# CBAM TRAINING

CASE STUDY – CEMENT INDUSTRY

EGYPT

December 6, 2023

EUROPEAN BANK FOR RECONSTRUCTION AND DEVELOPMENT (EBRD)

# CBAM CEMENT INDUSTRY

# CHARACTERISTICS OF THE CEMENT INDUSTRY IN EGYPT

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### Total production

Total capacity 83 MT
Current 52 MT

### Types of goods produced

Clinker, OPC, Blended Cement, White Cement

### Number of plants

25 with 44 production lines

### Total production exported to the EU

440,000 t/y
0.76% of total

### Other characteristics

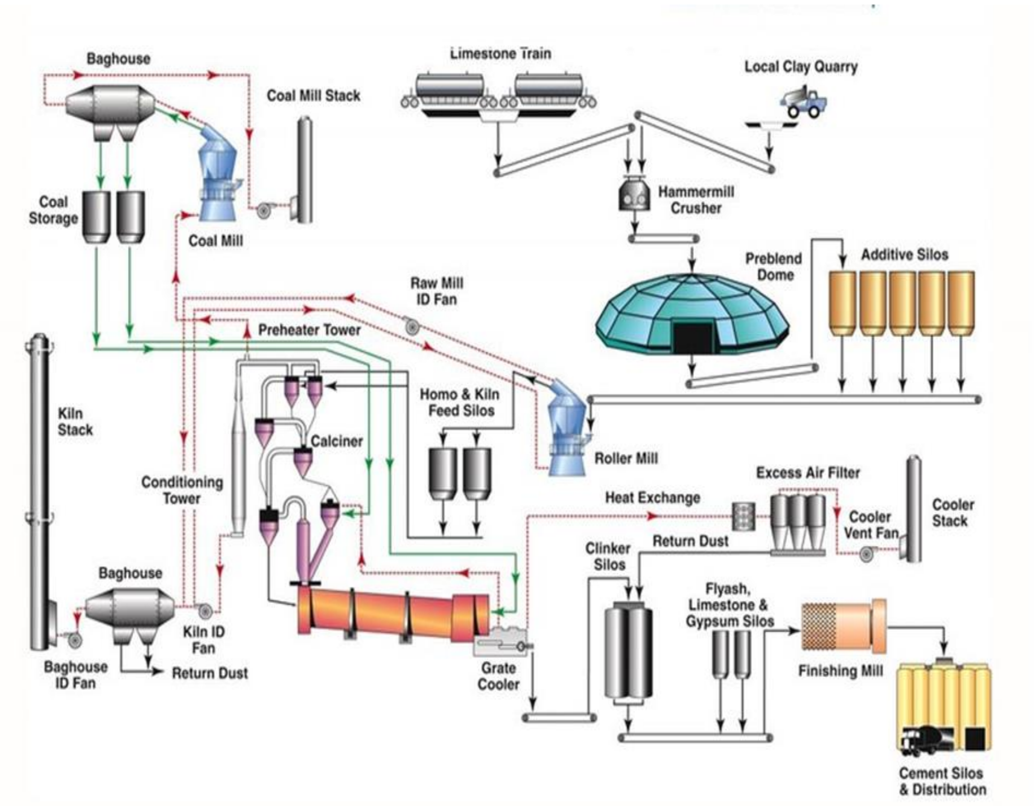
Dry process with 4-5 stages preheater pre-calciner using Coal as fuel
By-pass stack generating dust amounts 2.5% of production
Regulation requiring 10% energy substitution with RDF

### Number of plants that export to the EU

6-7 plants

# PRODUCTION PROCESS IN A TYPICAL CEMENT PLANT IN EGYPT

- All plants use the dry process with 4-5 preheater pre-calciner stages.
- Coal and Petcoke are used as primary fuel, and the Coal mill is Atex certified.
- The main raw materials, limestone and clay are obtained from local quarries. Due to the high chloride content in raw materials, a portion of kiln gases is extracted from the kiln through a by-pass stack. The separated by-pass dust amounts to 2.5 % of produced clinker. It is landfilled in depleted limestone quarries.
- The main product is Ordinary Portland cement with about 90% of clinker. Blended cement are produced for exporting purposes.
- Bag filters have been replacing EPs as Environmental regulations have been tightened. Stacks are equipped with continuous monitoring devices and connected to central Environmental Agency network.
- MOE issued a decree that requires a replacement of 10% thermal energy by RDF.
- Due to oversupply of cement, the GOE put a cap on production proportional to company capacity. This reduces the % of utilization



# RESULTS OF CARBON FOOTPRINT CALCULATIONS **($tCO_2$/t product)**

## SUMMARY OF ESTIMATED EMISSIONS (slides 13-15)

| Product | Scope 1 | Scope 2 | Scope 3 | Embedded Emissions |
|---|---|---|---|---|
| Clinker | 1.09 | 0.017 | 0 | 1.1 |
| Cement | 0 | 0.065 | 0.985 | 1.05 |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# GOODS IN SCOPE OF CBAM – CEMENT SECTOR

