SESSION 2: 9:30–9:50

ESTEP European Steel Technology Platform

ESTEP workshop

SecCarb4Steel

Preparation and use of biogenic and non-biogenic secondary carbon carriers (SCC) in processes for iron and steelmaking

A techno-economic and environmental assessment of coke-making with non-recyclable waste plastics in Europe: Evaluation of current and future market conditions

Mario Ávila[1], Inge Bellemans[1], Sofie Verbrugge[2], Kim Verbeken[1]

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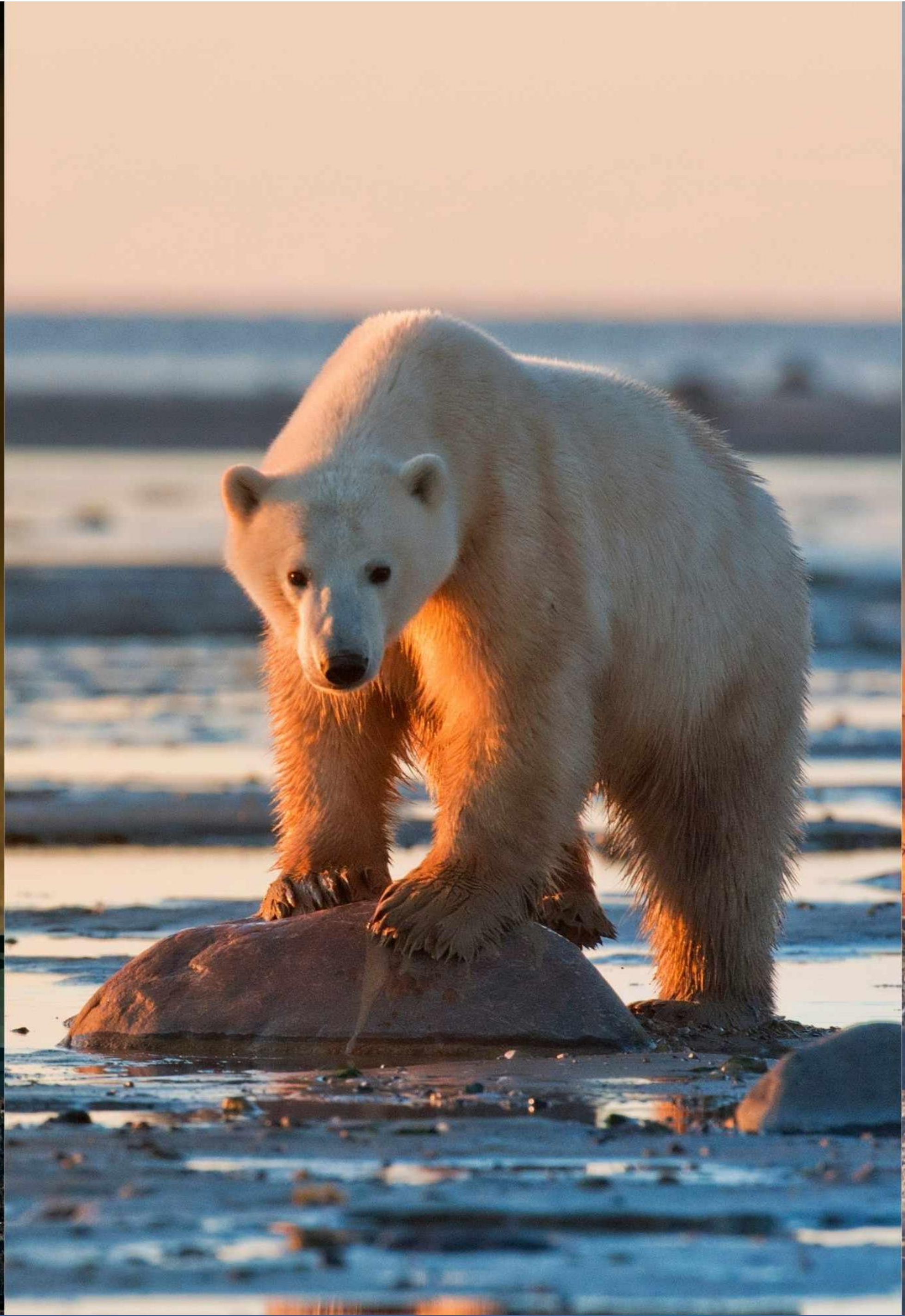
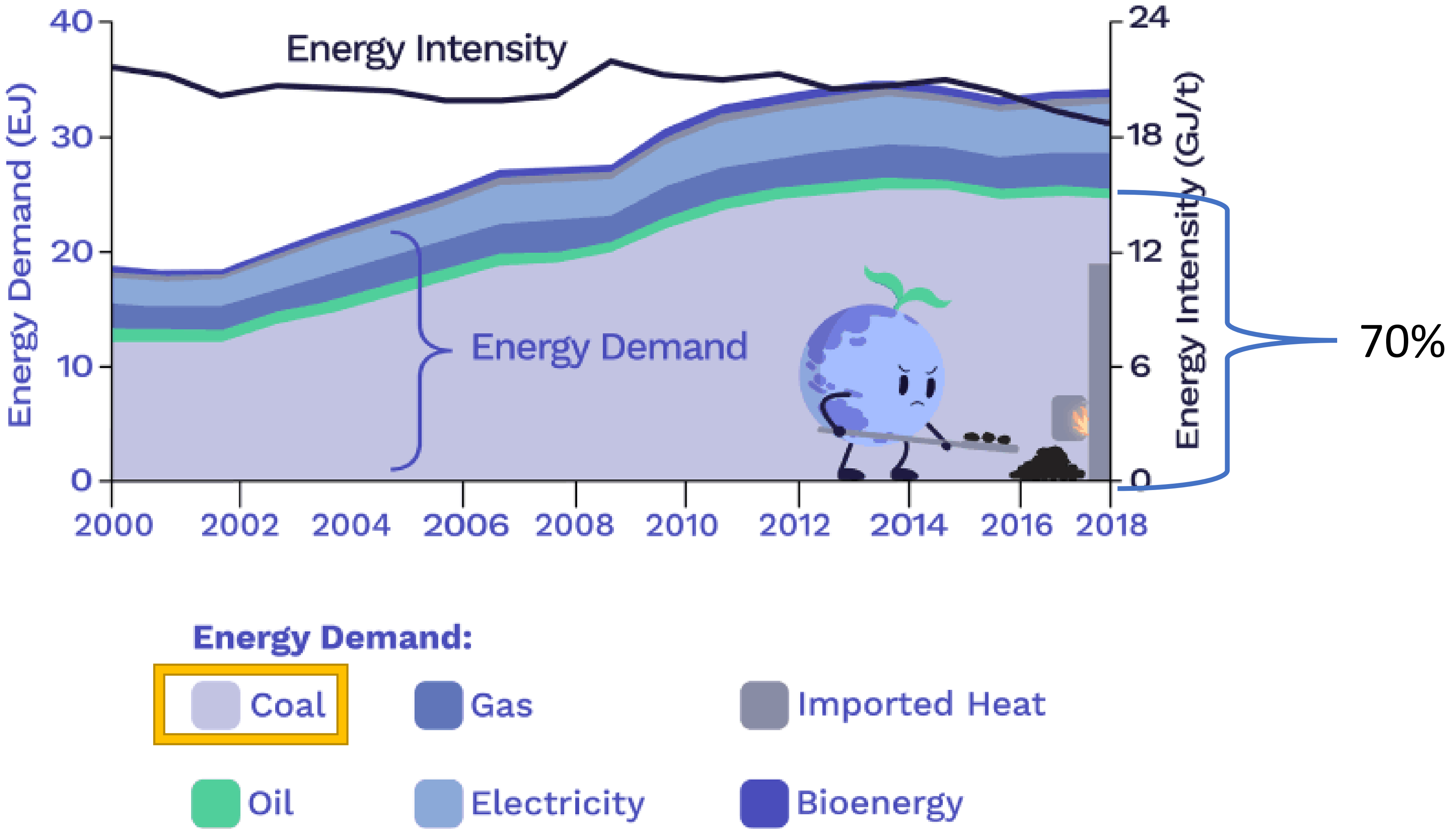




