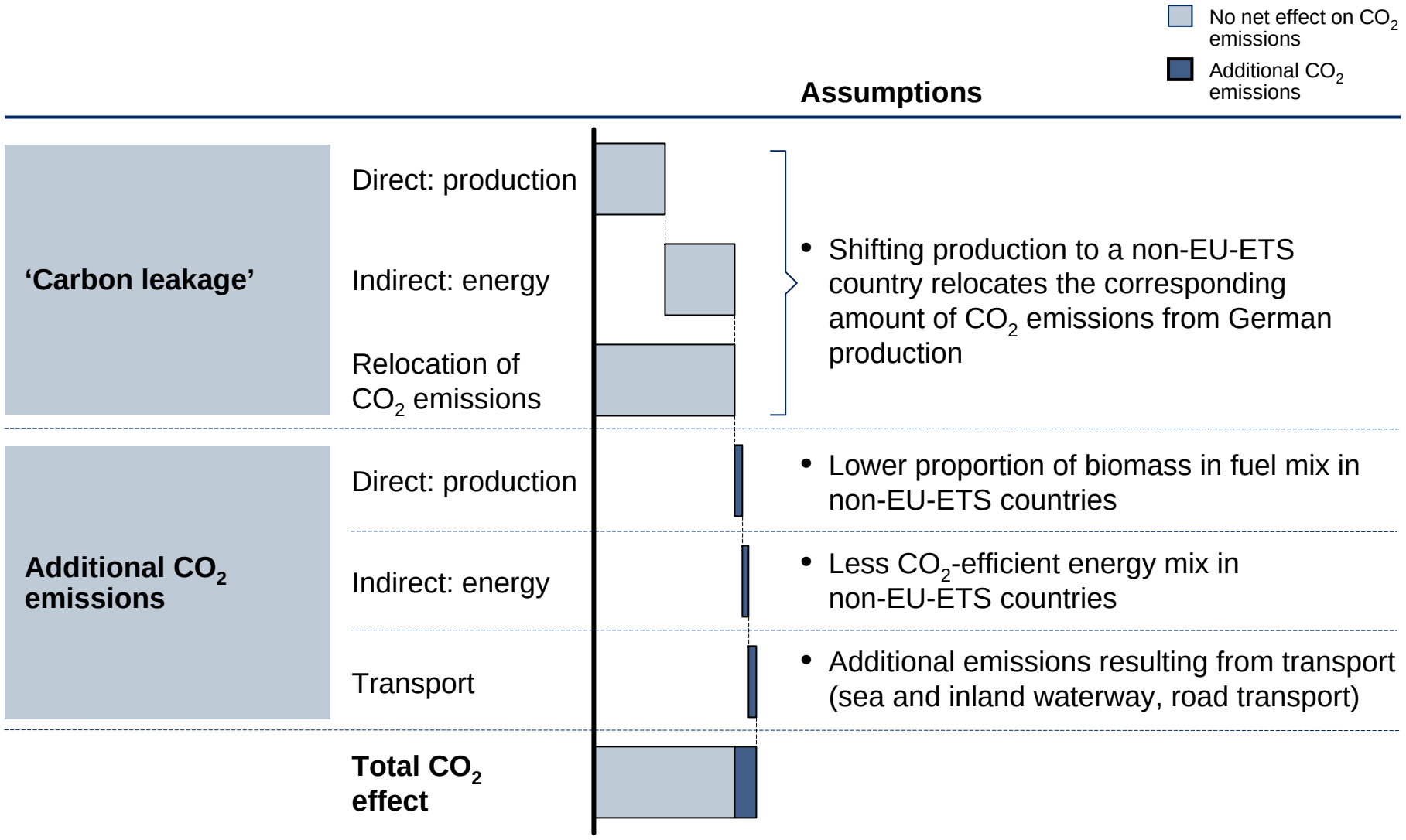
Method: Full cost comparison

Basic assumption	Effect of current and future CO_2 costs, transport costs, and production costs	Effect on German cement production
If the costs of clinker production in Germany, including CO_2 costs, are higher than costs for imported clinker, including transport costs, clinker will be imported		

