concawe

ENVIRONMENTAL SCIENCE FOR THE EUROPEAN REFINING INDUSTRY

Refining Fitness Check Concawe Step 2 data Highlights

Concawe Symposium

Brussels

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Concawe data collection

- Concawe questionnaire was based on data requested by JRC

1. IPPC* and LCPD** sheet

- Data requested for every year from 1998 to 2012
  - Total annual CAPEX in K€ for air emissions abatement
  - Total annual CAPEX in K€ for water emissions abatement
  - Indicate whether CAPEX and/or OPEX were incurred for selected emission abatement measures
    - 45 responses required
    - Choice between "Yes", "No", "Data Unavailable", "Not Applicable"

- Total of 705 cell entries for each refinery!

***IPPC:** Integrated Pollution Prevention and Control

** **LCPD:** Large Combustion Plants Directive

IPPC-LCPD sheet

2 Directive-specific information about the refinery

2.1 Integrated pollution prevention & control directive (IPPC), Large combustion plants (LCP) directive and Air quality directive (AQD)

Note that the total air & water emissions reduction CAPEX reported here must not exceed the total investment reported in the Solomon "Refinery Emissions & Effluent" CAPEX category

	1998		1999		2000	
	CAPEX	OPEX	CAPEX	OPEX	CAPEX	OPEX
Total air emissions abatement capital investments [KEUR]	100		493		665	
Total waste water treatment capital investments [KEUR]	511		509		570	
Total air and water emissions reduction capital investments [KEUR]	611		1002		1235	

2.1.1 SO_x emissions abatement measures adopted/installed, associated incurred costs and emissions reduction

	Techniques to reduce SO_x emissions to air	1998		1999		2000	
		CAPEX	OPEX	CAPEX	OPEX	CAPEX	OPEX
FCC	**Catalytic cracking unit (BREF § 4.5) (8)**						
	(a) Primary or process-related techniques:						
SOXCAT	SO_x reducing catalyst additives		Yes		Yes		Yes
ULSFED	Use of low sulphur feedstock (e.g. by feedstock selection or by feed hydrotreatment)	No	No	No	No	No	No
	Others (please specify)						
	Others (please specify)						
	(b) Secondary or end-of-pipe techniques:						
NRSCRB	Non-regenerative scrubbing (wet scrubbing or seawater scrubbing)	No		No		No	
RGSCRB	Regenerative scrubbing (dry and semi-dry scrubbing)	No		No		No	
	Others (please specify)						
	Others (please specify)						
CCU	**Coke Calcining unit (BREF § 4.7)**						
NRSCRB	Non-regenerative scrubbing (wet scrubbing or seawater scrubbing)	Not Applicable		Not Applicable		Not Applicable	
RGSCRB	Regenerative scrubbing (dry and semi-dry scrubbing)	Not Applicable		Not Applicable		Not Applicable	

Concawe data collection

2. RED sheet

- Data requested for every year from 1998 to 2012
  - Total annual CAPEX in K€ for biofuels infrastructure
    - On-site (within refinery fenceline)
    - Off-site depots
  - Itemised by type of biofuel:
    - BioMethanol
    - BioEthanol
    - BioMTBE
    - BioETBE
    - BioDiesel
    - Other
- Total of 90 cell entries for the refinery's on-site CAPEX, plus 90 cell entries for each off-site depot

RED sheet

2 Directive-specific information about the refinery

2.6 Renewable energy directive

2.6.3 Additional storage capacity and infrastructure investment costs at refinery site

	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007	
	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR
bioMethanol		3.1		3.5		7.4		9.5		0.4		8.7		5.7		4.8		3.0		8.5
bioEthanol		1.1		0.0		1.2		7.4		7.7		6.6		0.6		5.9		6.8		9.4
bioMTBE		9.4		6.2		4.0		5.9		4.1		2.8		8.0		3.2		5.8		1.0
bioETBE		4.2		2.9		9.1		2.5		4.0		9.5		2.1		4.7		8.6		1.8
bioDiesel		6.8		4.6		9.0		7.6		5.4		1.9		4.8		9.3		7.7		8.2
Other (see comments		3.2		3.9		5.4		9.3		9.2		5.4		0.2		1.3		5.3		1.1

2.6.4 Additional storage capacity and infrastructure investment cos Depot 1 name: abc1

	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007	
	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR
bioMethanol		6.1		8.6		8.0		7.2		1.1		6.8		6.5		0.1		5.0		3.7
bioEthanol		9.9		5.7		5.2		7.4		1.2		9.0		0.6		0.5		5.1		9.7
bioMTBE		1.5		7.8		0.9		2.4		4.2		8.5		2.7		5.5		5.8		6.6
bioETBE		1.7		3.9		3.1		8.7		8.0		1.2		4.3		1.2		1.4		9.9
bioDiesel		6.6		5.2		2.5		2.0		3.7		8.8		8.2		4.5		0.4		1.8
below)		7.6		9.2		5.2		2.3		4.4		5.8		4.0		5.8		0.5		4.1

2.6.4 Additional storage capacity and infrastructure investment cos Depot 2 name: abc2

	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007	
	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR	s	KEUR
bioMethanol		1.6		9.9		0.3		7.6		1.9		5.9		2.2		4.6		3.7		5.3
bioEthanol		6.6		9.5		3.9		6.7		8.4		7.6		3.6		1.3		6.6		8.2
bioMTBE		2.7		1.7		5.7		9.8		1.9		8.3		6.5		7.3		3.8		6.9
bioETBE		3.1		2.6		4.7		5.3		1.5		7.6		2.9		6.1		2.5		4.3
bioDiesel		4.5		4.9		1.9		2.2		6.6		9.7		8.4		4.5		8.2		1.5
below)		6.1		4.0		6.6		7.3		2.8		9.6		3.2		9.6		5.5		4.5