European
Green Deal

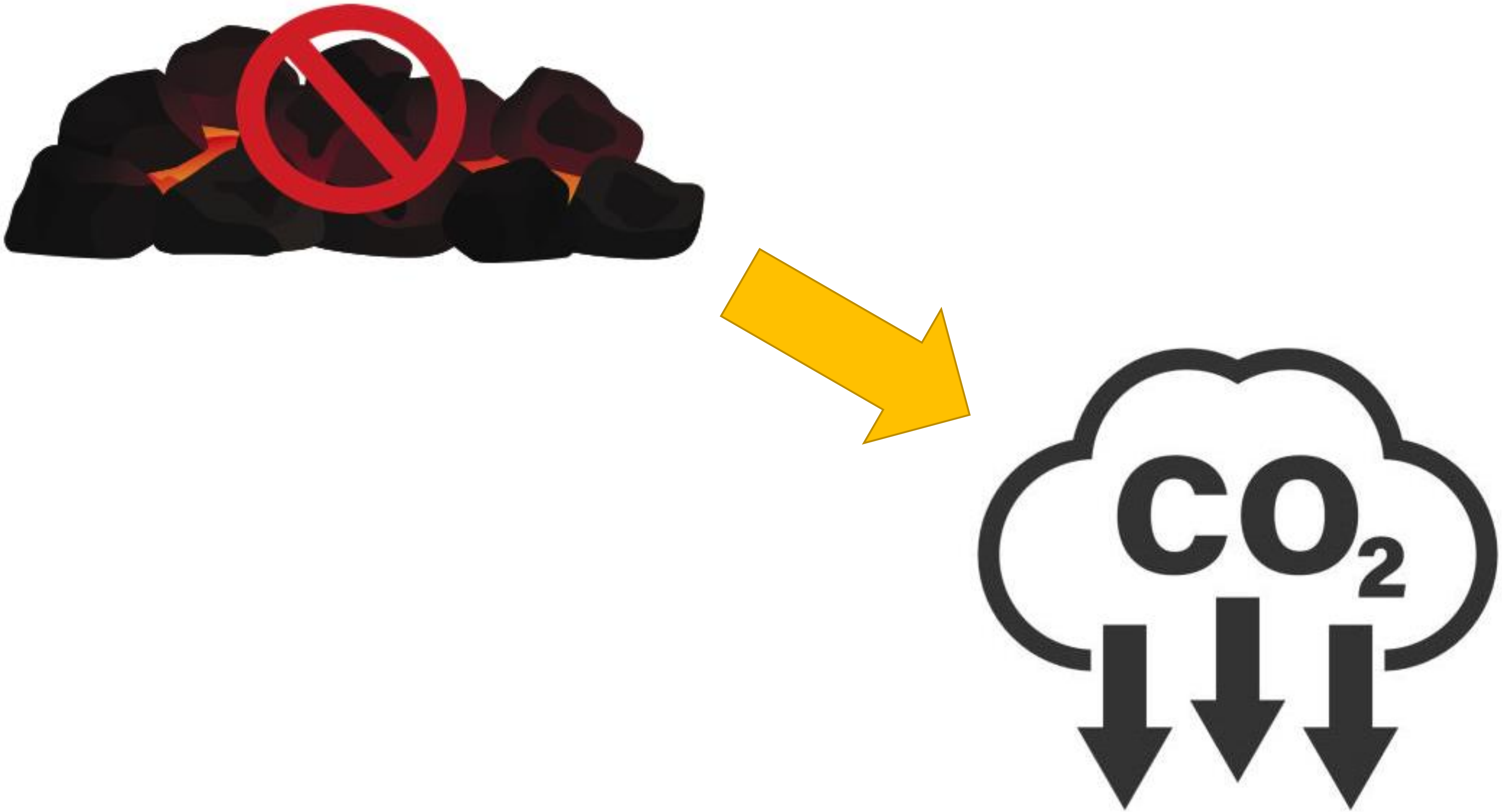

"Fit for 55"

