INSTYTUT CHEMICZNEJ PRZERÓBKI WĘGLA

From coking coal to coke - perspectives for met coke production in European Union

Aleksander Sobolewski, Bartosz Mertas

Institute for Chemical Processing of Coal, Zabrze, Poland

Contents

- Introduction
- Coal&coke market – EU over world
- EU environmental protection provisions
- Technology for coke quality improvement
- Conclusions

Introduction

Steel $\Rightarrow$ still main construction material in XXI century

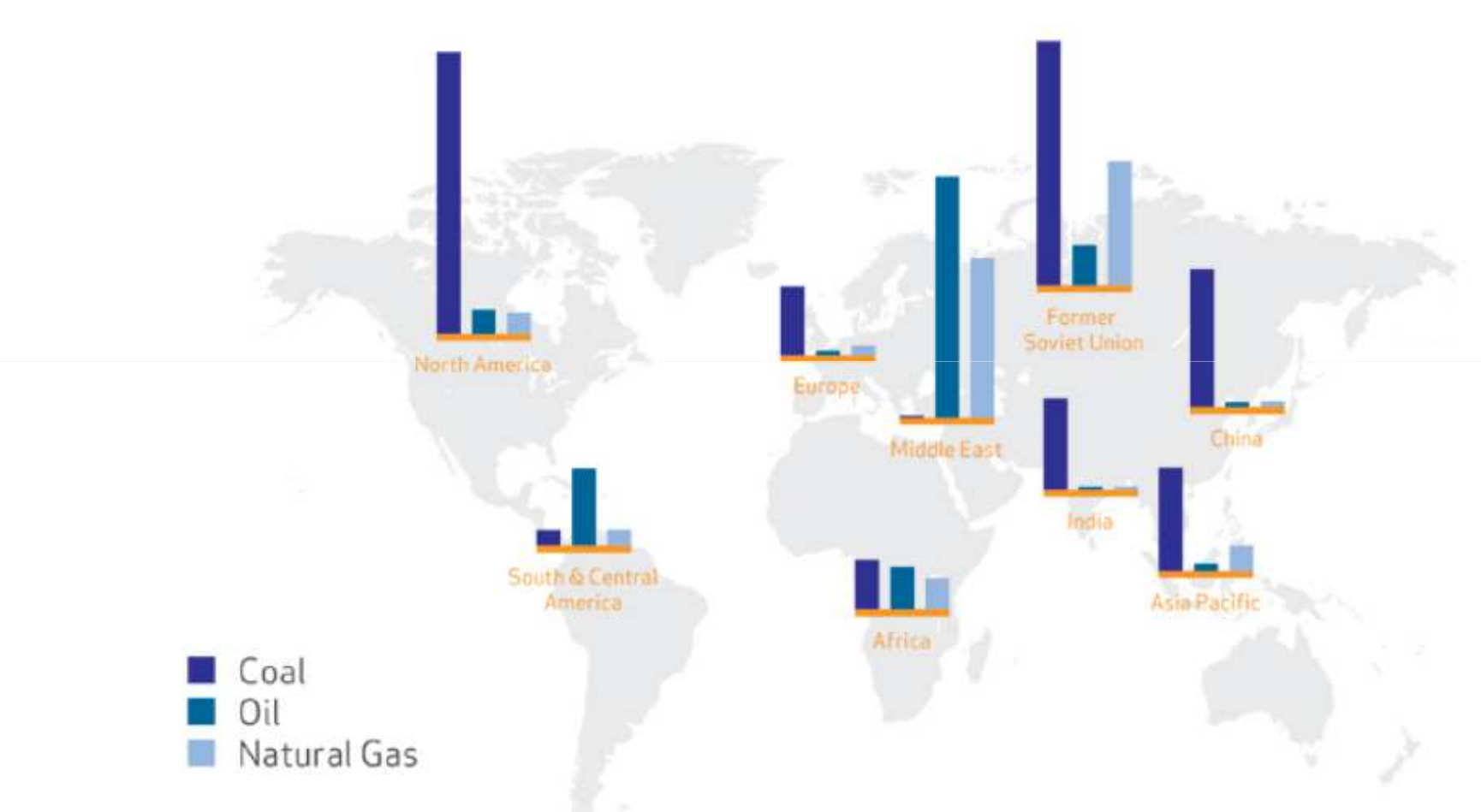
Blast-furnace $\Rightarrow$ still main production technology

Coke $\Rightarrow$ still indispensable charge material

Coal $\Rightarrow$ good quality coal still indispensable for production of good quality coke