2.6.4 Additional storage capacity and infrastructure investment cos Depot 3 name: abc3

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007

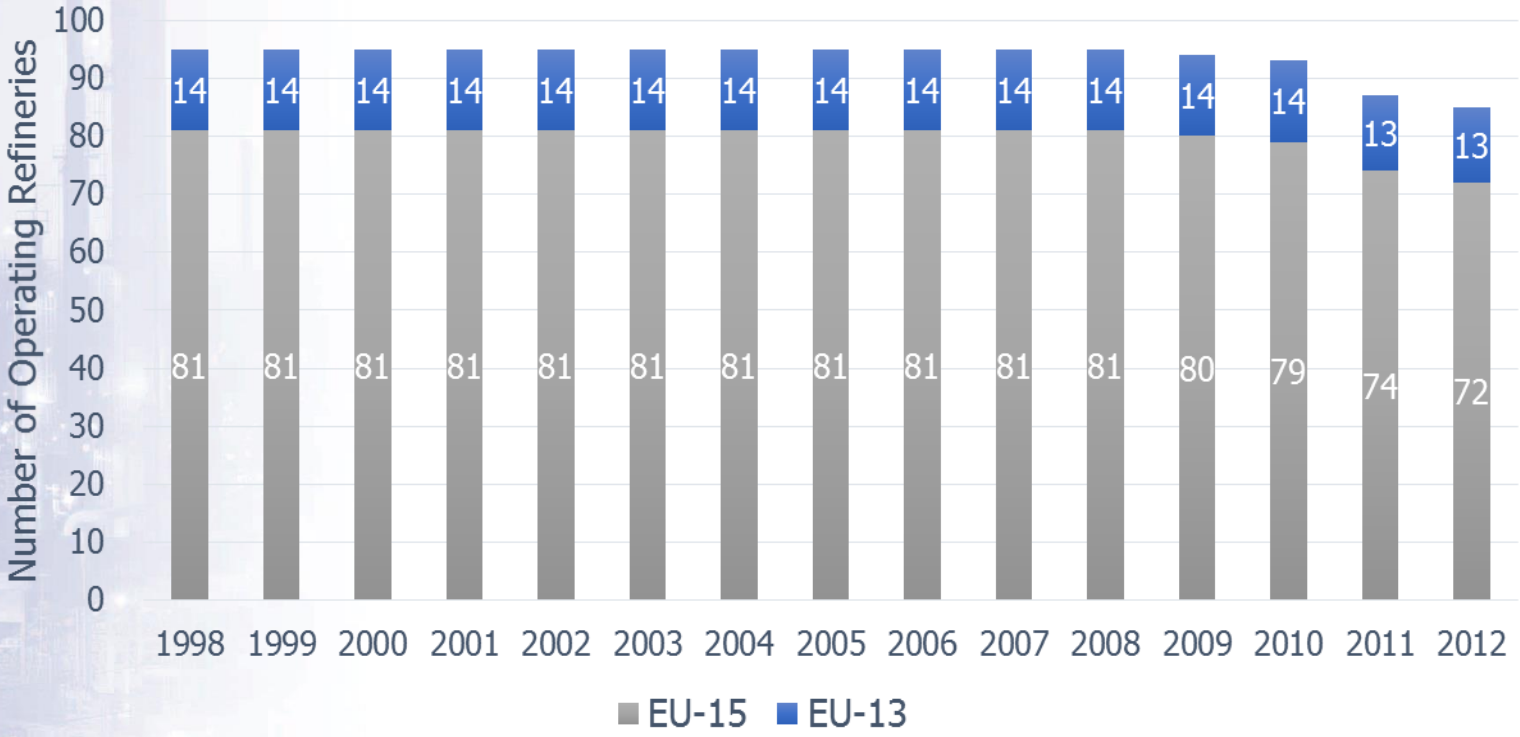
Refining Fitness Check: Step 2 data

- **Aggregation Groups (Solomon methodology)**
  - EU-28
  - EU-15
  - EU-13
  - Nine Geographical Regions
  - Petrochemical Integrated Sites
  - Five Complexity Groups:
    - 1 x Hydroskimming + Thermal group
    - 4 x Gas Oil Conversion (GOC) groups defined by Complexity Factor
- 67 refineries responded to the questionnaire

Refining Fitness Check: Step 2 data

❑ EU-28 Refineries

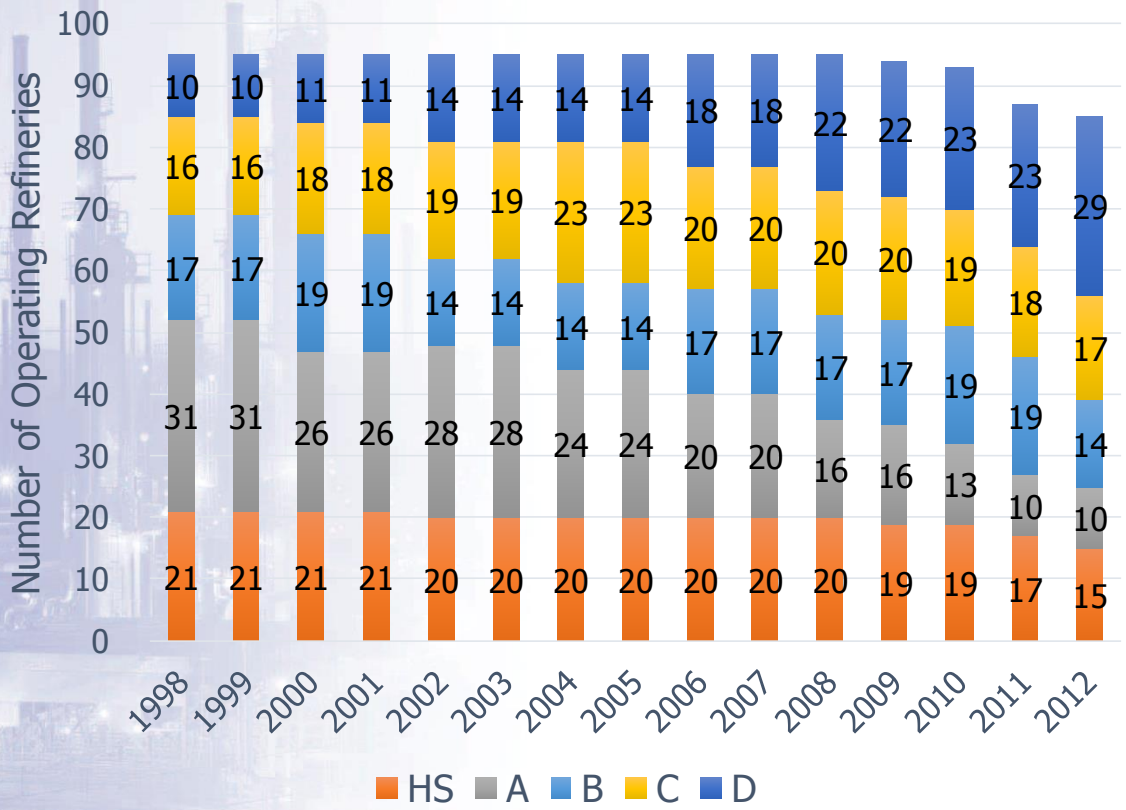
95 mainstream refineries operating in 1998, dropping to 85 in 2012