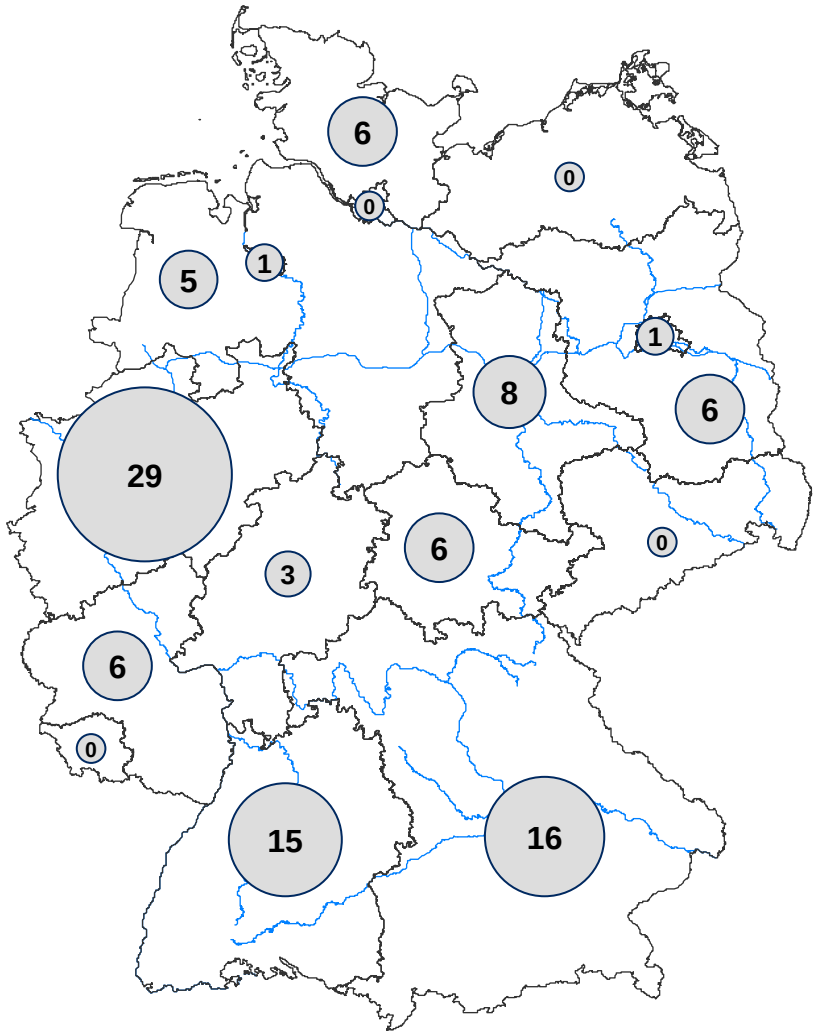
Source: McKinsey

Method: 'Carbon leakage' and additional CO_2 emissions



Source: McKinsey

Clinker production, Germany (according to federal state)*

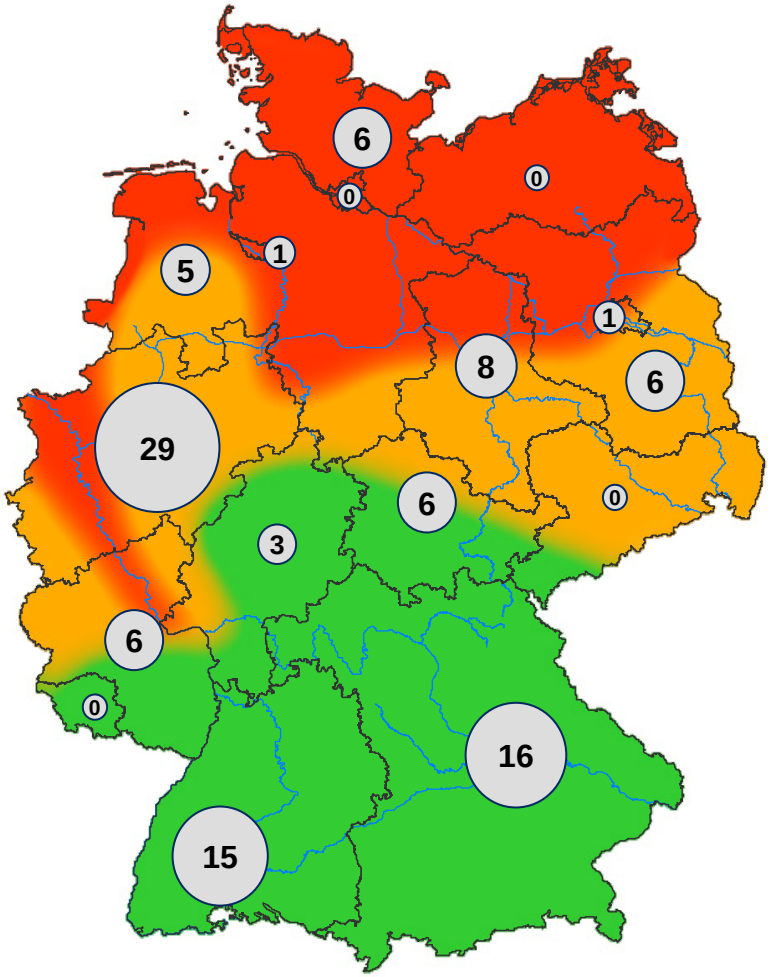


* Assumption: Regional distribution of production based on allocated quantity of CO_2 emissions certificates 2005 - 2007

Source: German Emission Trading Authority (Deutsche Emissionshandelsstelle, DEHSt), International Cement Review, VDZ, expert interviews, McKinsey analysis

Clinker production with increased competitive pressure, 2020

Assumption: CO_2 price EUR 35/t	
Risk:	34%
Possible risk***:	32%
Overall risk:	50%
No risk:	34%



x %-share of overall production 2020*; 100% ≙ ~ 24m t

Risk – Cost difference** > EUR 5/t

Possible risk – Cost difference** between EUR +/-5/t

No risk – Cost difference** < EUR -5/t

Definition of "risk" – Clinker production in Germany could be replaced with cheaper clinker imports from non-EU-ETS-countries

* Assumptions: Regional distribution of production for 2007 assumed for 2020

** Cost difference between locally produced clinker including CO_2 costs and imported clinker plus transport costs

*** Calculated at 50% in the overall risk

Source: German Emission Trading Authority (Deutsche Emissionshandelsstelle, DEHSt), International Cement Review, expert interviews, McKinsey analysis

Sensitivity analysis 2020 – Extreme values

Production at risk (in %)
Relocated and additional emissions (in million metric tons of CO_2)

	Transport costs Basis: Egypt - Rotterdam		
CO_2 costs	**High costs** 120% of basic scenario	**Basic scenario** 100%	**Low costs** 57% of basic scenario
Low costs EUR 25/t CO_2	25 5		
Basic scenario EUR 35/t CO_2		50 11	
High costs EUR 50/t CO_2			86 18