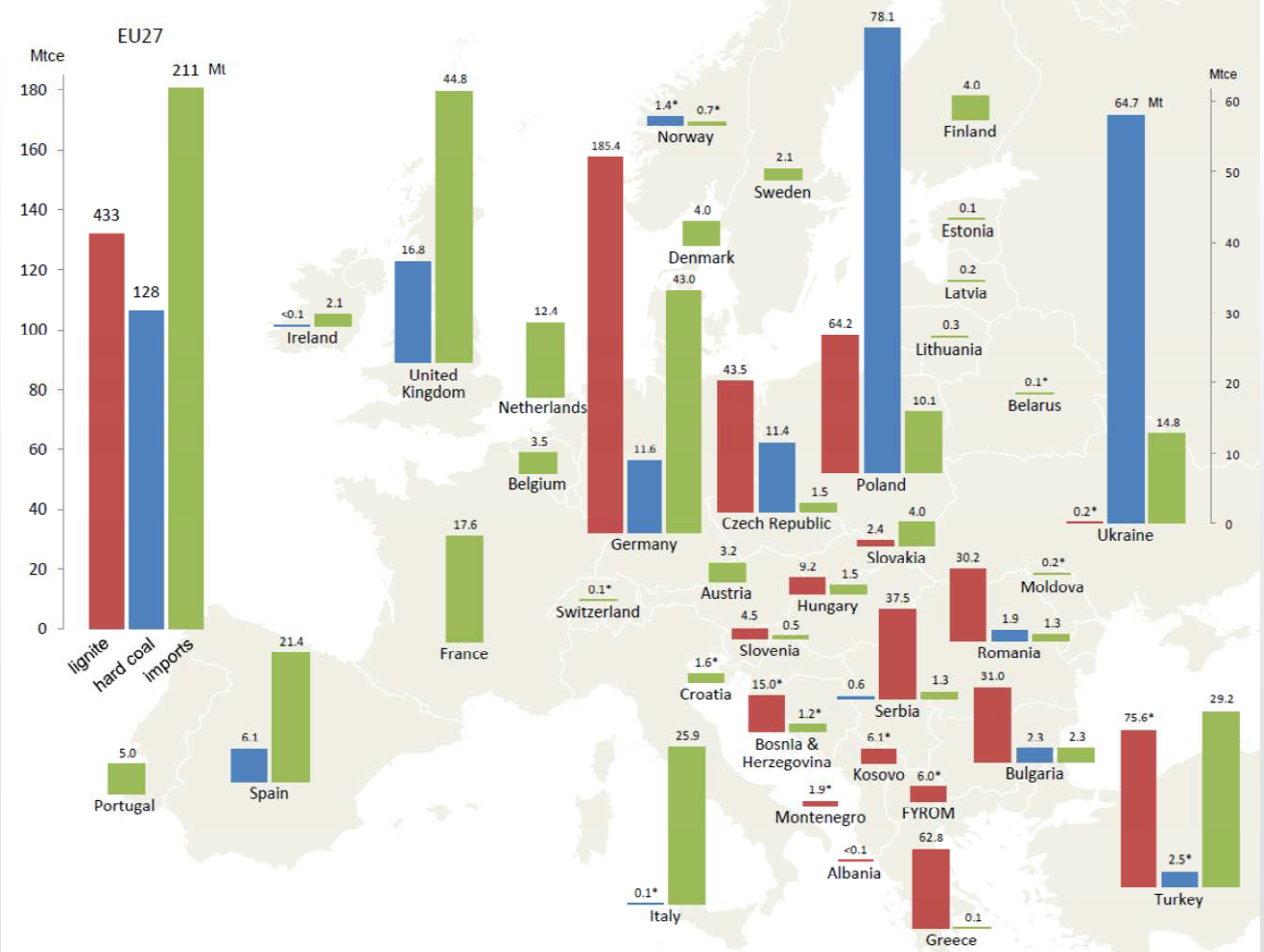
Technology $\Rightarrow$ there is still place for further improvement of coke quality

Location of the world's main fossil fuel reserves (billion tonnes of oil equivalent)



Source: BP Statistical Review of World Energy 2011

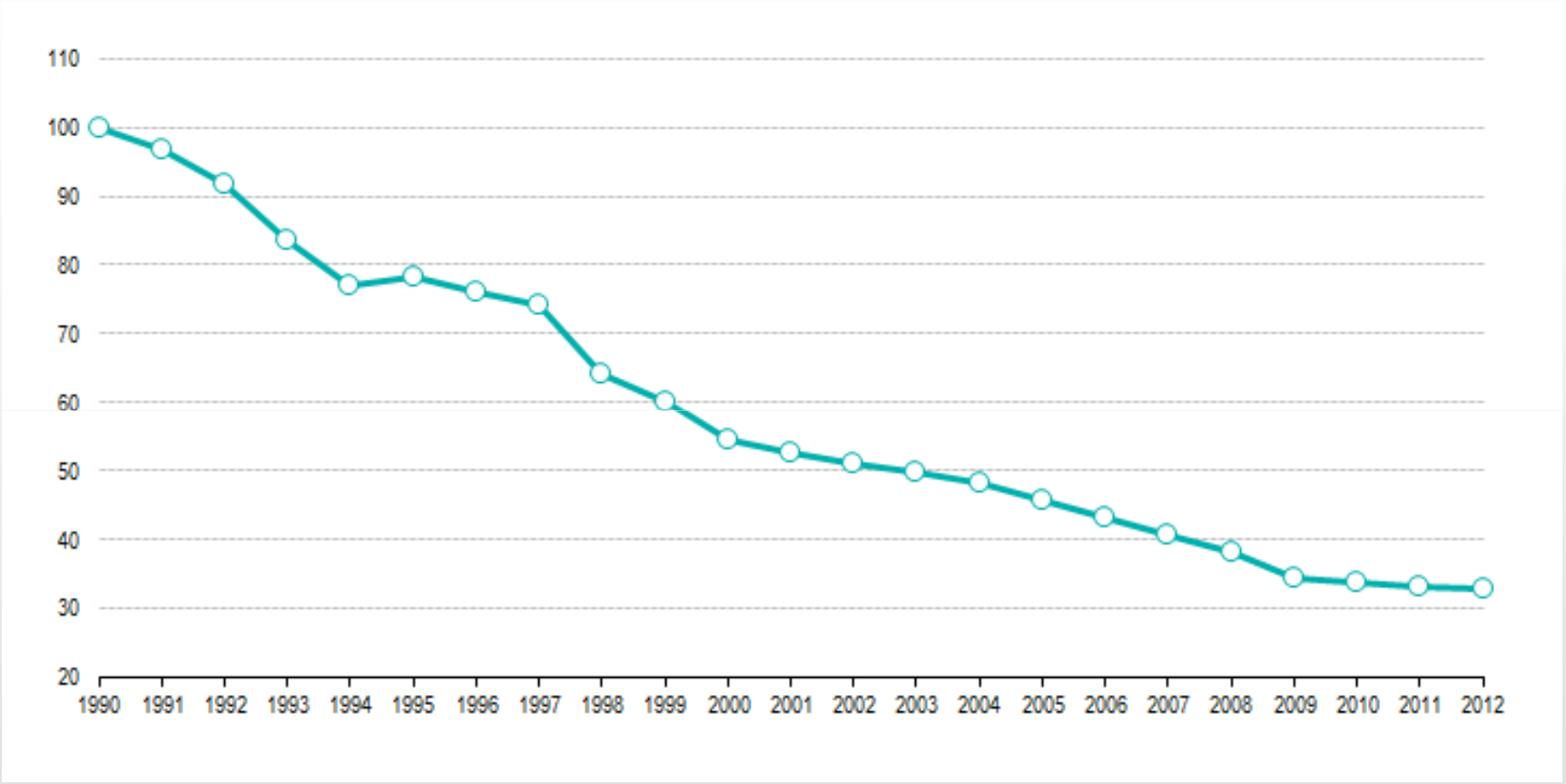
Europe‘s hard coal and lignite production and imports in 2012