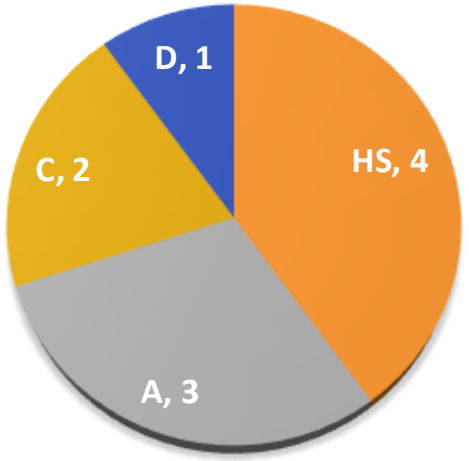
➢ 82 Mainstream refineries operating in September 2014

Refining Fitness Check: Step 2 data

EU-28 Refinery Complexity Groups



Closures per complexity group



Since 2012:
2013 -> 2 closures (A and HS Groups)
2014 -> 1 closure (A Group)

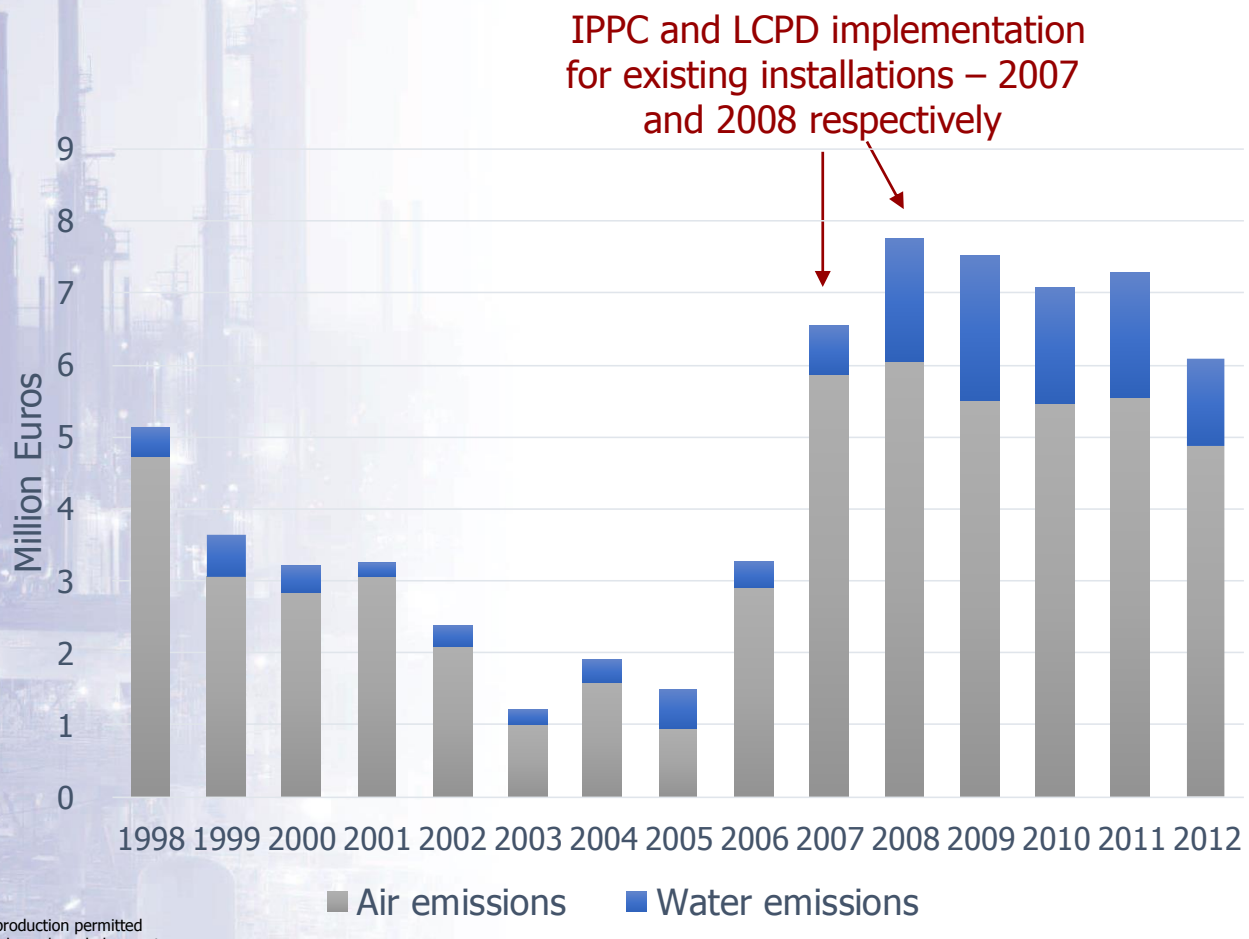
Refineries have become more complex

Note: Cartagena refinery as an D refinery from 2008 to 2011

Refining Fitness Check: Step 2 data

❑ Air & Water Emission Abatement Measures

EU-28 Average CAPEX per Responding Refinery

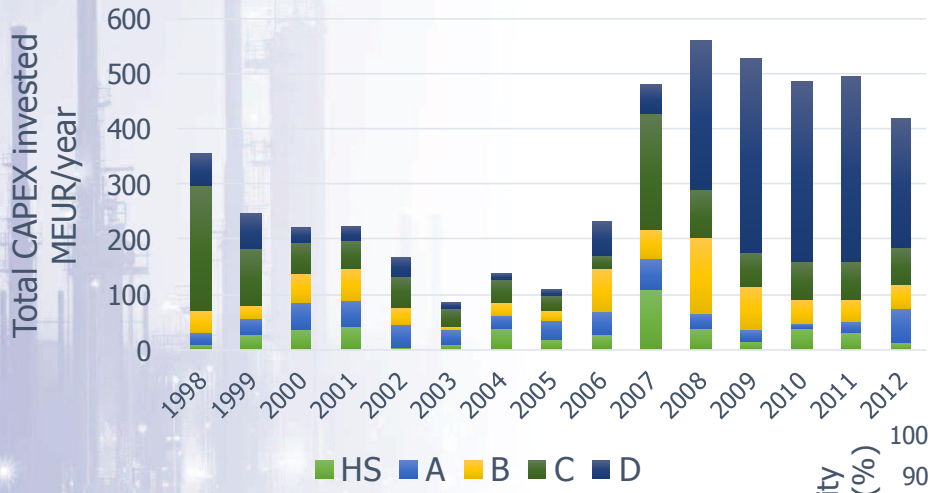


- ❑ Total of **4.7 Billion EUR** CAPEX from 1998 to 2012
- ❑ Increase in CAPEX intensity after 2006:
  - On average, each responding refinery invested 6.8 MEUR per year since 2006
- ❑ 82% of the investments were in air abatement measures

Refining Fitness Check: Step 2 data

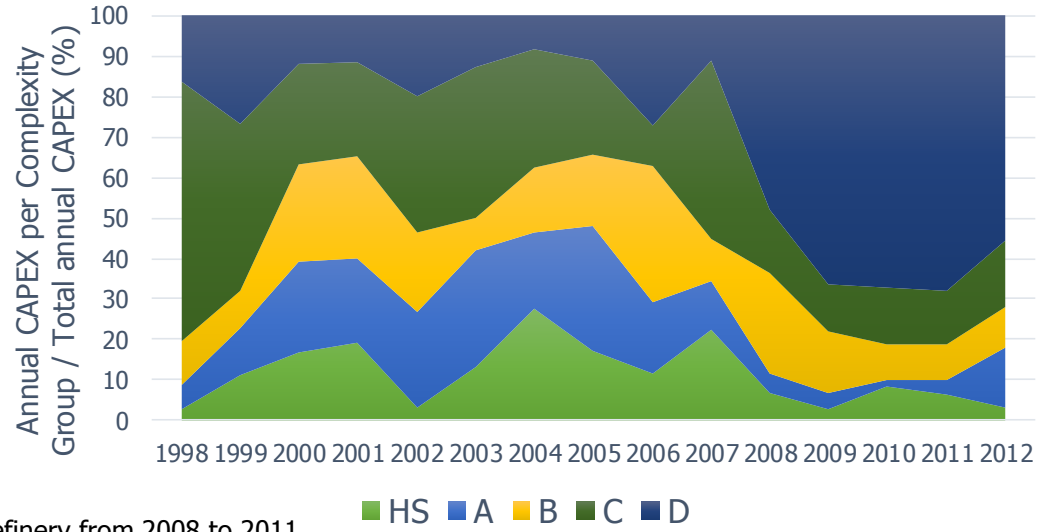
❑ Air & Water Emissions Abatement Measures

Annual CAPEX per Complexity Group



- Complexity group D registered the biggest amount of Capex across the entire period (39% of Total Capex)

- Complexity group HS was the least Capex intensive



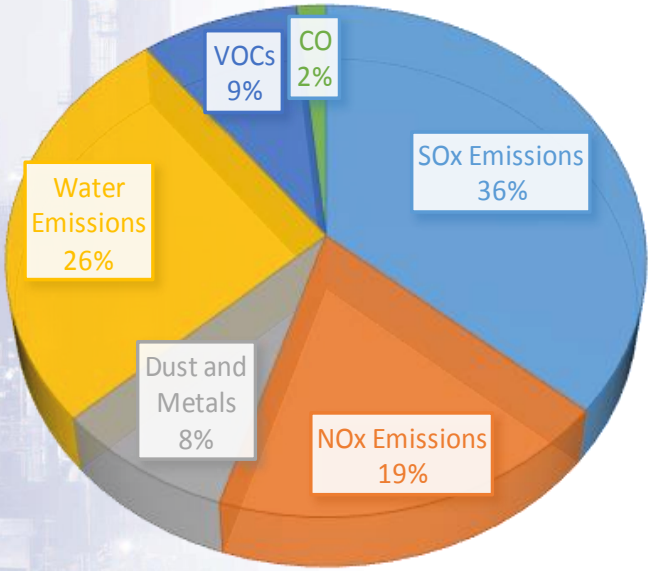
Note: Cartagena refinery as a D complexity type refinery from 2008 to 2011

Refining Fitness Check: Step 2 data

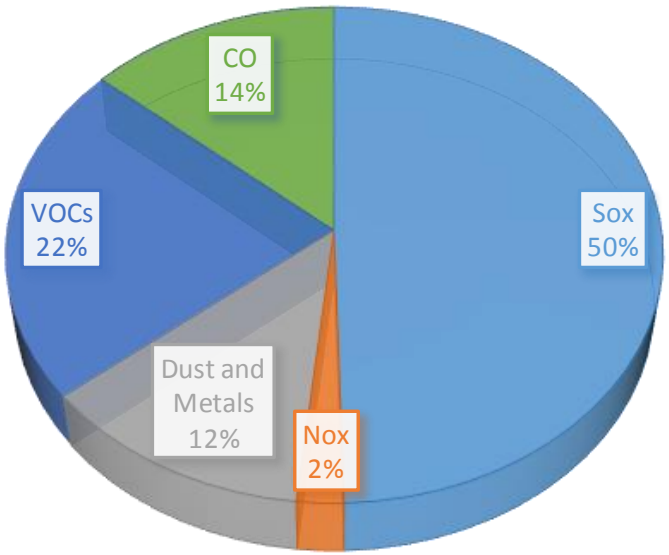
❑ Air & Water Emissions Abatement Measures