Source: Expert interviews, McKinsey analysis

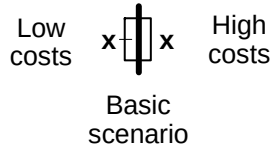
Definition of the scenarios

	Low costs	Basic scenario	High costs
CO_2 prices	• EU-ETS will be implemented in reduced form (lower targets; more JI/CDM*) • EU with stronger focus on areas such as feedstock and food costs and on value creation in Europe	• EU maintains the stipulated reduction targets, and EU-ETS will be implemented as planned • Other key countries also agree on CO_2 reduction	• EU maintains own position on climate change – Implementation of additional measures (e.g. CCS**) on CO_2 reduction – Major restriction of JI/CDM*
Transport costs	• Slowing of global economy • Significant surplus capacities in shipping transport • Larger ships (Capesize) used for clinker transport	• Less growth in global economy resulting from less growth in China • Balanced supply and demand for shipping	• Further strong economic growth • Continued surplus demand for sea freight

* Joint Implementation (JI) and the Clean Development Mechanism (CDM) ** CCS: Carbon Capture and Storage

Source: McKinsey analysis

Assumed cost drivers

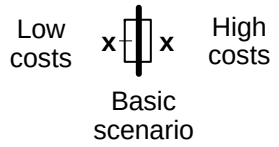


	Scenario assumptions		
	Main cost drivers		**Costs**
Transport costs EUR/t clinker	• Basic scenario: • High costs: • Low costs:	Panamax; freight rates 57% of 2008 Panamax; freight rates 78% of 2008 Capesize; freight rates 36% of 2008	Transport Alexandria - Rotterdam 11 – 24 20
CO_2 prices EUR/t CO_2	• Basic scenario: • High costs: • Low costs:	EUR 35/t CO_2 EUR 50/t CO_2 EUR 25/t CO_2	25 – 50 35
Production costs – Germany vs. Egypt EUR/t clinker	Egypt*	• Basic scenario: Electricity 200% of 2008; Share of secondary fuels 20% • Large difference: Electricity 50% of 2008; Share of secondary fuels 30% • Small difference: Electricity 150% of 2008; Share of secondary fuels 10%	Difference in production costs 17 – 20 18

* Scenarios with different cost drivers for non-EU-ETS countries based on example of Egypt – Basic scenario assumed for Germany