**Clinker**
Simple good
Produced from fuels and raw materials considered to have zero embedded emissions under CBAM

**Cement**
Complex good
Produced from other CBAM goods (either simple or complex goods)

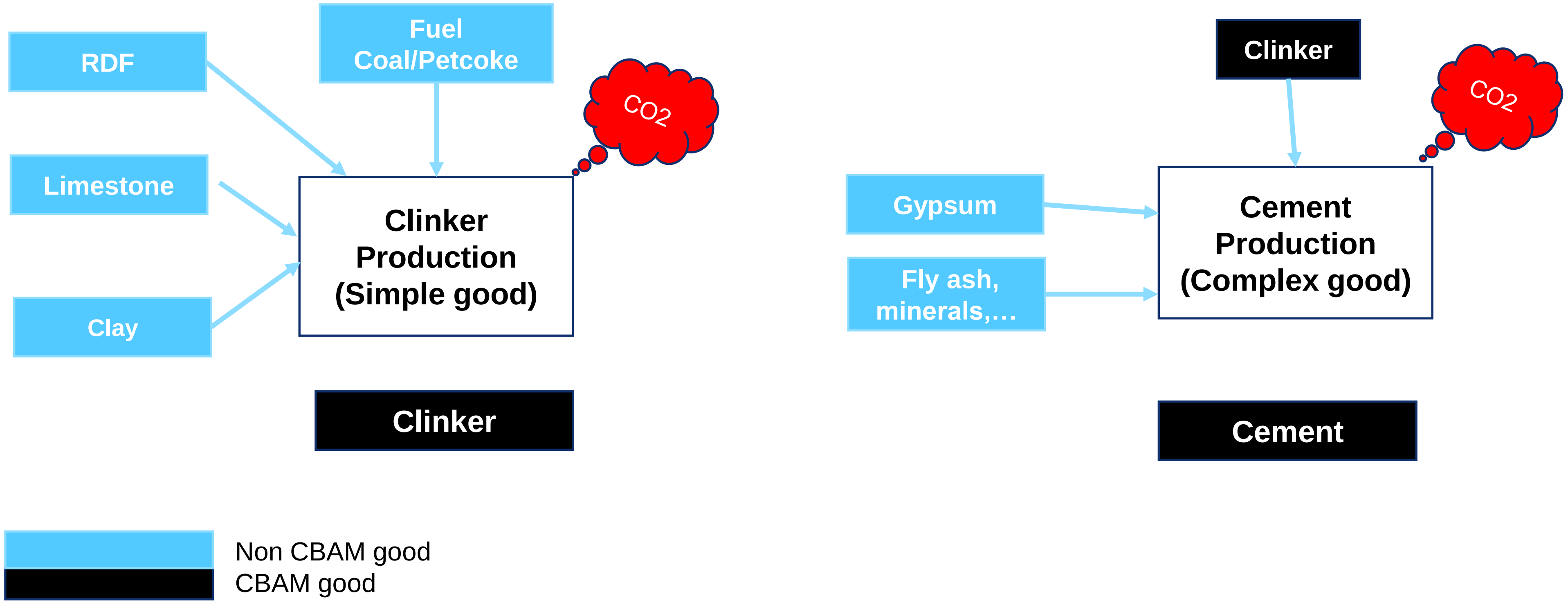
| CN code | Aggregated goods category | Greenhouse gas |
|---|---|---|
| **Cement** | | |
| 2507 00 80 – Other kaolinic clays | **Calcined clay** | Carbon dioxide |
| 2523 10 00 – Cement clinkers | **Cement clinker** | Carbon dioxide |
| 2523 21 00 – White Portland cement, whether or not artificially coloured | **Cement** | Carbon dioxide |
| 2523 29 00 – Other Portland cement | | |
| 2523 90 00 – Other hydraulic cements | | |
| 2523 30 00 – Aluminous cement | **Aluminous cement** | Carbon dioxide |

# GOODS IN SCOPE OF CBAM FOR THE CEMENT SECTOR

# SIMPLE/ COMPLEX GOODS IN CEMENT SECTOR

In the context of the CBAM, all types of cement are defined as complex goods as they are produced from precursors such as clinker, which is a good category in the scope of the CBAM.

Clinker on the other hand, is a simple good. Its embedded emissions do not include any precursors.