Source: EURACOAL Annual Report 2012

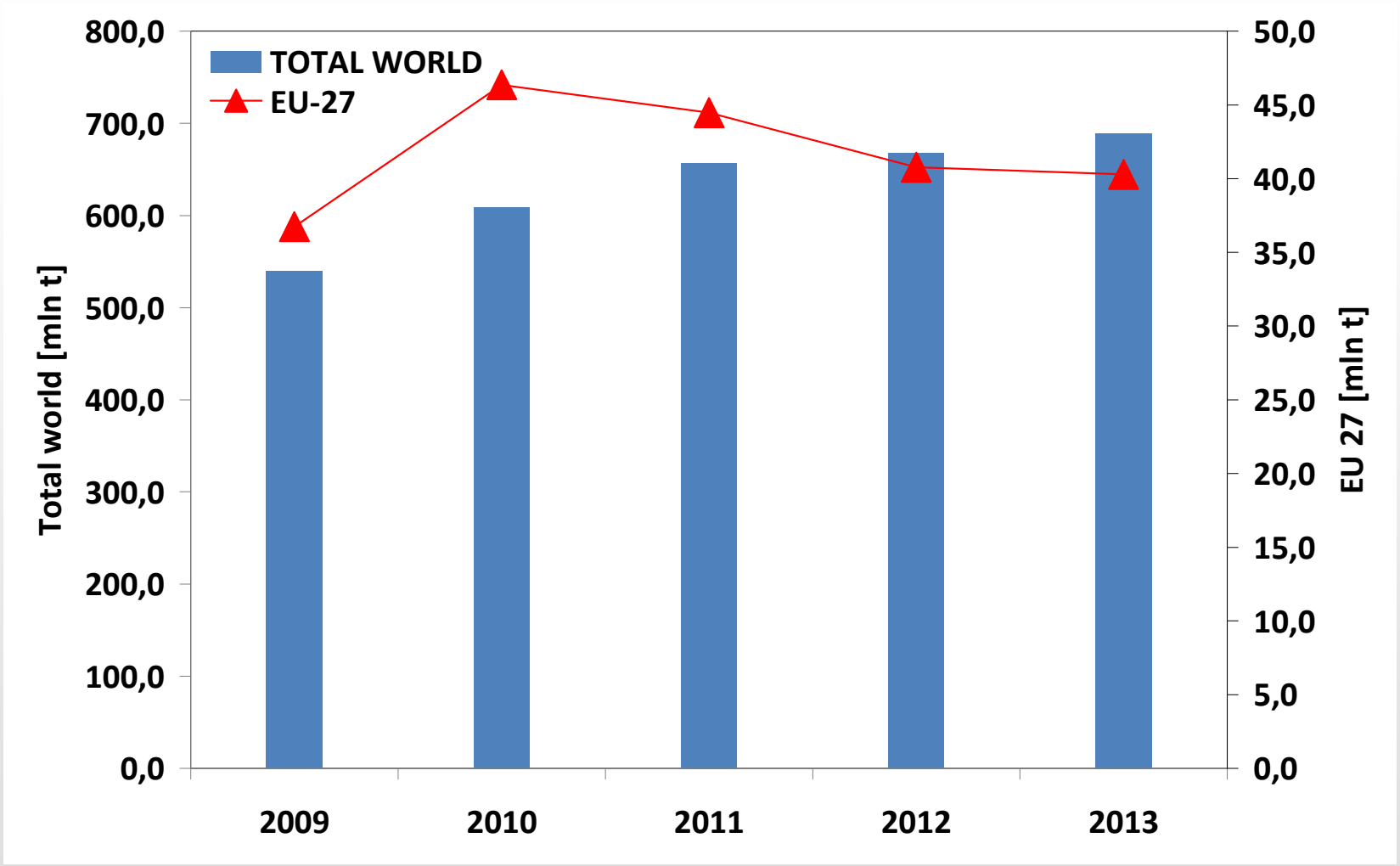
INSTYTUT CHEMICZNEJ PRZERÓBKI WĘGLA

Hard coal production in EU27



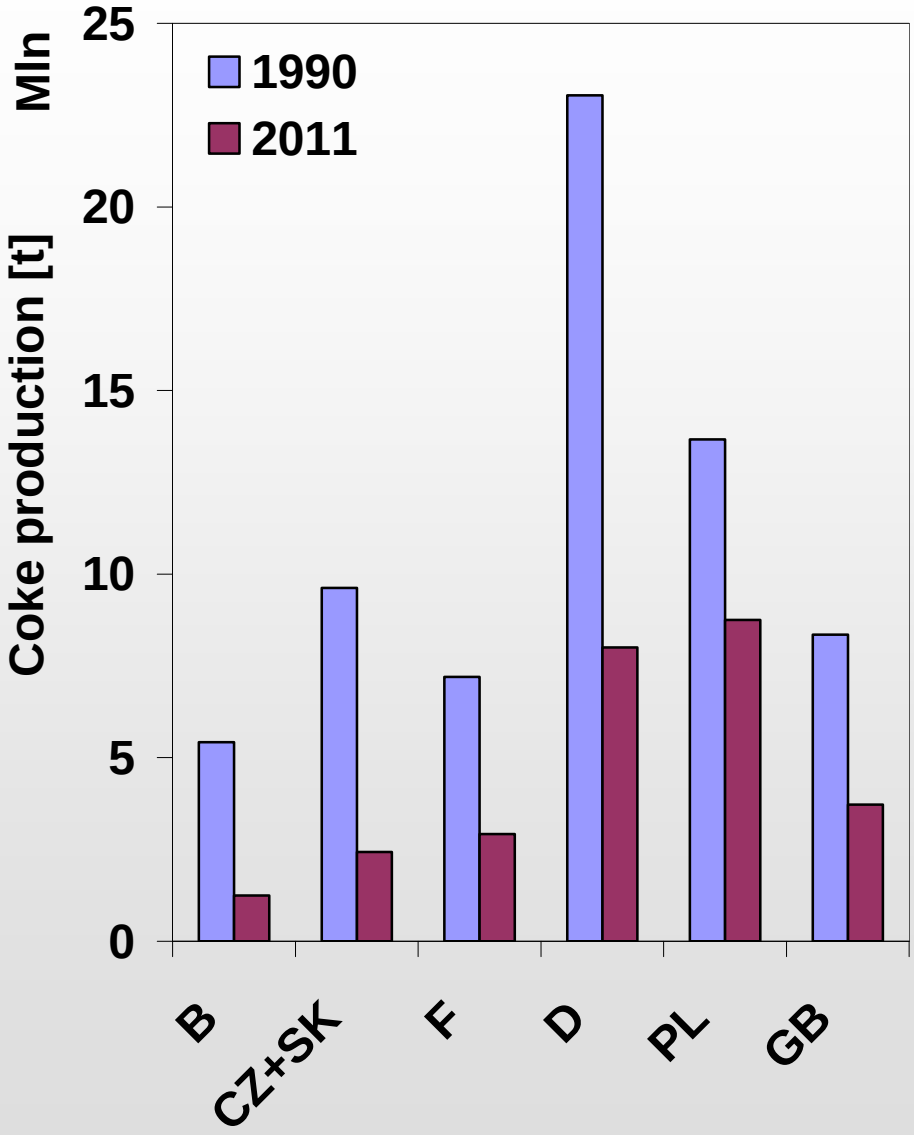
Source: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Coal_consumption_statistics