Source: Expert interviews, McKinsey analysis

Selection of cost drivers

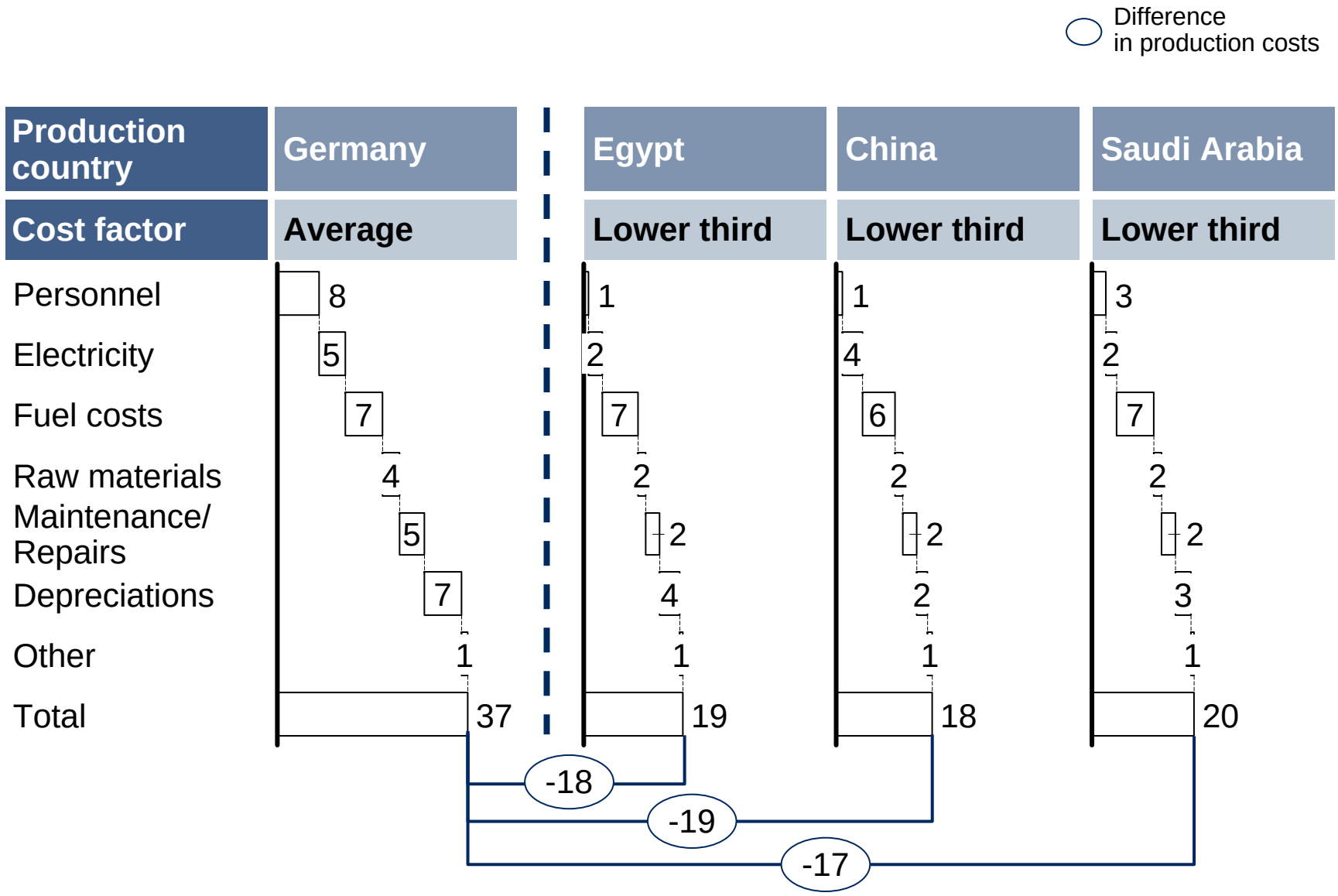


	Costs per scenario	Production at risk in %
Transport costs EUR/t clinker	11 — 20 — 24	37 — 50 — 70
CO_2 prices EUR/t CO_2	25 — 35 — 50	29 — 50 — 74
Production costs – difference compared to abroad* EUR/t clinker	17 — 18 — 20	41 — 50 — 52

* Scenarios with different cost drivers for non-EU-ETS countries based on example of Egypt – Base case assumed for Germany