CAPEX & OPEX: Positive responses for costs in a given category

% OF **CAPEX** RESPONSES



% OF **OPEX** RESPONSES

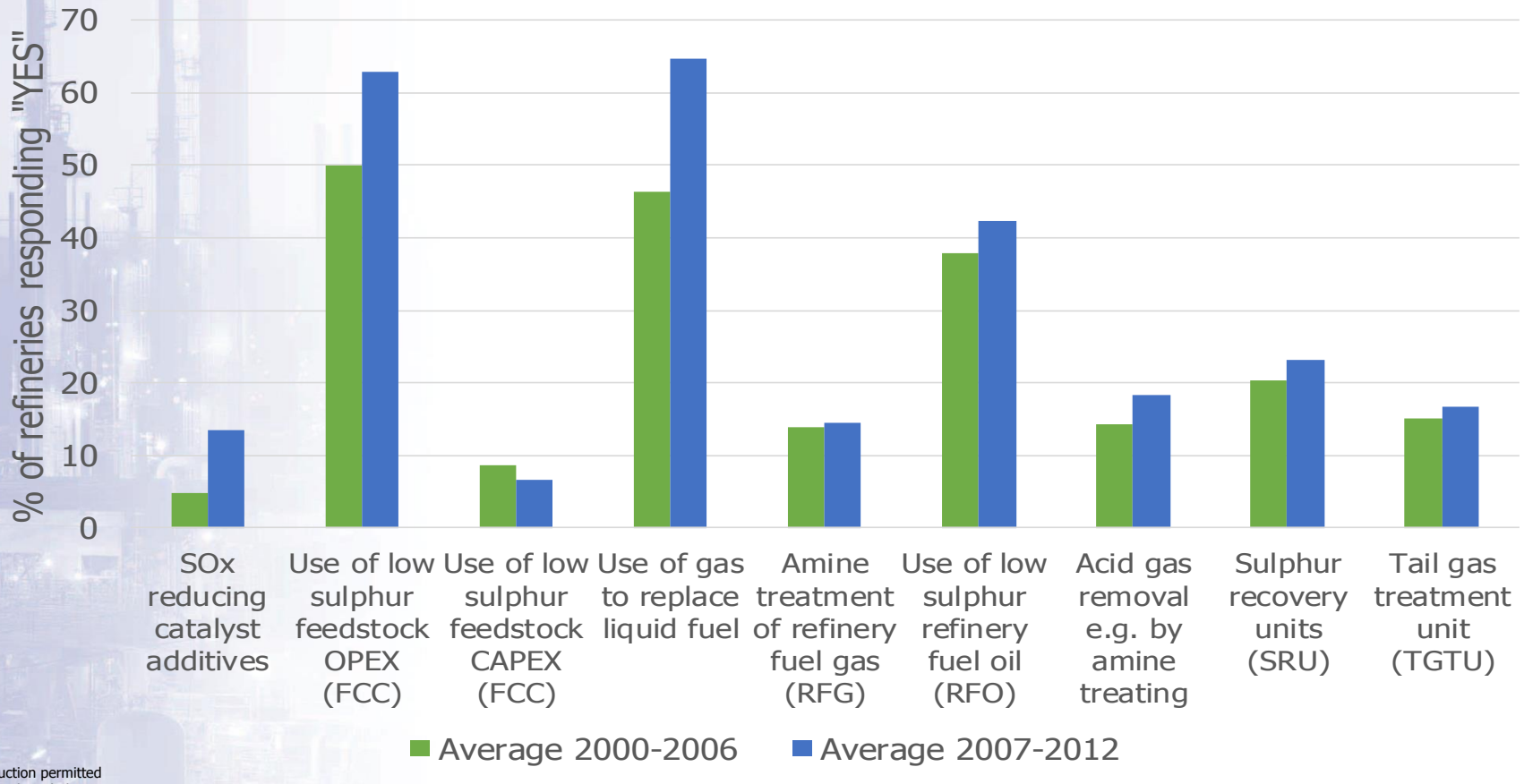


❑ More than 60% of these positive responses were for costs incurred in the 2007-2012 period

Refining Fitness Check: Step 2 data

❑ EU-28 Air Emission Abatement Measures

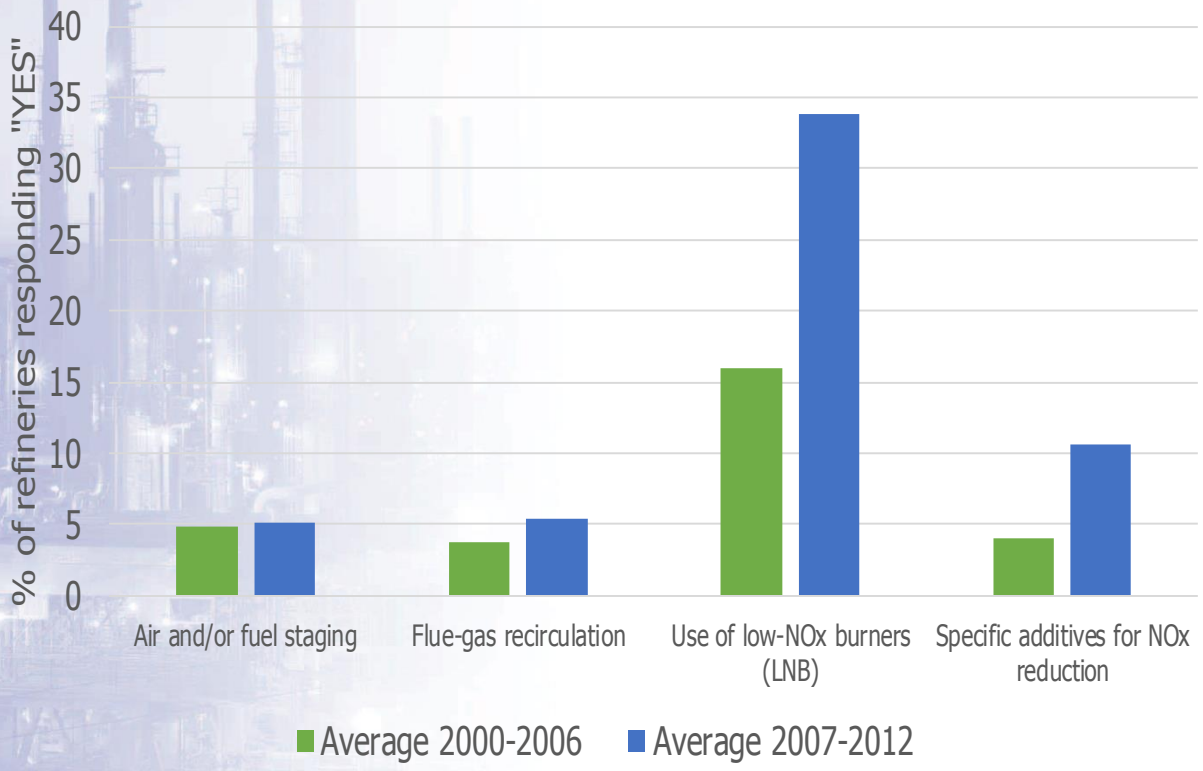
SOx emissions abatement measures incurring annual CAPEX and/or OPEX