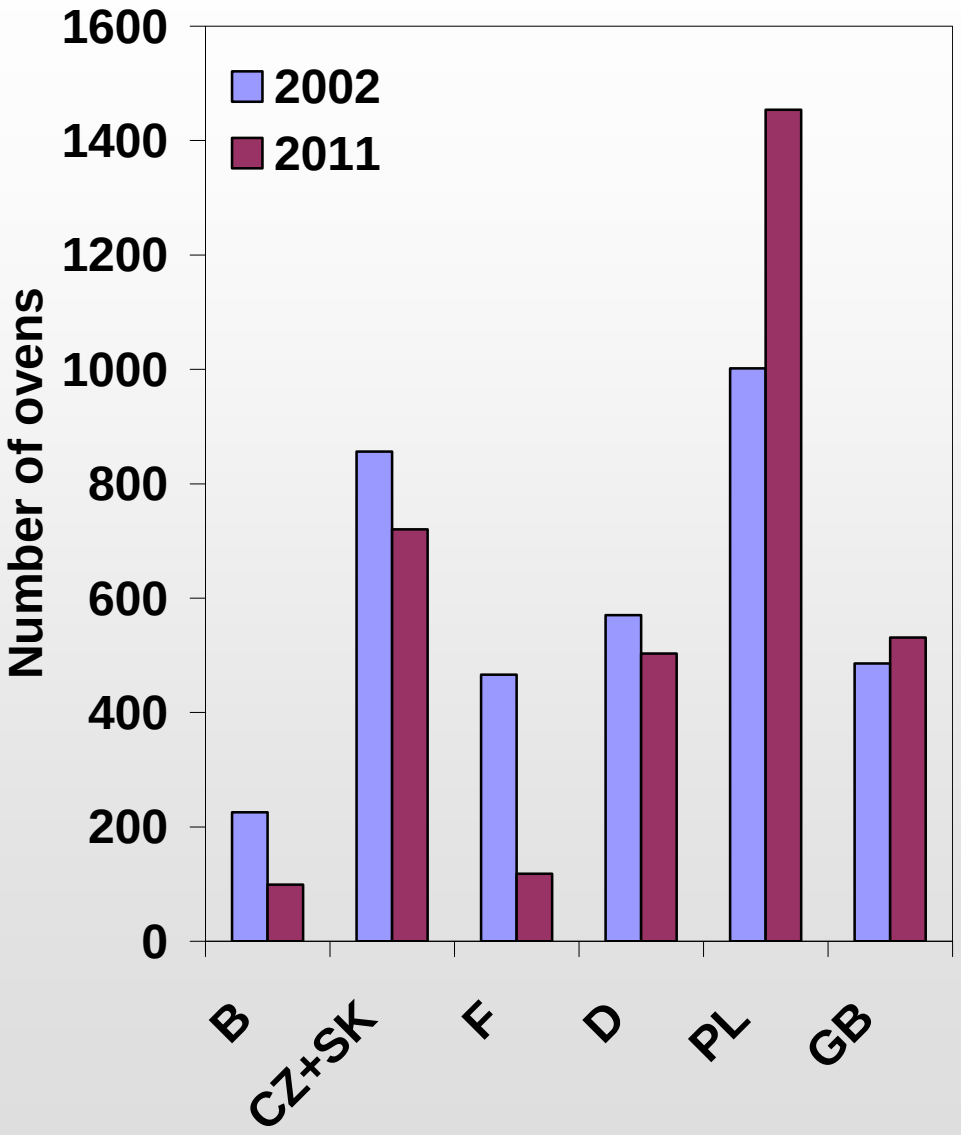
Coke consumption in years 2009-2013 [mln ton]



Source: Polski Koks S.A. – presentation during conference Koksownictwo 2013

Coke production in EU





Environmental EU policy

Where UE goes?

- **Own raw materials**

- **Import of raw material (coal, ore)**

- **Import of semi-products (coke, concentrate)**

- **Import of raw products**

Import of highly processed market ready products??