Energy Demand and Intensity in Iron and Steel 2000-2018

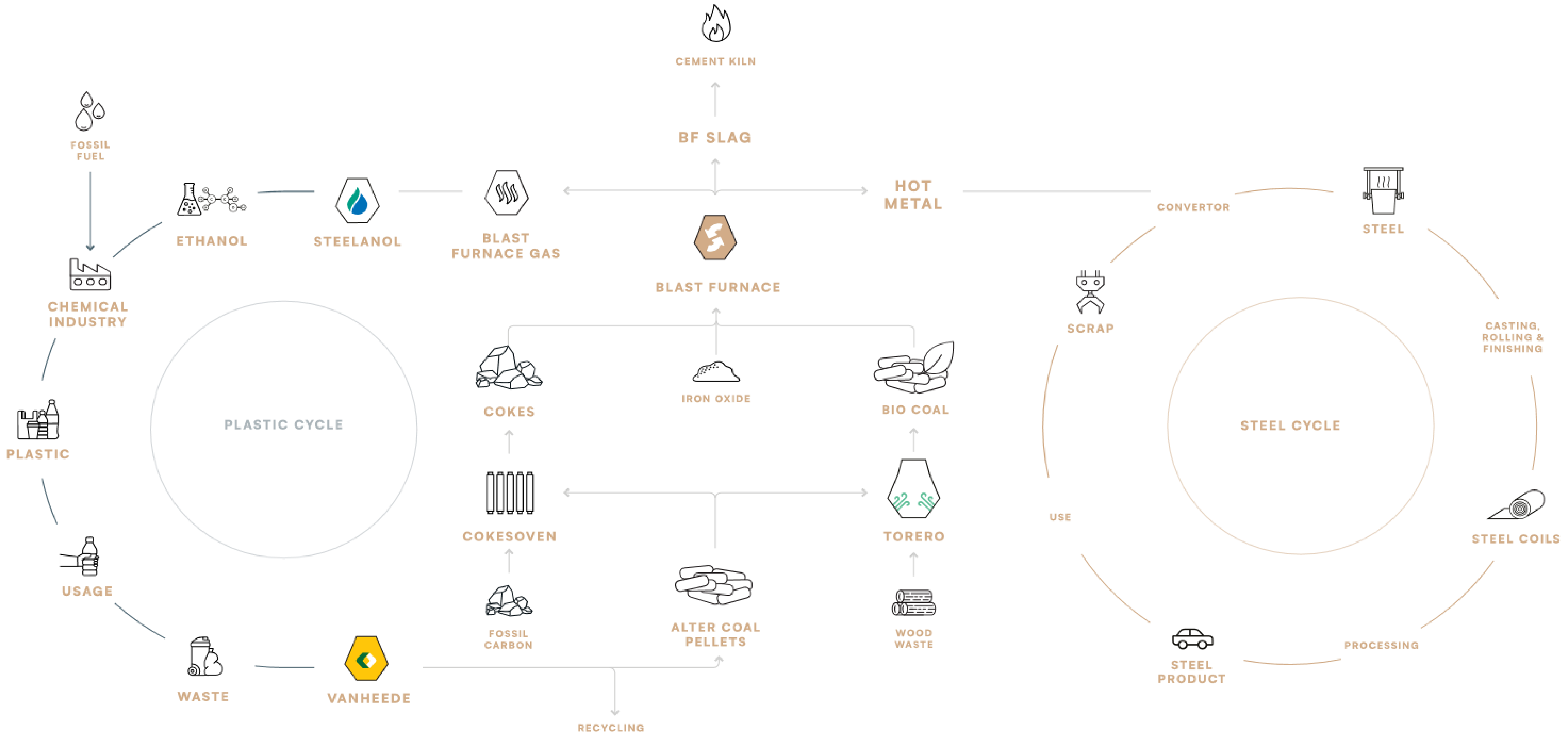


https://climatescience.org/advanced-steel-climate

Decreasing use of fossil fuels



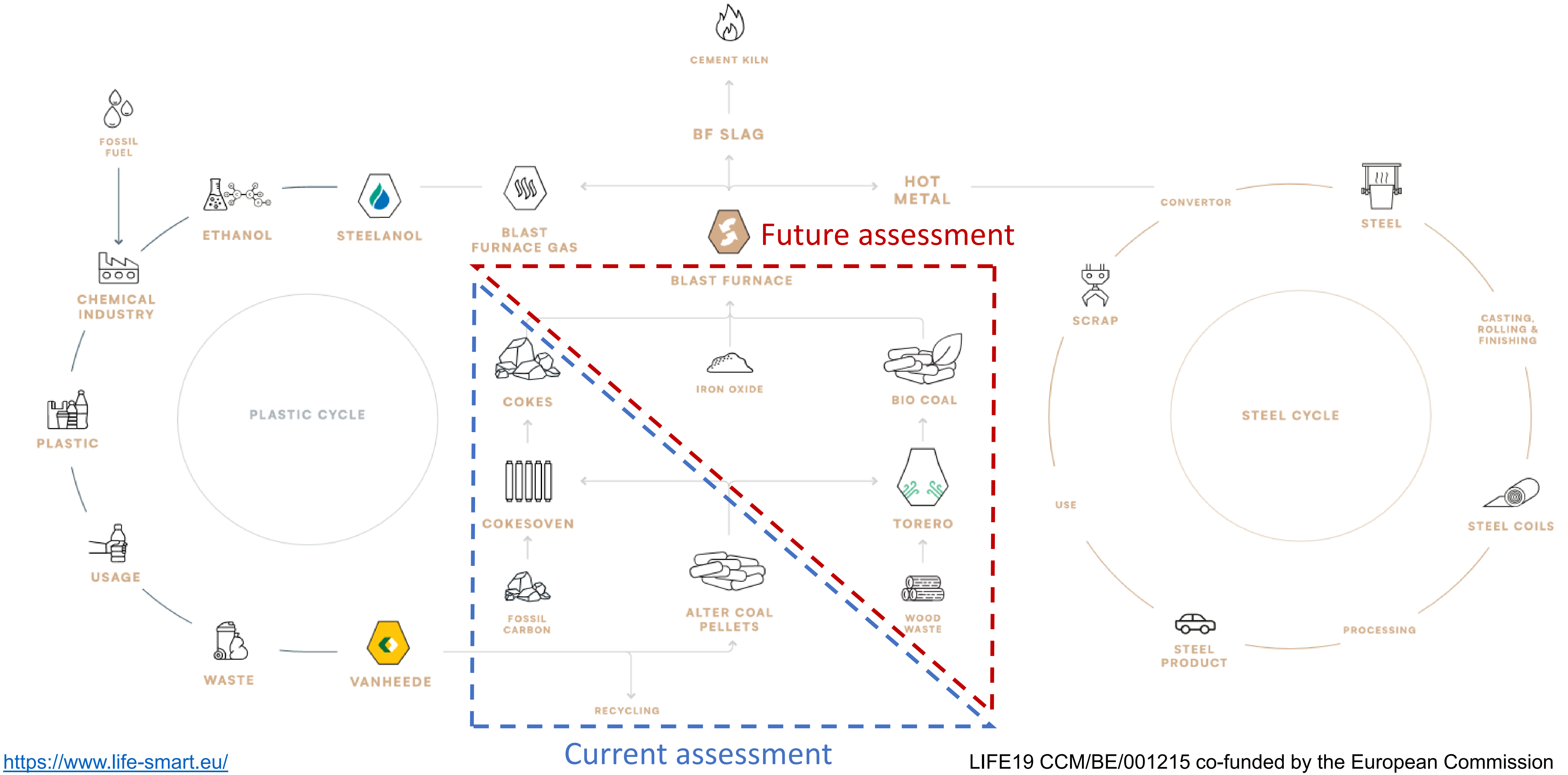
Life Smart project



https://www.life-smart.eu/

LIFE19 CCM/BE/001215 co-funded by the European Commission

Life Smart project



LIFE19 CCM/BE/001215 co-funded by the European Commission

Life Smart project – 1st part

2 wt% waste plastic pellets

+

98 wt% coking coal

metallurgical coke

30-40 kton/year of waste plastics

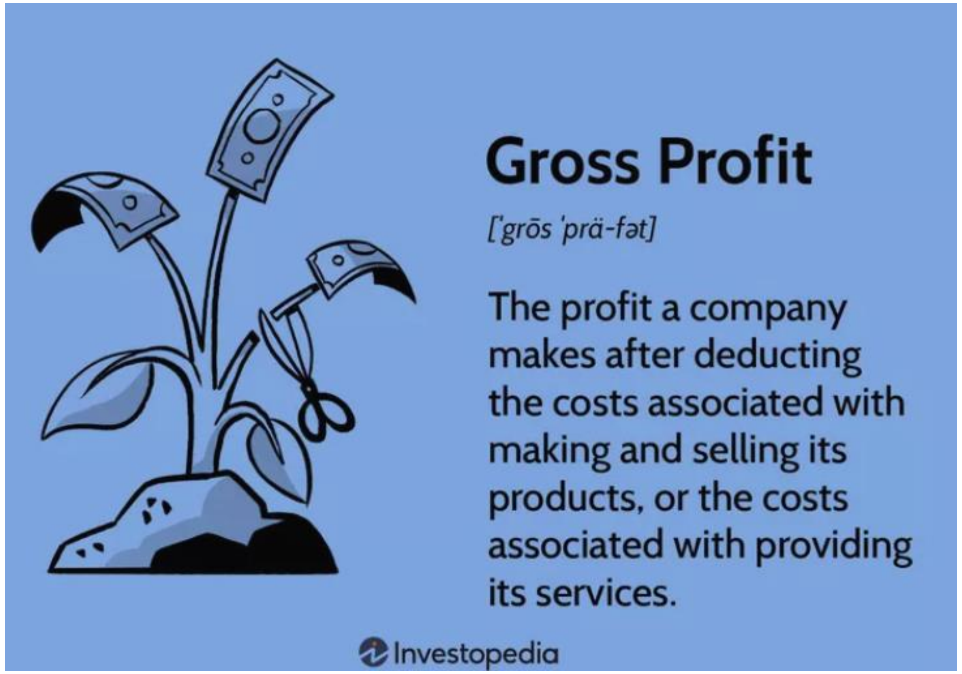
to be used at AMB

Techno-Economic Assessment

Involves technical analysis

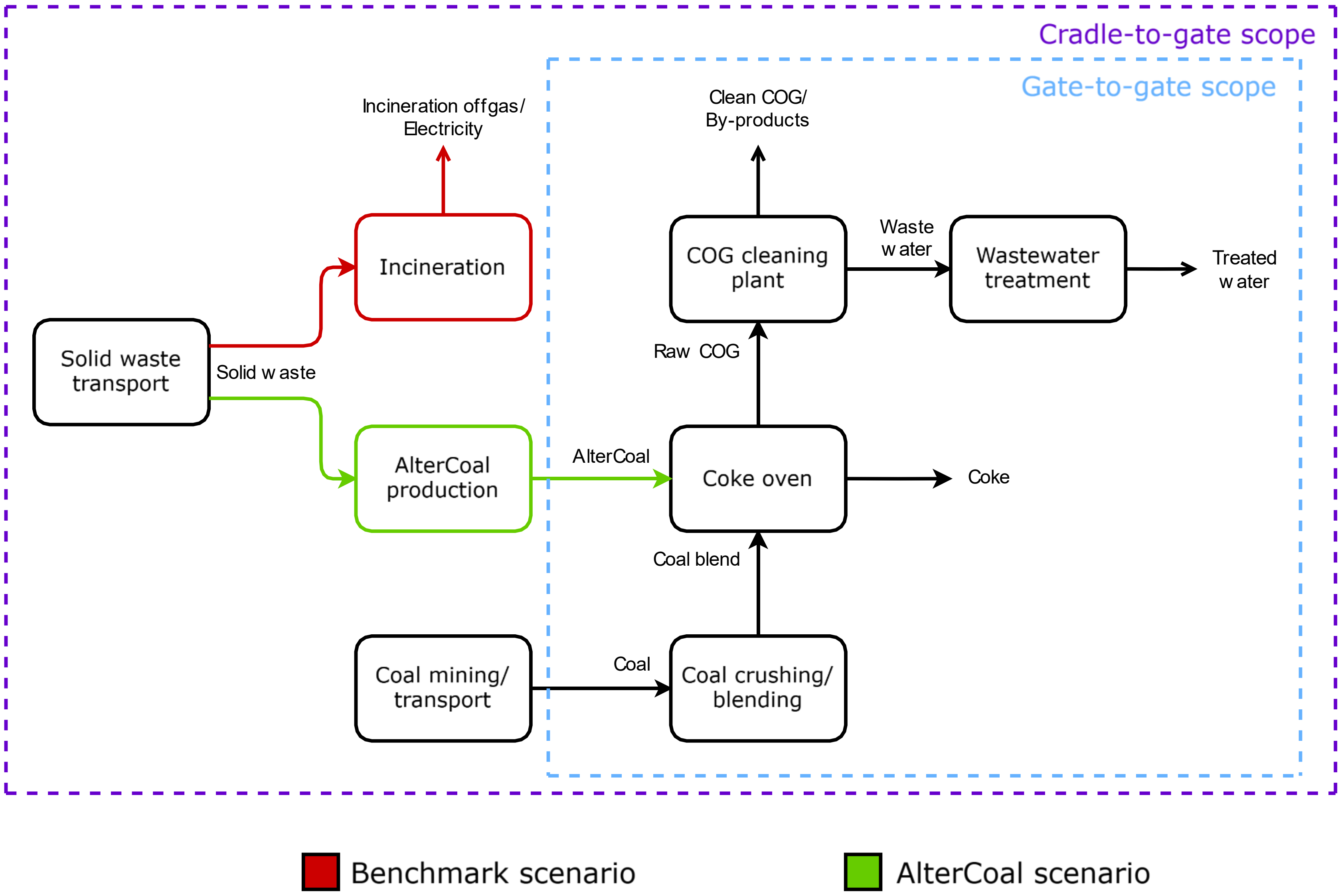