Source: Expert interviews, McKinsey analysis

Clinker production costs
EUR/t clinker, 2020

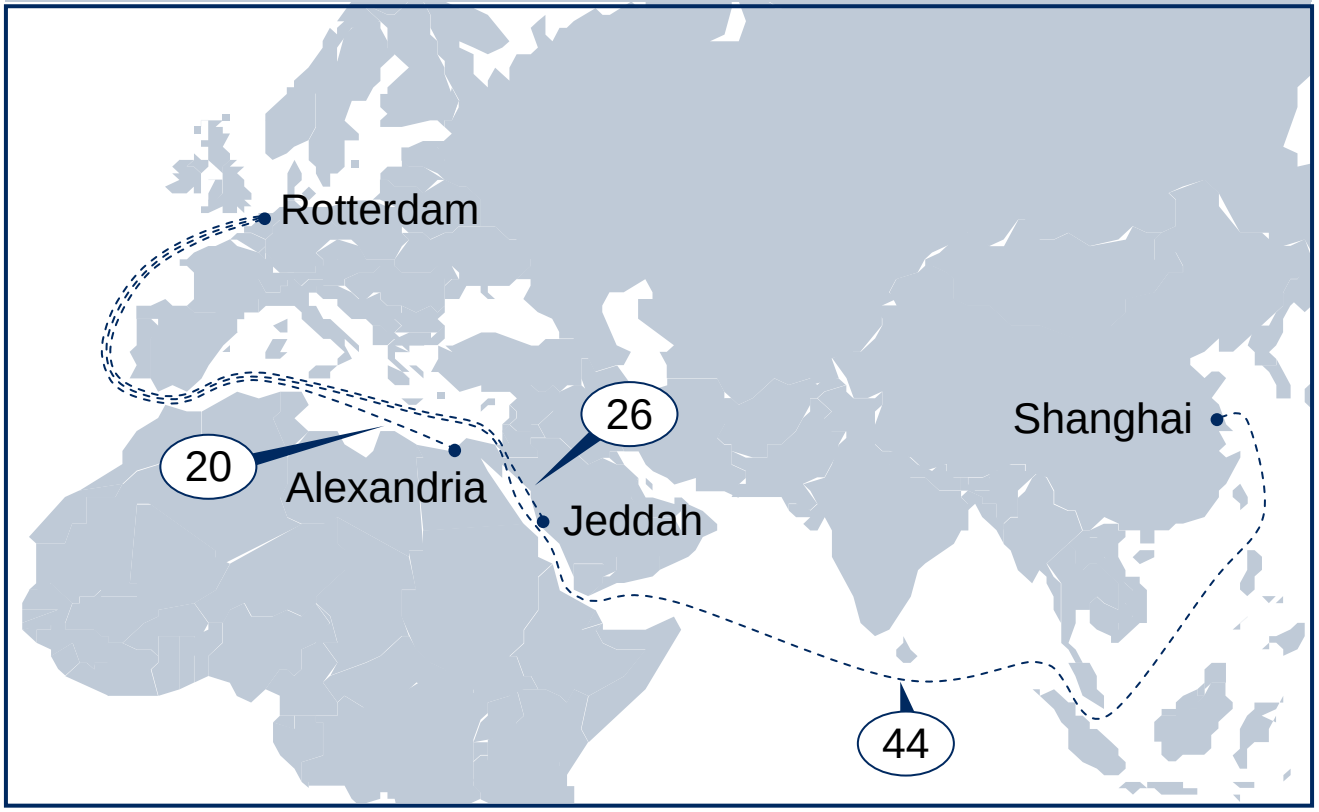


Source: VDZ, expert interviews, McKinsey analysis

Transport costs to Germany – Examples
EUR/t clinker, 2020

x Sea freight costs

Sea freight – Non-EU-ETS-country to Europe/Germany



Inland transport – Non-EU-ETS Country	
EUR/t	
Road transport to sea port*	6.3

Inland transport – Germany**	
EUR/t per 100 km	
Inland shipping	3.5
Road transport	8.6

* Assumption: ~ 50 km average distance from clinker production to port, incl. fixed costs
** Variable cost only - additional fixed costs (e.g., changeover costs) considered in calculation
Source: Expert interviews, McKinsey

Assumptions for production costs (constant values)
Real values

		Location of works (cost position)				Sources and assumptions	
Factor	**Unit**	**Germany** (average)	**Egypt** (better than average)	**Saudi Arabia** (better than average)	**China** (better than average)	**Germany**	**Egypt/ S-A/China**
Capacity	t/year	694.400	3,000,000	3,000,000	2,100,000	VDZ	OneStone Consulting
Utilization	Percent	90	90	90	90	VDZ (base 320 days/year)	McKinsey
Electricity consumption	kWh/t clinker	65	65	65	65	VDZ	VDZ
Energy consumption	kJ/kg clinker	3,688*	3,300	3,300	3,300	VDZ	Expert interview
Coal calorific value	kJ/kg	26,000	26,000	26,000	22,000	VDZ	VDZ
Raw material costs	EUR/t clinker	3.5	1.5	1.5	1.5	VDZ	Expert interview
Specific plant overheads (e.g. insurance, labs)	EUR/t clinker	1.3	0.8	0.8	0.8	McKinsey	McKinsey
Maintenance/ repairs	EUR/t	4.5	2.5	2.5	2.5	McKinsey assumption	Expert interview
Investment costs	EUR/metric tons of clinker p.a.	165	85	70	50	VDZ, BDI Study, 86% of a cement works	OneStone Consulting
Depreciation period	Year	25	25	25	25	Annual reports	Annual reports
Proportion of biomass in secondary fuels	Percent	30	80	80	70	VDZ	HOLCIM/ VDZ ECRA presentation