Refining Fitness Check: Step 2 data

❑ EU-28 Air Emission Abatement Measures

NOx emissions abatement measures incurring annual CAPEX and/or OPEX



❑ Other less used abatement measures include:

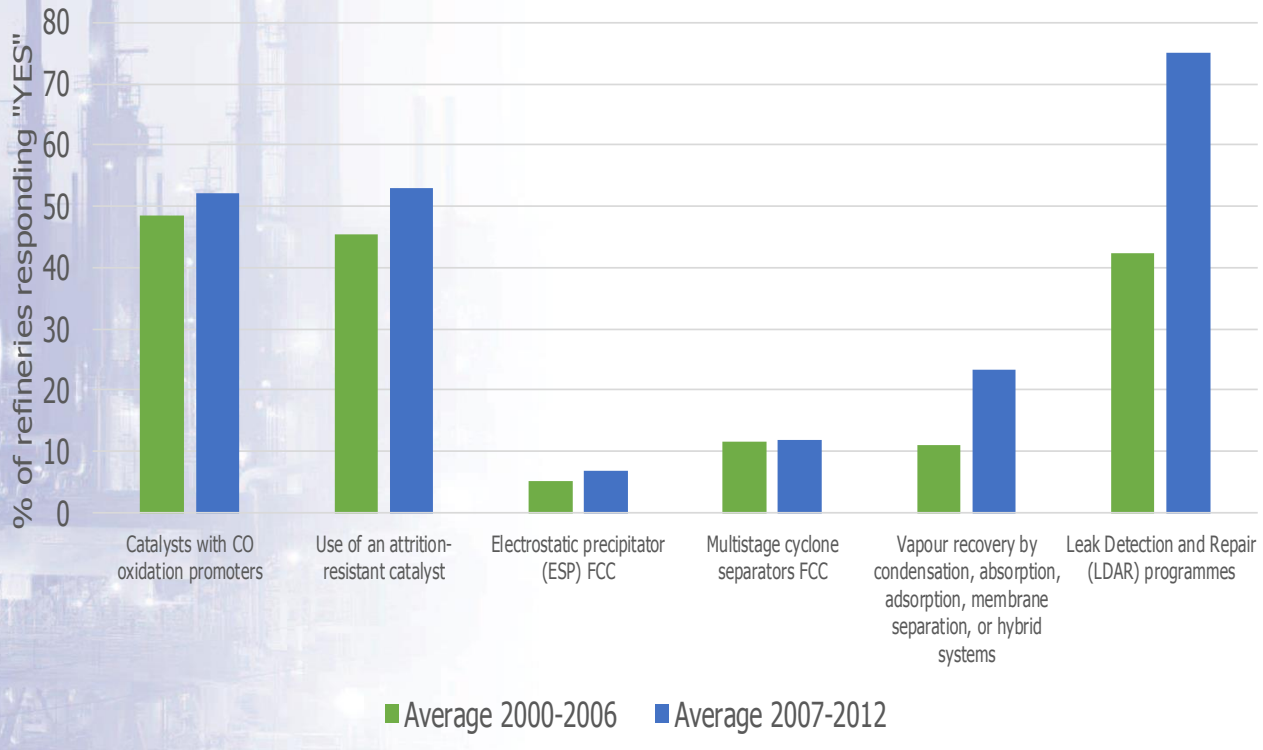
- Selective catalytic reduction (SCR) FCC
- Selective non-catalytic reduction (SNCR) (FCC/Calcining unit/Comb. Units)
- Air and/or fuel staging
- Flue-gas recirculation
- Diluent injection
- Use of low-NOx burners (LNB)
- Selective catalytic reduction (SCR) (comb. Units)
- Low temperature NOx oxidation (using ozone) (Comb units/FCC)
- SNOx combined technique
- Specific additives for NOx reduction