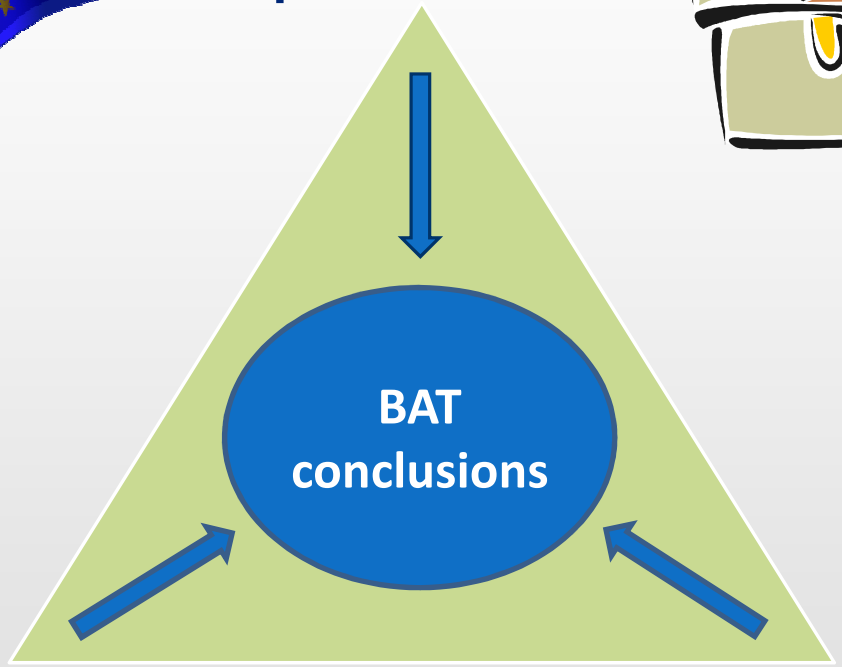
Environmental EU policy

Sustainable development ?

YES

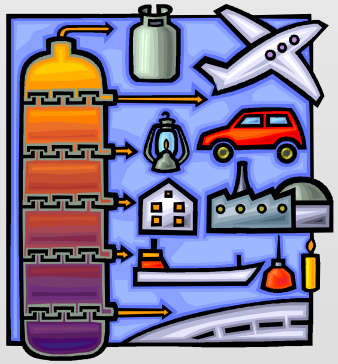
BAT (Best Available Technology)

EU governments representatives



NGO, green parties representatives

Industry representatives



BAT (Best Available Technology)

Negotiations

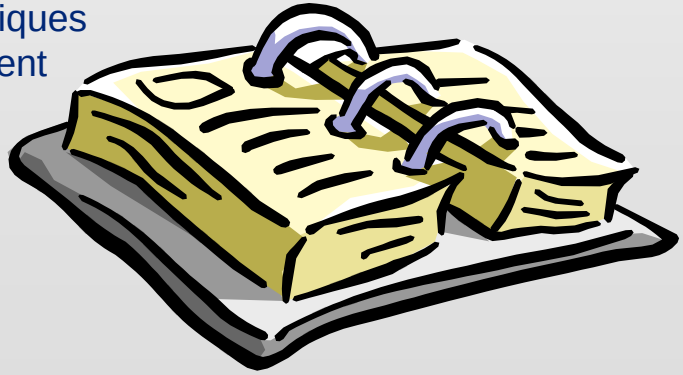
producers

community representatives

Process of acts preparation

Decisions

Best Available Techniques Reference Document



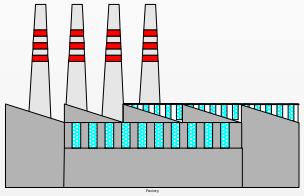
New coke production capacities

Lp.	Country	Location	Production capacity [t.t /rok]	Height [m]	Type	Date of modernisation / construction	Type of modernisation /construction
1	Russia	Czerepowiec	700	5,50	gravity	2013	foundations
2	Germany	HKM	1150	7,85	gravity	2013	ground
3	India	SAIL (Burnpur)	881	7,00	gravity	2013	ground
4	Indonesia	Krakatau Posco (Citegon)	1110	7,60	gravity	2013	ground
5	India	SAIL (Bhilai)	881	7,00	gravity	2014	foundations
6	India	SAIL (Rourkela)	420	4,50	gravity	2014	foundations
7	India	Bokaro	500	7,00	gravity	2014	foundations
8	Brazil	Usiminas	550	6,00	gravity	2014	foundations
9	Ukraine	Krzywy Róg	958	4,30	gravity	2015	foundations
10	India	NHDC	881	7,00	gravity	2015	ground
11	Indonesia	PT Gunung Raja Paksi	755	5,50	stamped	2015	ground
12	Poland	WZK Victoria	103	3,25	stamped	2016	ground
13	Italy	Ilva	623	5,00	gravity	2016	foundations
14	India	JSW (Vijayanagar)	2500	5,50	stamped	2016	ground
15	India	VIZAG (Visakhapatnam)	840	7,00	gravity	2016	ground
16	Brazil	CSN	500	7,00	gravity	2016	foundations
	Total		13 352				

Source: Polski Koks S.A. – presentation during conference Koksownictwo 2013

Introduction
DILLEMA: produce coke or buy coke

BF coke



own production

purchase on market

Pros and cons:

- coke plant operation: investment and operational cost
- feedstock delivery safety: (coal or coke)
- one’s own COG
- environmental protection issues
- coke production profit