Emphasis on economic aspects

Assisting on decision-making



https://www.investopedia.com/terms/g/grossprofit.asp

Scenarios and scope



Mass-energy balance

Input		
Raw materials		
Coal (dry)	kg/t coke	1220 – 1350
Energy		
BF gas + COG	MJ/t coke	3200 – 3900
Electricity	MJ/t coke	20 – 230 (1)
Steam	MJ/t coke	60 – 800 (3)
Compressed air	Nm^3/t coke	1 – 15
Oxygen	Nm^3/t coke	0.0007
Nitrogen (8)	Nm^3/t coke	0.0047
Acetylene	g/t	0.24
Water		
Process water (10)	m^3/t coke	0.24 – 1.5
Quenching water (11)	m^3/t coke	0.5 – 1

Output		
Products		
Coke (dry)	kg/t	1000.0
COG NetCV of COG Energy	Nm^3/t coke kJ/Nm^3 MJ	360 – 518 17 000 – 18 000 7 200 – 9 000
Steam (2)	MJ/t coke	9 – 267/1500 (4)
Air emissions (5)		
Dust	g/t coke	15.7 – 298 (1)
SO_X (6)	g/t coke	80 – 900 (2820) (7)
NO_X	g/t coke	336 – 1783 (1)
NH_3	g/t coke	0.5 – 24.7
H_2SO_4	g/t coke	2 (9)
HCN	g/t coke	0.05 – 1.87
H_2S	g/t coke	12 – 100 (1)
CO	g/t coke	200 – 4460 (1)
CO_2	kg/t coke	160 – 860 (12)
CH_4	g/t coke	1 – 80 (13)
TOC	g/t coke	12 – 24 (2)
Benzene	g/t coke	0.1 (14) – 45
PAH (15)	mg/t coke	115 – 1091 (16)
PCDD/F	ng I-TEQ/Nm^3	<0.1 (17)
Production residues (waste/ by-products)		
Benzene	kg/t coke	5.3 – 14
Light oil (BTX)	kg/t coke	9.1 – 14
H_2SO_4 (9)	kg/t coke	4.2 – 9
Tar	kg/t coke	26 – 48
$(NH_4)_2SO_4$ as SO_4^{2-} (18)	kg/t coke	28 – 48
Sulphur (19)	kg/t coke	0.9 – 2
Sodium phenolate	kg/t coke	1.4
Waste water	m^3/t coke	0.1 – 0.5