% of responding refineries who reported costs in the given category

Refining Fitness Check: Step 2 data

❑ EU-28 Air Emission Abatement Measures

CO, Dust or VOCs emissions abatement measures incurring annual CAPEX and/or OPEX

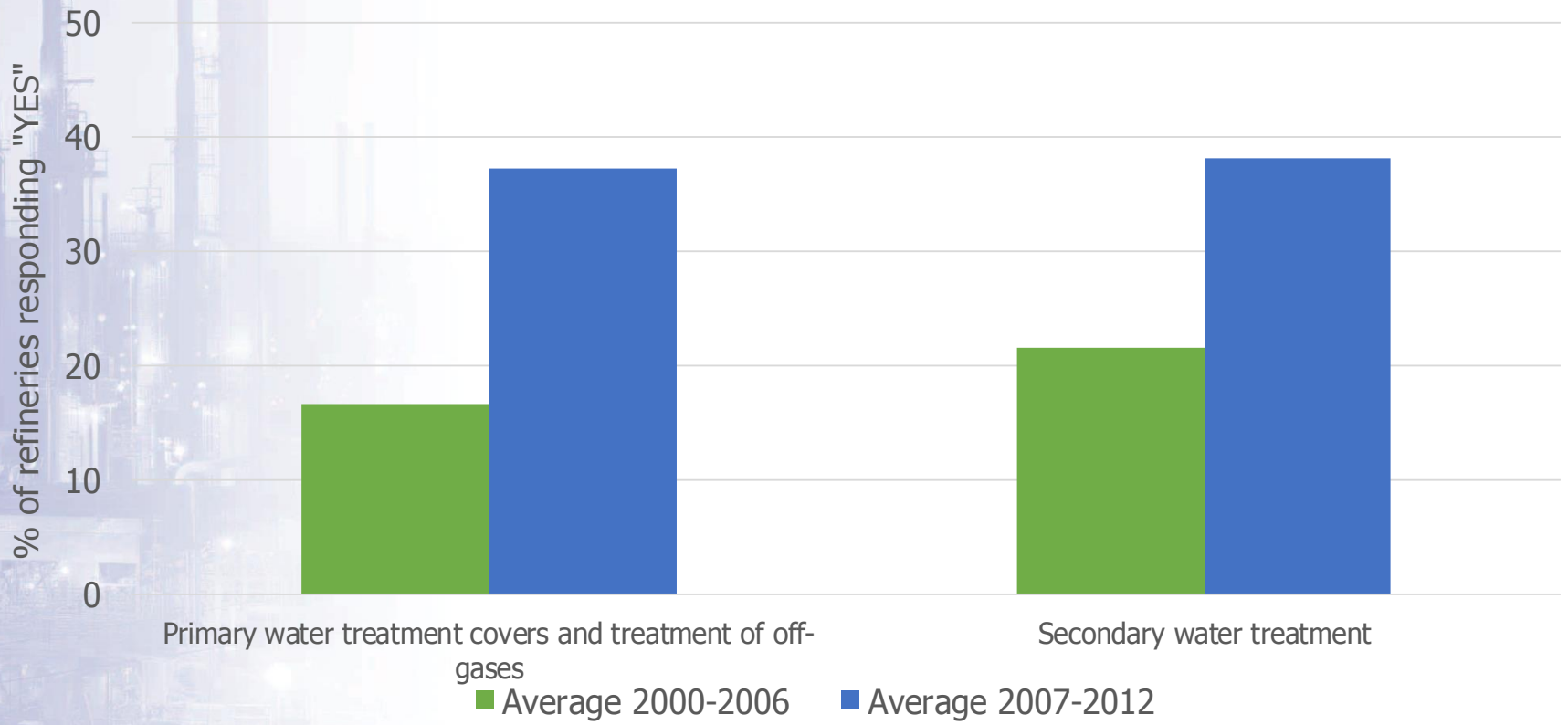


- ❑ Other less implemented abatement measures include:
  - Carbon monoxide (CO) boiler
  - Third stage blowback filter (FCC)
  - Electrostatic precipitator (ESP) (combustion unit)
  - Centrifugal washers

Refining Fitness Check: Step 2 data

❑ EU-28 Water Emissions Abatement Measures

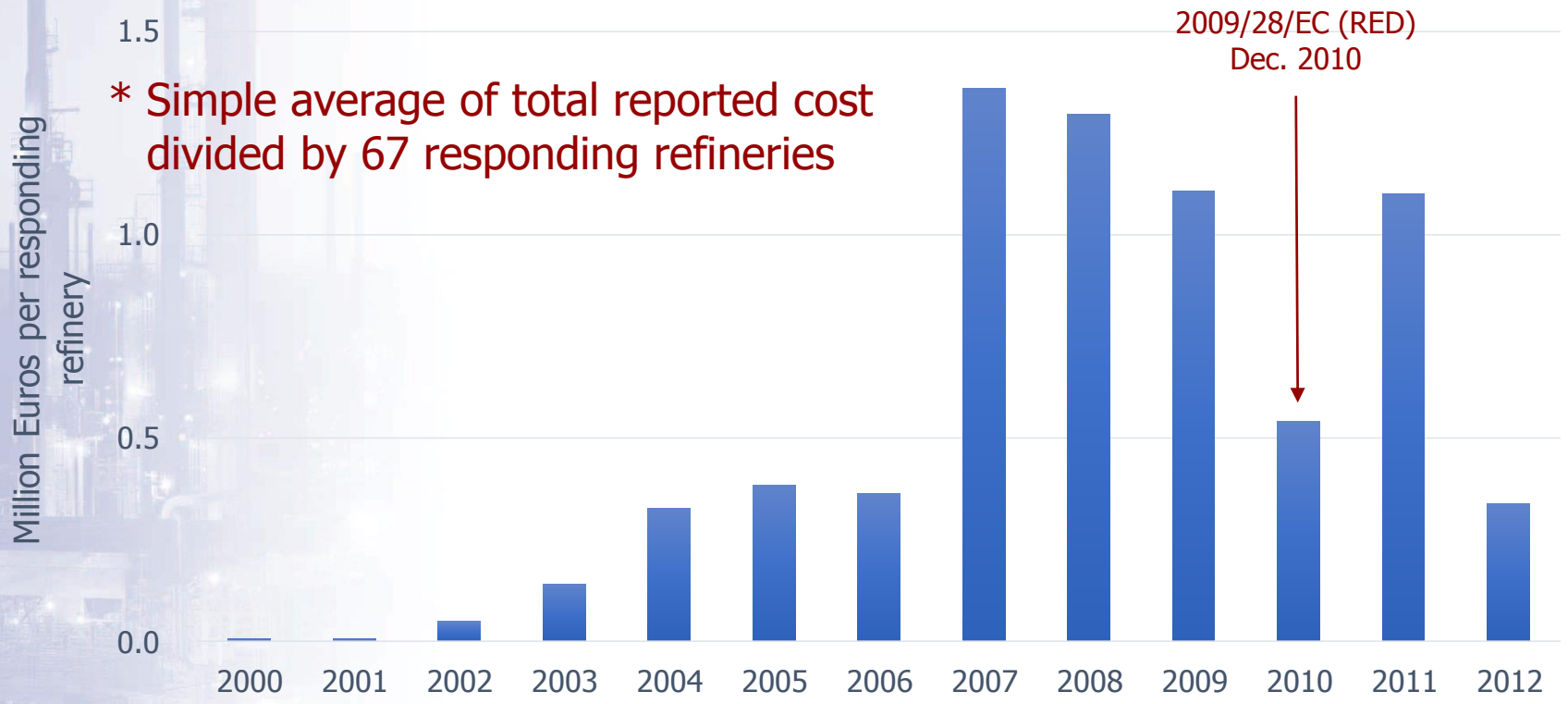
Waste water treatments incurring annual CAPEX