Introduction
DILLEMA: produce coke or buy coke

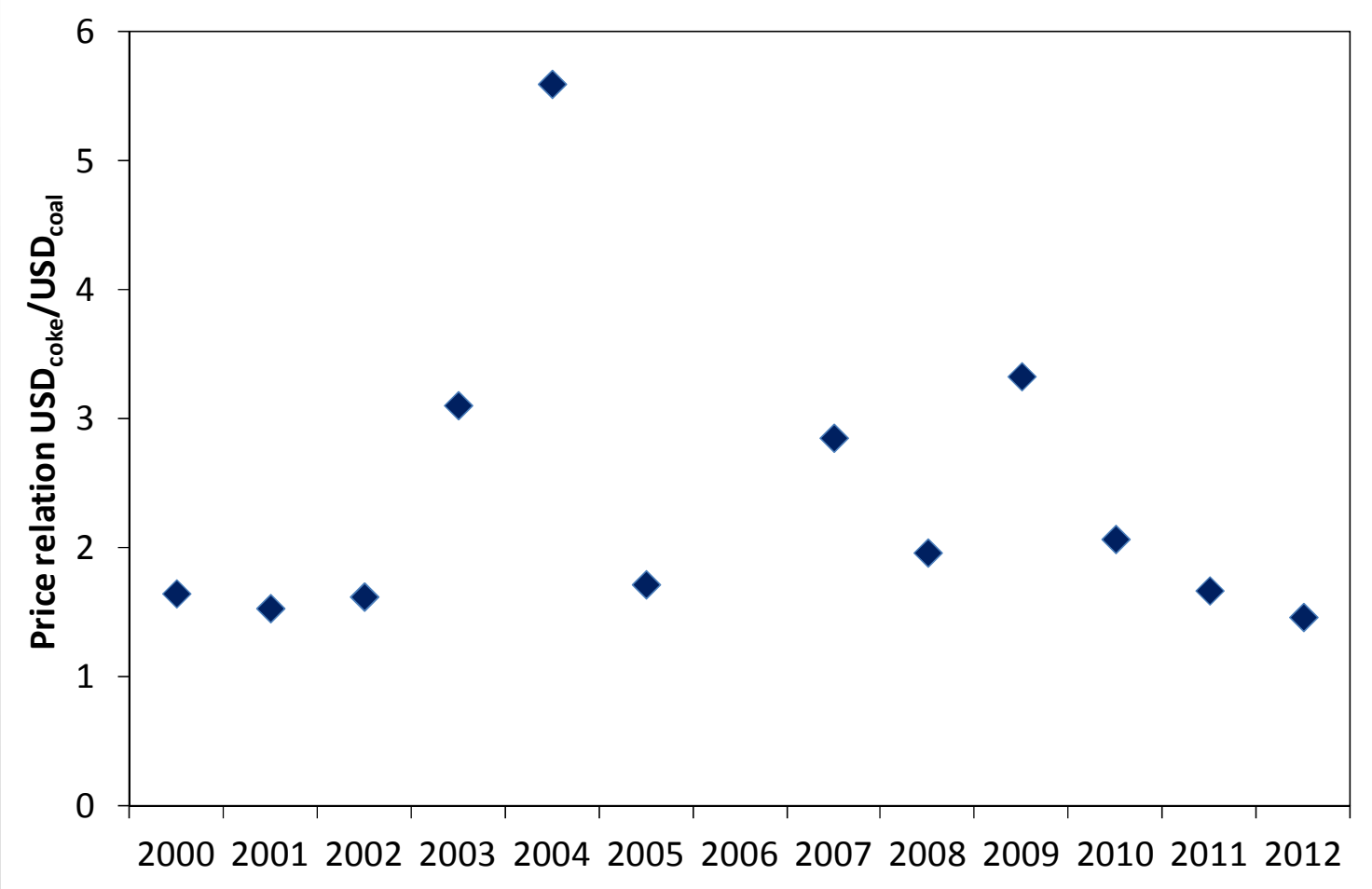
1 tonne of coal charge

(average moisture content)

0.75 tonne of coke

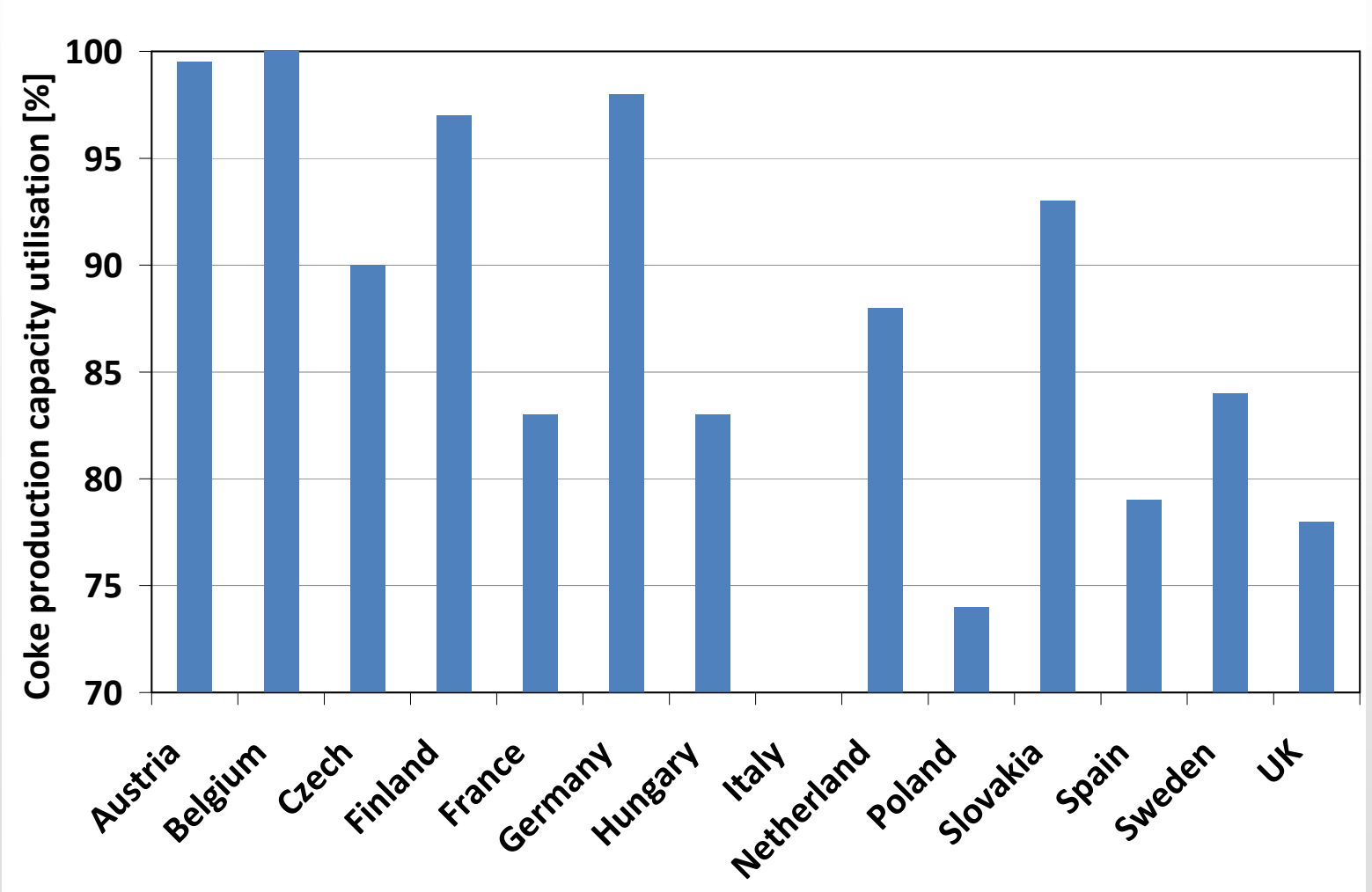
(wet basis)