Data from “Best Available Techniques (BAT) Reference Document for Iron and Steel Production”

https://dx.doi.org/10.2791/97469

	Coal blend conversion	AlterCoal conversion
Coke	77.8%	28.9%
Coke breeze	3.2%	0.5%
Tar	2.9%	21.4%
BTX	0.9%	3.7%
Sulphur	0.1%	0.0%
COG	14.1%	45.3%

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CRM GROUP

VANHEEDE.COM ALTERNATIVE FUELS

Plant dimensions

High-Capacity Coke Oven Batteries
Comparison for 2 Million Tons of Coke Per Year

Oven height	7.6 m	6.0 m	4.3 m
Number of batteries	2	4	5
Number of ovens	140	220	325
Oven width	590 mm	450 mm	450 mm
Useful volume p. oven	76 m^3	34 m^3	20 m^3
Numb. of pushes/charges p. day	135	300	520
Total length of sealings (doors, standpipes, charging holes)	4.8 km	6.0 km	6.5 km
Required space for the batteries	40,000 m^2	50,000 m^2	55,000 m^2
Sets of oven machines	2	3	5
Operation teams	1	2	3

Advantages of large ovens:
- Reduced number of batteries / ovens
- Reduced number of pushes/charges ➡ less emissions
- Reduced length of sealings ➡ less emissions
- Reduced plant space requirement
- Reduced number of oven machines (and coal towers, quench systems, coke wharves)
- Reduced number of manpower

Coal blend bulk density = 793 kg/m^3

Coal blend humidity = 10%

Useful volume: 3 416 000 m^3/year

Benchmark scenario

Coal input: 2 709 kton/year

Coke output: 1 917 kton/year

AlterCoal scenario

Coal input: 2 619 kton/year

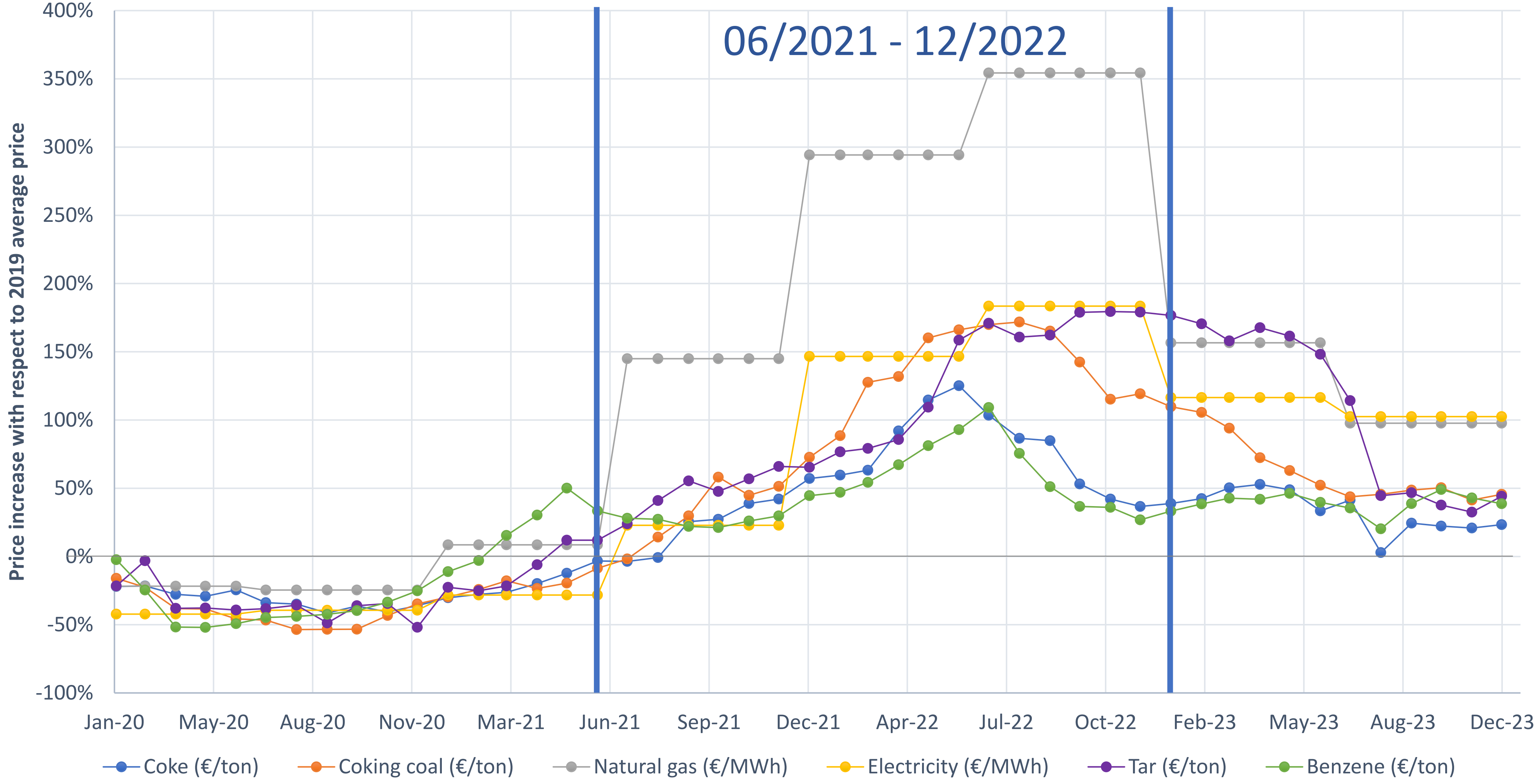
SRF input: 48.6 kton/year

Coke output: 1 868 kton/year

Neuwirth, Ralf. (2014). High capacity coke ovens. 38. 24-27.