Refining Fitness Check: Step 2 data

❑ Renewable Energy Directive (Biofuels)

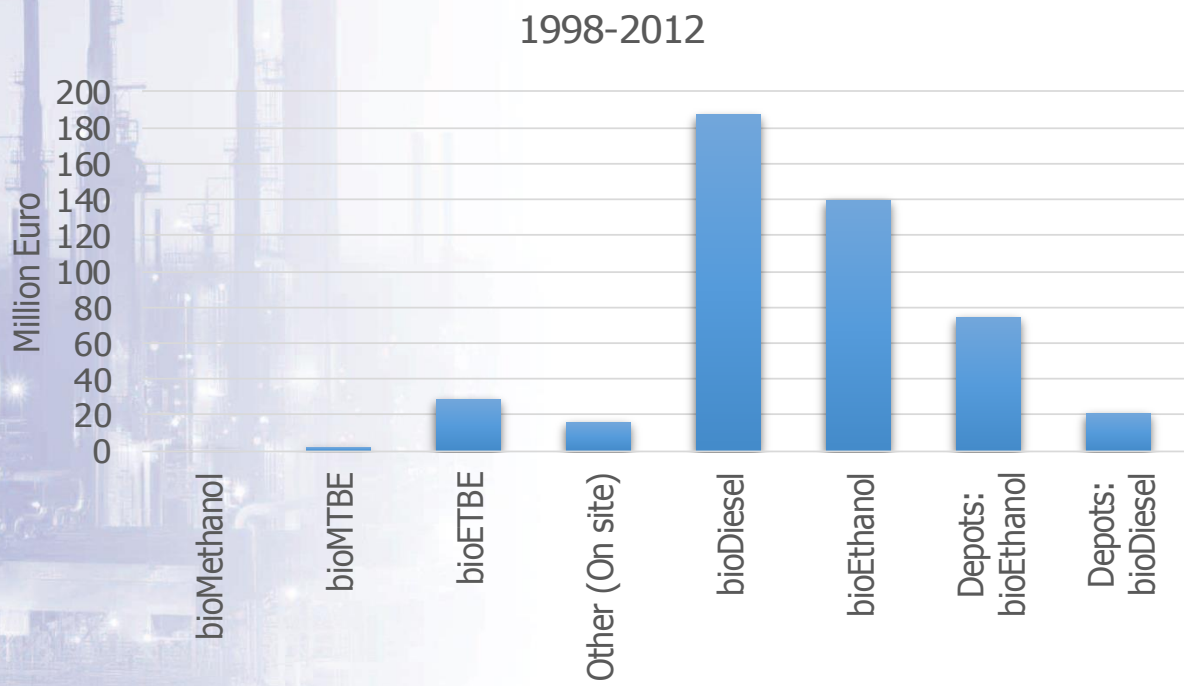
Additional Storage Capacity and Infrastructure
EU-28 Average CAPEX per Refinery (including off-site depots)

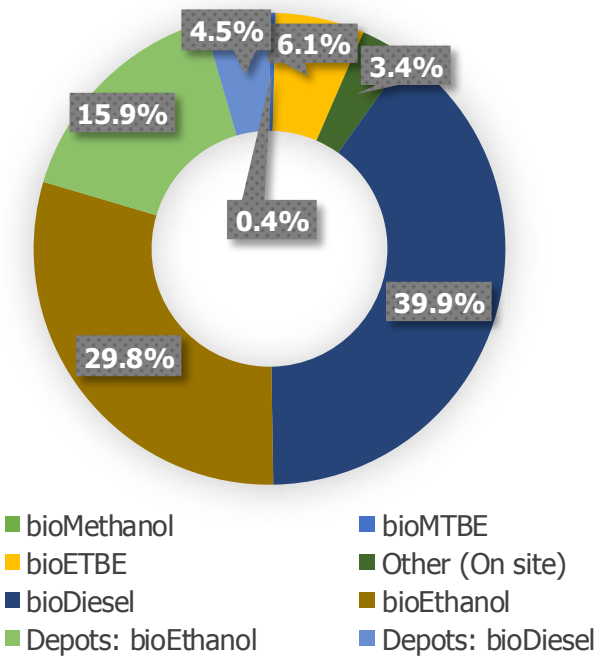


Refining Fitness Check: Step 2 data

❑ Renewable Energy Directive (Biofuels)

Additional Storage Capacity and Infrastructure
Total CAPEX per type of Investment





- ❑ Total of **470 Million EUR** invested since 2000
- ❑ 70% of the investments were in biodiesel and bioethanol on-site facilities

Refining Fitness Check: Step 2 data

❑ CONCLUSIONS

- ❑ 95 refineries operating in 1998 dropping to 82 in 2014
- ❑ Refineries have become more complex in the last years
- ❑ 4.7 Billion EUR of capital expenditure in Air & Water emissions abatement measures (1998-2012)
- ❑ Largest share of the investments took place after 2006 (when relevant regulation for the sector came into force)
- ❑ 82% of the reported Capex was in Air abatement measures
  - ❑ Investments related to SOx emissions were the most widely implemented
- ❑ Biofuels infrastructure projects followed the trend of increasing Capex after 2006
  - ❑ Total of MEUR invested in biofuels infrastructure since 2000
  - ❑ 70% of the investments were in biodiesel and bioethanol on-site facilities

Refining Fitness Check: Step 2 data

Thank You!

Questions?