Source: Expert interviews, McKinsey analysis * Falling to 3613 by 2020

Assumptions for production costs (2008 - 2020)
Real values

		Forecast							
Factor	**Country**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**Source**
Share of secondary fuels in fuel mix Percent	• Germany	50	51	52	53	54	55	56	VDZ, McKinsey
	• Egypt	5	8	10	13	15	18	20	VDZ, McKinsey
	• Saudi Arabia	5	6	7	8	8	9	10	VDZ, McKinsey
	• China	5	6	7	8	8	9	10	VDZ, McKinsey
Secondary fuel price in percentage of primary fuel costs	• All	0	7	13	20	27	33	40	Expert interview
Electricity price EUR/MWh	• Germany	66	79	77	71	64	66	67	EEX, McKinsey Integrated Perspective, Middle Case (v5831)
	• Egypt	25	27	29	31	33	35	38	HSBC, EIU 2007 for 2008; McKinsey: 50% increase by 2020
	• Saudi Arabia	21	23	26	29	31	34	31	SEC for 2008; McKinsey: 50% increase by 2020
	• China	60	60	60	60	60	60	60	CEIC for 2008, McKinsey: constant
Electricity net cost and taxes in EUR/MWh	• Germany	16	16	16	16	16	16	16	VDZ, expert interview
Personnel full costs EUR thousand/FTE	• Germany	44	45	46	47	47	48	49	VDZ 2007 for 2008, Global Insight for forecast to 2020
	• Egypt	5	6	6	7	7	8	8	W. Wyatt database, EIU, McKinsey
	• Saudi Arabia	12	14	16	16	17	17	17	James F. King (2005), McKinsey
	• China	5	7	8	10	11	12	14	Expert interview, China Labor Statistical Yearbook 2005, McKinsey
Employees per plant FTE	• Germany	100	100	100	100	100	100	100	VDZ, McKinsey
	• Egypt	300	300	300	300	300	300	300	VDZ, McKinsey
	• Saudi Arabia	300	300	300	300	300	300	300	VDZ, McKinsey
	• China	150	150	150	150	150	150	150	VDZ, McKinsey
Coal price EUR/t	• Germany	94	77	75	74	74	74	74	McKinsey Integrated Perspective, Middle Case (v5831)
	• Egypt	78	64	62	62	62	62	62	IntCemRev (Yemen), Development similar to Germany
	• Saudi Arabia	78	64	62	62	62	62	62	IntCemRev (Yemen), Development similar to Germany
	• China	55	43	39	37	37	38	43	JFK
Clinker factor in %	• Germany	71	70	70	69	68	68	67	McKinsey
Export taxes EUR/t	• Egypt	10	9	7	5	3	2	0	IntCemRev, McKinsey: lin. reduction by 2020
	• Saudi Arabia	0	0	0	0	0	0	0	McKinsey
	• China	0	0	0	0	0	0	0	McKinsey

Source: VDZ, expert interviews, McKinsey analysis

Assumptions for transport costs (1/3)
Real values

Factor	Unit	Capesize	Panamax	Source
Load volume	t	150,000	70,000	Clarkson
Speed	kt	14	14	McKinsey
MDO* consumption	t/day	15	14	McKinsey
HFO** consumption	t/day	56	27	McKinsey
Docking fee/day	EUR	777	616	Port of Rotterdam
Port charges/visit	EUR	70,000	43,750	Port of Rotterdam
Towage charges/visit	EUR	4,800	3,600	Port of Rotterdam
Anchorage charges/visit	EUR	3,200	1,560	Port of Rotterdam
Pilot charges/visit	EUR	13,000	9,436	Port of Rotterdam
Time in port	Days	7	6	Port of Rotterdam