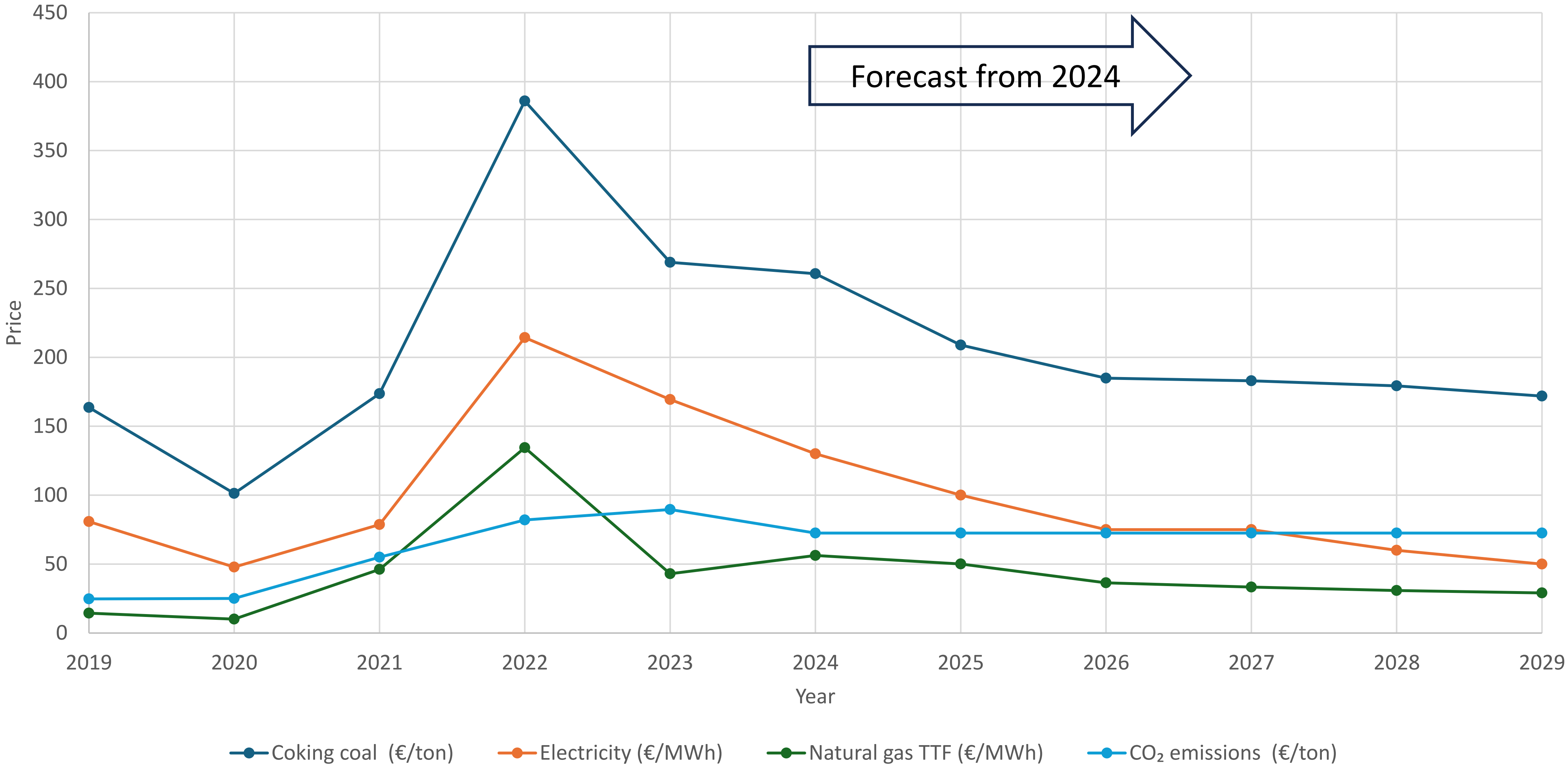
https://www.engineeringtoolbox.com/classification-coal-d_164.html

Energy market EU 2019-2023



https://businessanalytiq.com/procurementanalytics/index/coking-coal-price-index/ https://www.steelonthenet.com/files/blast-furnace-coke.html https://ec.europa.eu/eurostat/statistics-explained/images/2/24/F6Development_of_natural_gas_prices_for_non-household_consumers.png https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_205__custom_11990994/default/table?lang=en https://businessanalytiq.com/procurementanalytics/index/benzene-price-index/