Introduction
DILLEMA: produce coke or buy coke



Coke/coking coal price relation

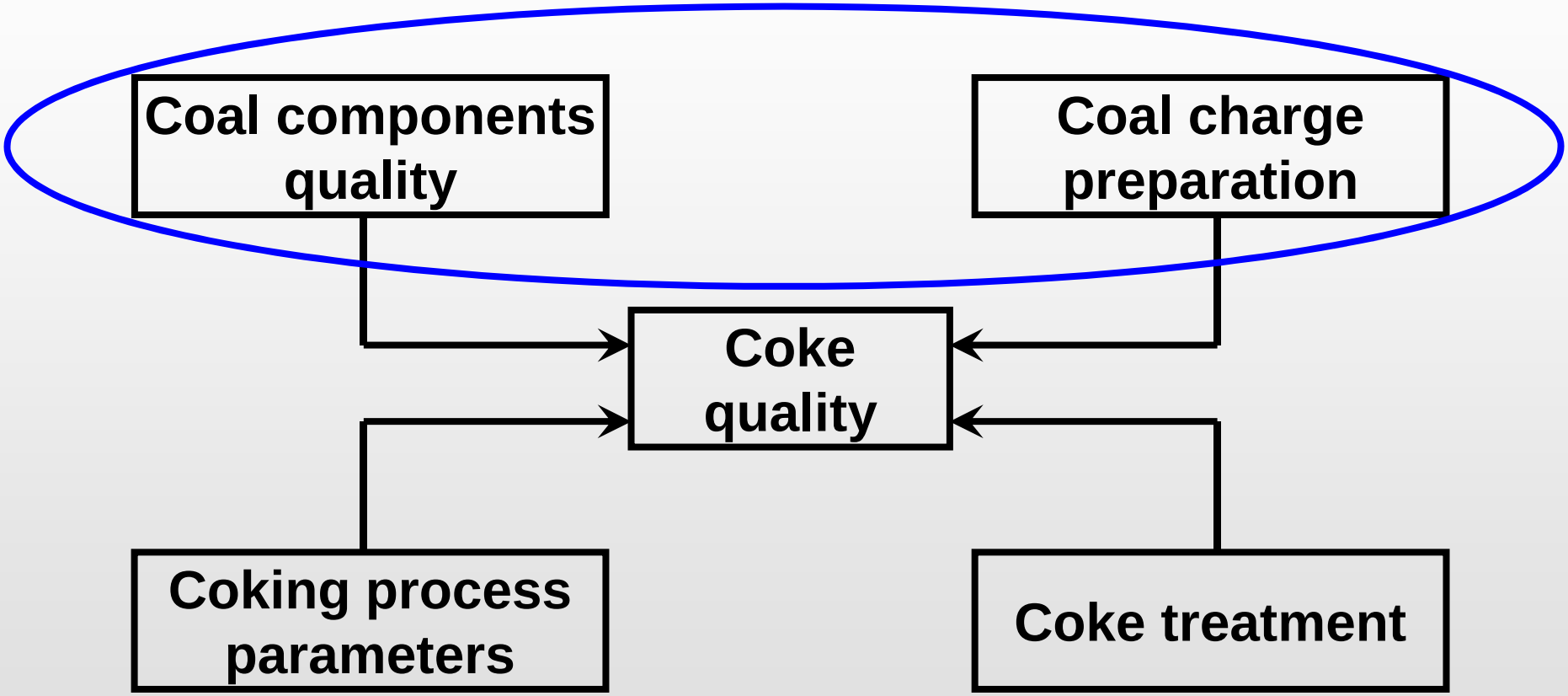
Utilisation of production capacity in EU 27



Coal quality versus blend composition
Coke quality requirements

Parameter		Country of origin		
		Poland	EU 15	China
Mechanical strength	M_{40}, %	75 – 82	76 - 85	82 – 91
Abrasion	M_{10}, %	6.0 - 7.0	6.0 - 7.0	5.6 - 8.0
Reactivity	CRI, %	28 – 35	25 - 30	23 – 30
Strength after reaction	CSR,%	57 – 63	58 - 65	58 – 70
Ash content	A^d, %	8.5 - 10.0	< 10	9.5 - 13.5
Sulphur content	S^d, %	0.5 - 0.7	0.5 - 0.7	0.48 - 0.55
Phosphorus content	P^d, %	0.055 - 0.065	0.025 - 0.065	0.025 - 0.030
Alkalis content (Na_2O, K_2O)	%	0.35 - 0.45	0.25 - 0.40	0.25 - 0.40

Factors influencing coke quality



Coal charge preparation

Method	DISADVANTAGE	ADVANTAGE
Stamping	➢ high investment cost ➢ need significant modernisation of existing technological lines	➢ proved coke quality improvement ➢ possibility to use weaker coals ➢ battery capacity increase ➢ technology positively verified
Heat-Recovery	➢ need to built new coke oven plant ➢ need to provide heat consumer ➢ lower coke yield ➢ no references in EU	➢ possibility to use weaker coals ➢ lower gas emission ➢ simple technological operation
CDQ	➢ high investment and operational cost ➢ shorter CDQ chamber refractory life expectancy ➢ need for surplus gas utilisation	➢ battery capacity increase ➢ heat consumption decrease ➢ lower amount of waste water

Stamp charging technology

Description:

- **wet coal charge is stamped (on the charging machine or under coal tower)**
- **increased bulk density (wet charge) to 1100 kg/m^3**
- **recommended for blend with poorer coking parameters**

Technical characteristics (example):

Capacity:	750.000 Mg/y
No. of chambers:	86
Chamber height:	5,0 m
Chamber length:	15,90 m
Chamber width:	0,51/0,49 m
Coking time:	25,5 h

Remarks: **the first 5-meter high stamp charging coke oven battery in Poland in Kombinat Koksochemiczny "Zabrze" PLC Coke Plant Radlin - start-up 2008**

the first stationary stamp charging in EU

the only other new coke oven battery in EU 15 since 2000 is Dillingen Coke Plant

Possible quality improvement:

CSR $\Rightarrow$ +5 ÷ +9% **M40 $\Rightarrow$ +6 ÷ +8%**

Heat recovery technology

Description:

- **heating direct and indirect**
- **heating by coking gas combustion directly inside coking chamber**
- **production only of coke and energy**

Technical characteristics (example):

No. of chambers:	86
Chamber height:	2,4 m
Chamber length:	13,7 m
Chamber width:	4,5 m

Coking time - extended (typically 48 h)

By-products - none (heat and power production)

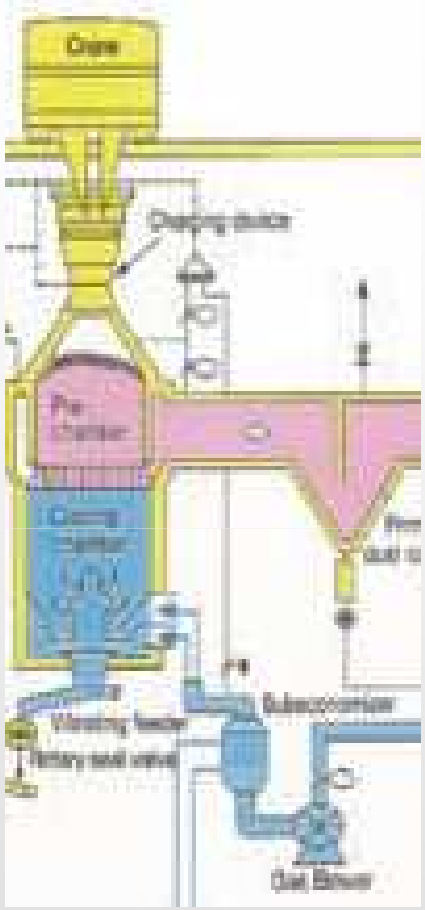
Remarks: **production of big lumps of coke - need for crushing**

bigger coke quality improvement for blends with higher volatile matter content

Possible quality improvement:

CSR ⇒ +2÷ +10% **M40 ⇒ +2%**

CDQ technology



Description:

- **hot coke goes to cooling chamber where is quenched with circulating inert gas**
- **slow cooling down - cooling time ~1 h**
- **possibility for waste heat recovery (production of steam and electricity)**
- **technology popular in Northern and Central European countries, Russia and Japan**

Technical characteristics (example):

Capacity:	52-56 t_{coke}/h
Chamber volume:	100/150 m^3
Steam production:	25 t/h

Remarks: **slow cooling down - smaller stress in coke lump**
smaller water ballast in coke

Possible quality improvement:
CSR ⇒ +3% M40 ⇒ +1 ÷ +2%

Challenges for cokemaking industry

1. The necessity to keep the quality requirements demanded by coke import traders with production based on the Polish coking coals stocks.
2. Implementation and common use of high-tech tools for controlling and operating the technological process.
3. Ensuring the production competitiveness:

How to cost effectively produce a high quality coke?

Conclusions

- In recent years there is noticed continuous increase of coke production but mainly outside Europe.
- Blast-furnace is still main technology for steel production.
- BF operator faces dilemma either buy coking coal for own coke plant or buy coke on free market. Both are subjects to the risks.
- The most often situation for BF operator is: own coke production (100% own battery capacity) what supplies 70-80% of maximum coke consumption plus supplementary coke purchase on the market up to full coke consumption.
- Coke production is profitable when relation between coke price C_c and coal blend price C_b is $\geq$ 1,75. Highly profitable results is when $C_c/C_b > 2{,}5$.

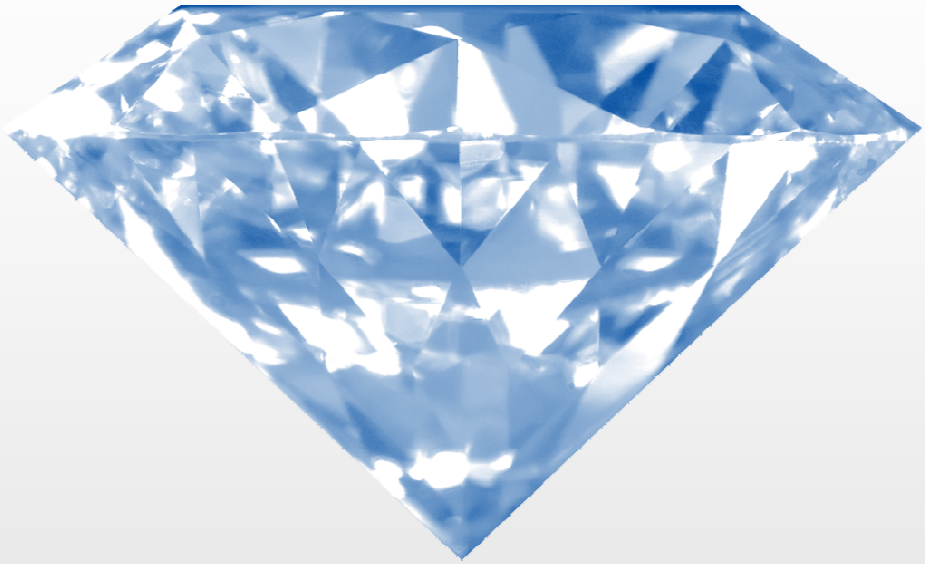
Conclusions

- There are observed difficulties in „hard” coking coals purchase on global market. At the same time price trend is raising. It forces to find technological actions capable to increase coke quality produced from poor blend.

- Well known and very good method for coke quality improvement is also use of charge stamping. New erected coke oven batteries in EU are usually equipped with stamping system (Diilingen, Radlin, Czestochowa, Przyjazn).

- Environmental protection restrictions in EU caused difficulties in new investment plans on new coke oven batteries erection. Producers are constrained to renovation of existing batteries only. This situation opens market for merchant coke plants.

- EU environmental protection policy has immense influence on coke market.



INSTYTUT CHEMICZNEJ PRZERÓBKI WĘGLA

(Institute For Chemical Processing Of Coal)

ul. Zamkowa 1; 41-803 Zabrze, Poland

Phone: **+48 32 271 00 41**
Fax: **+48 32 271 08 09**

E-mail: **office@ichpw.zabrze.pl**
Internet: **www.ichpw.zabrze.pl**

Tax ID No. (NIP): **648-000-87-65**
Nat. Business Reg. No. (REGON): **000025945**