* Marine Diesel Oil
** Heavy Fuel Oil
Source: VDZ, expert interviews, McKinsey

Assumptions for transport costs (2/3)
Real values

Factor	Unit	Value	Source
Loading costs (port)	EUR/t	2.5	Expert interview
Probability of empty return journey	Percent	90	Port statistics – Bremen, Rotterdam
Road transport (fixed costs)	EUR/t	2	Expert interview
Road transport (variable costs ex. fuel)	EUR/ (t • km)	0.049	McKinsey
Road transport (variable fuel costs)	l/(t • km)	0.026	McKinsey
Changeover from sea port to river	EUR	1.5	Expert interview
River transport	ct/km	3.5	Expert interview
Road to air distance factor	km/km	1.28	Springer
Distance to sea port – Egypt, Saudi Arabia, China	km	50	McKinsey

Source: VDZ, expert interviews, McKinsey

Assumptions for transport costs (3/3)
Real values

		Forecast							
Factor	**Unit**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**Source**
Freight rates (Capesize)	EUR/d	65,000	40,625	23,663	24,228	30,111	35,825	41,111	JFK
Freight rates (Panamax)	EUR/d	45,500	24,375	15,237	15,408	19,130	22,734	26,048	JFK
MDO* fuel price	EUR/t	550	550	550	550	550	550	550	Analyst reports, McKinsey: constant
HFO** fuel price	EUR/t	306	306	306	306	306	306	306	Analyst reports, McKinsey: constant
Diesel price (Germany)	EUR/l	1.4	1.4	1.4	1.4	1.4	1.4	1.4	POS price, McKinsey: constant
Suez canal charges (Capesize)	EUR/t	1.3	1.3	1.3	1.3	1.4	1.4	1.4	R K Johns/Leth
Suez canal charges (Panamax)	EUR/t	1.9	1.9	1.9	1.9	2.0	2.0	2.0	R K Johns/Leth

* Marine Diesel Oil
** Heavy Fuel Oil
Source: VDZ, expert interviews, McKinsey

Assumptions for CO_2 balance – indirect emissions from electricity production (1/2)

Real values

			Forecast							
Factor	**Unit**	**Country**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**Source**
Indirect emissions	t CO_2/MWh	Germany	0.53	0.53	0.53	0.52	0.52	0.52	0.51	McKinsey BDI Study
		Egypt	0.53	0.53	0.52	0.51	0.51	0.50	0.50	McKinsey GHG Abatement Cost Curve Model (Africa without RSA)
		Saudi Arabia	0.54	0.54	0.54	0.53	0.53	0.53	0.52	McKinsey GHG Abatement Cost Curve Model (Middle East)
		China	0.68	0.67	0.66	0.66	0.65	0.64	0.63	McKinsey GHG Abatement Cost Curve Model

Source: VDZ, expert interviews, McKinsey analysis

Assumptions for CO_2 balance – direct emissions from transport (2/2)
Real values

Factor	Unit	Value	Source
CO_2 Balance: Ocean	g/(t • km)	2.2	ELCD, similar scenario
CO_2 Balance: River	g/(t • km)	23.0	ELCD, similar scenario
CO_2 Balance: Road	g/(t • km)	44.0	ELCD, similar scenario
Methane bal.: Ocean	g/(t • km)	5.6 E-05	ELCD, similar scenario
Methane bal.: River	g/(t • km)	3.6 E-03	ELCD, similar scenario
Methane bal.: Road	g/(t • km)	3.6 E-04	ELCD, similar scenario
CO_2/Methane	t CO_2equ./ t Methane	23	EIA

Source: VDZ, expert interviews, McKinsey analysis