Current and future market conditions



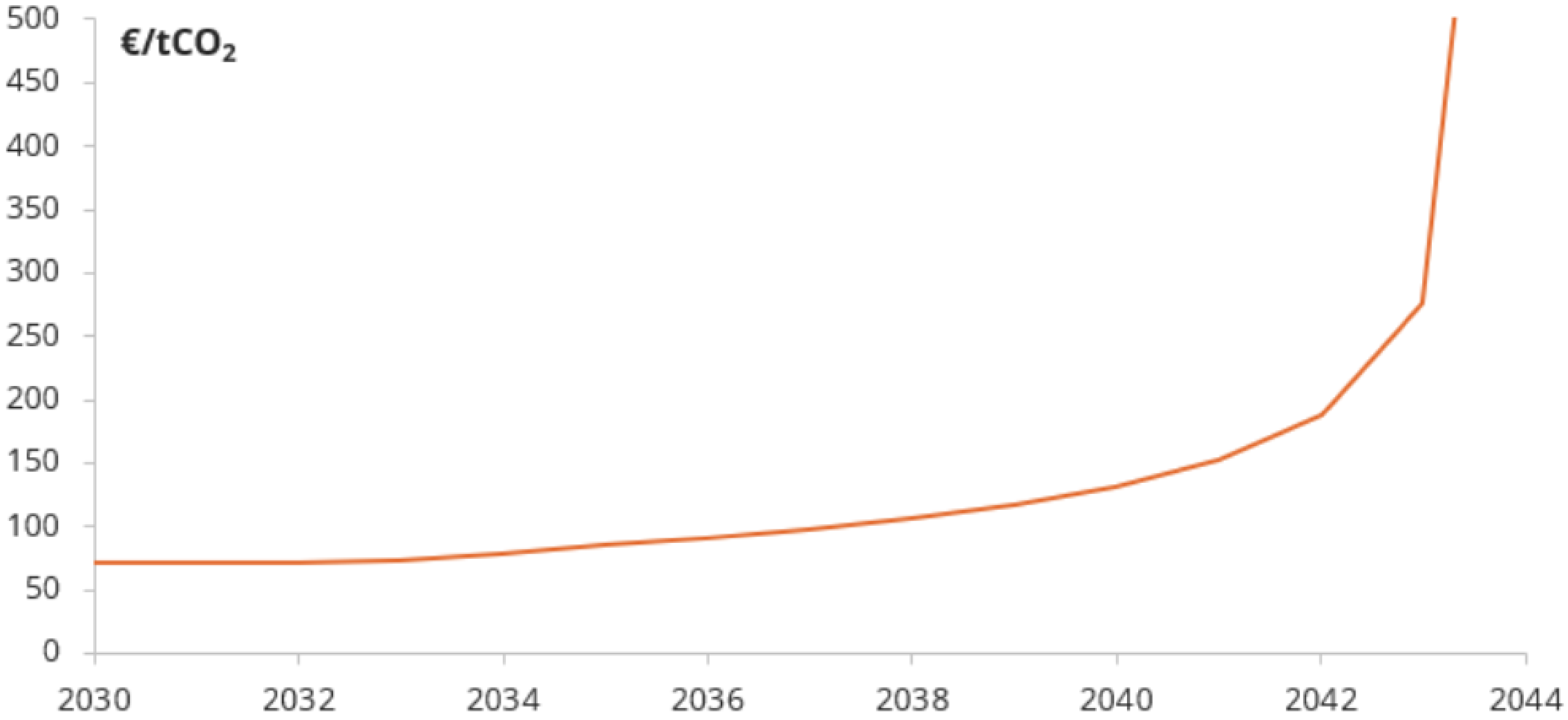
https://www.enerdata.net/publications/executive-briefing/carbon-price-projections-eu-ets.html https://www.spglobal.com/ratings/en/research/articles/230622-europe-s-utilities-face-a-power-price-cliff-from-2026-12767724#:~:text=A%20fall%20of%20that%20magnitude,(see%20Italy%20section%20below) https://www.oxfordenergy.org/wpcms/wp-content/uploads/2023/07/NG-184-A-New-Global-Gas-Order-Part-1.pdf https://enerknol.com/u-s-metallurgical-coal-prices-at-a-price-premium-compared-to-u-s-coal-eia/ https://www.barchart.com/futures/quotes/U7M24/interactive-chart https://www.industry.gov.au/sites/default/files/2024-03/resources-and-energy-quarterly-march-2024.pdf

Cost forecast of international coal transport emissions 2024-2026

Year	2024	2025	2026
Taxable maritime emissions	40%	70%	100%
Cost in Benchmark scenario	€9 802 936	€17 155 139	€24 507 341
Cost in AlterCoal scenario	€9 479 937	€16 589 890	€23 699 843
Difference in cost	-3.3%	-3.3%	-3.3%

https://climate.ec.europa.eu/eu-action/transport/reducing-emissions-shipping-sector_en; https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/ets2-buildings-road-transport-and-additional-sectors_en#monitoring-and-reporting-regulation-guidance-and-templates; https://www.enerdata.net/publications/executive-briefing/carbon-price-forecast-under-eu-ets.pdf https://www.enerdata.net/publications/executive-briefing/carbon-price-projections-eu-ets.html

Cost forecast of ETS allowances from 2030



https://www.enerdata.net/publications/executive-briefing/carbon-price-projections-eu-ets.html

Results direct emissions

Direct emissions (tonCO_2/year)				
Source of emissions	Benchmark Scenario	AlterCoal Scenario	Net difference (ton)	Relative difference
COG combustion for heating	245 691	245 732	41	0.0%
Steam production	44 317	45 270	953	2.2%
Biogenic carbon	0	-33 482	-33 482	-
Total	290 009	257 520	-32 488	-11.2%

Results indirect emissions

Indirect emissions (tonCO_2/year)				
Source of emissions	Benchmark Scenario	AlterCoal Scenario	Net difference (ton)	Relative difference
Coal (mining, transport, and grinding)	1 844 564	1 783 787	-60 777	-3.3%
Electricity from coke-making process	144 292	148 144	3 852	2.67%
AlterCoal (SW transport, production, and transport to steelplant)	0	2 506	2 506	-
Incineration (SW transport, emissions, and electricity generation)	95 745	0	62 263	-
Biogenic carbon	-33 482	0	0	0.0%
Total	2 051 119	1 934 438	-116 682	-5.7%

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Conclusions

- Gross profit of the AlterCoal Scenario was higher than that of the Benchmark Scenario in the three years analysed.
- The forthcoming EU ETS regulations, which will include the maritime transport sector starting in 2024, are expected to significantly impact coke-making costs in the EU, likely encouraging the industry to adopt more sustainable maritime transportation methods, such as biofuels or hybrid cargo ships, to maintain profitability.
- Direct emissions are reduced in 11.2% and indirect emissions are reduced in 5.7% in the AlterCoal Scenario

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