# DETERMINATION OF EMBEDDED EMISSIONS IN THE CEMENT SECTOR

# OVERVIEW OF EMBEDDED EMISSIONS IN CEMENT

**Scope 1 Direct emissions** =

Process emissions (CO2 from reaction) + fuel emissions + imported steam + imported waste gases – exported steam – exported electricity – exported CO2

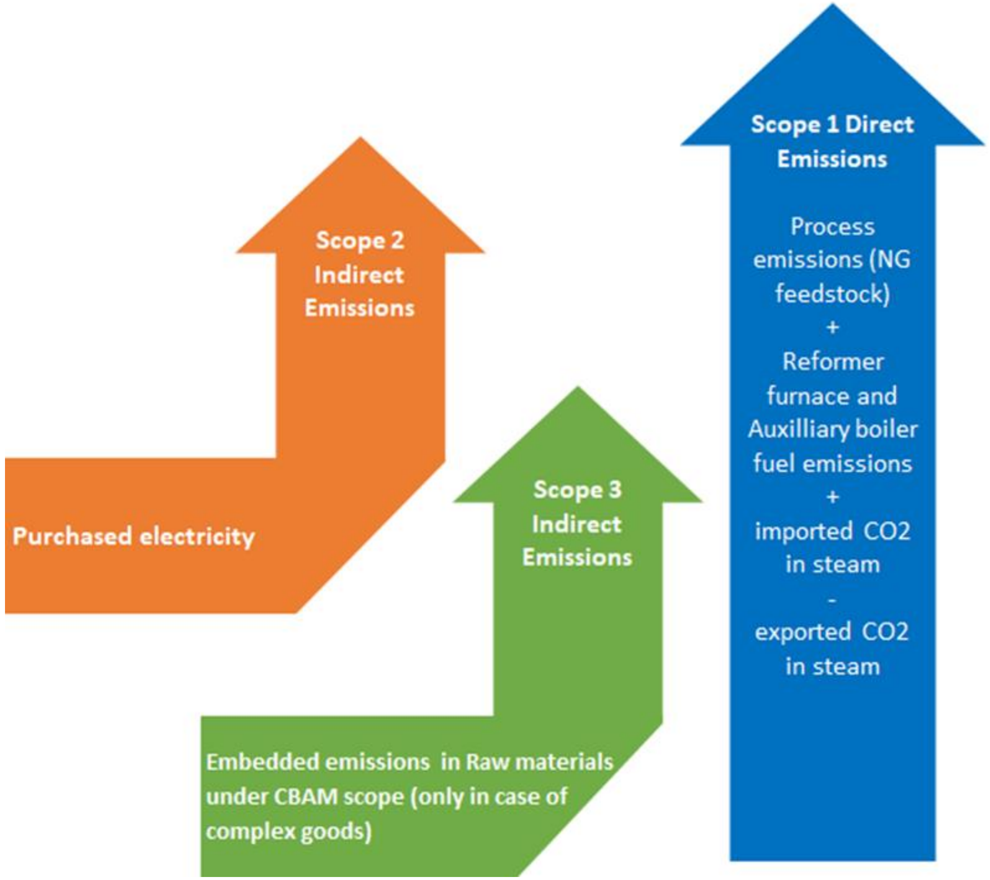
**Scope 2 Indirect emissions** =

Purchased electricity

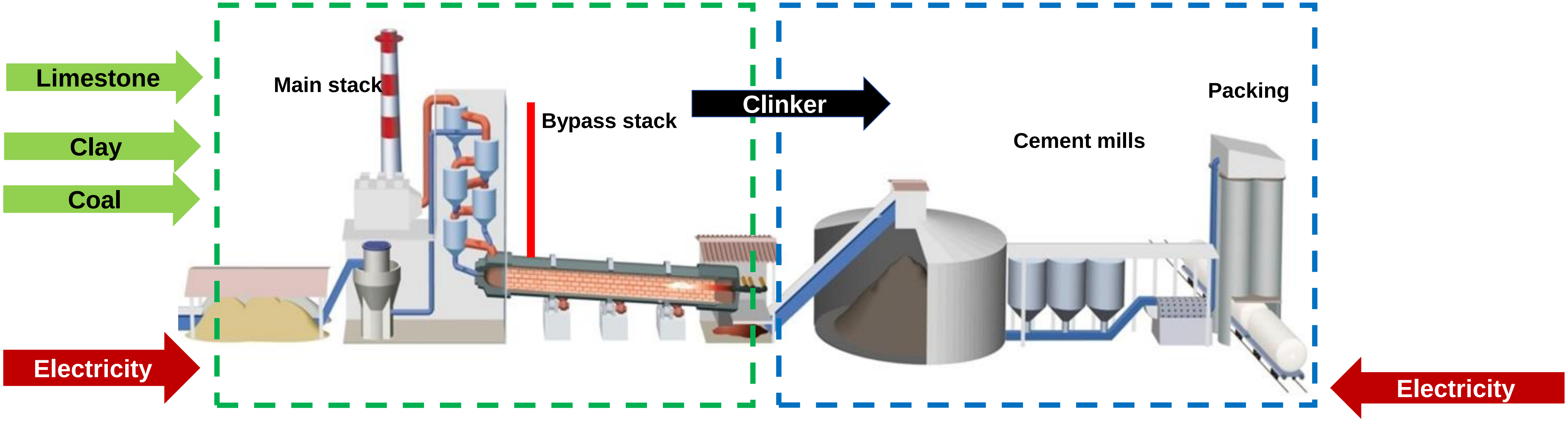
**Scope 3 emissions upstream** =

Embedded CO2 in raw material under CBAM scope (only in case of complex goods)

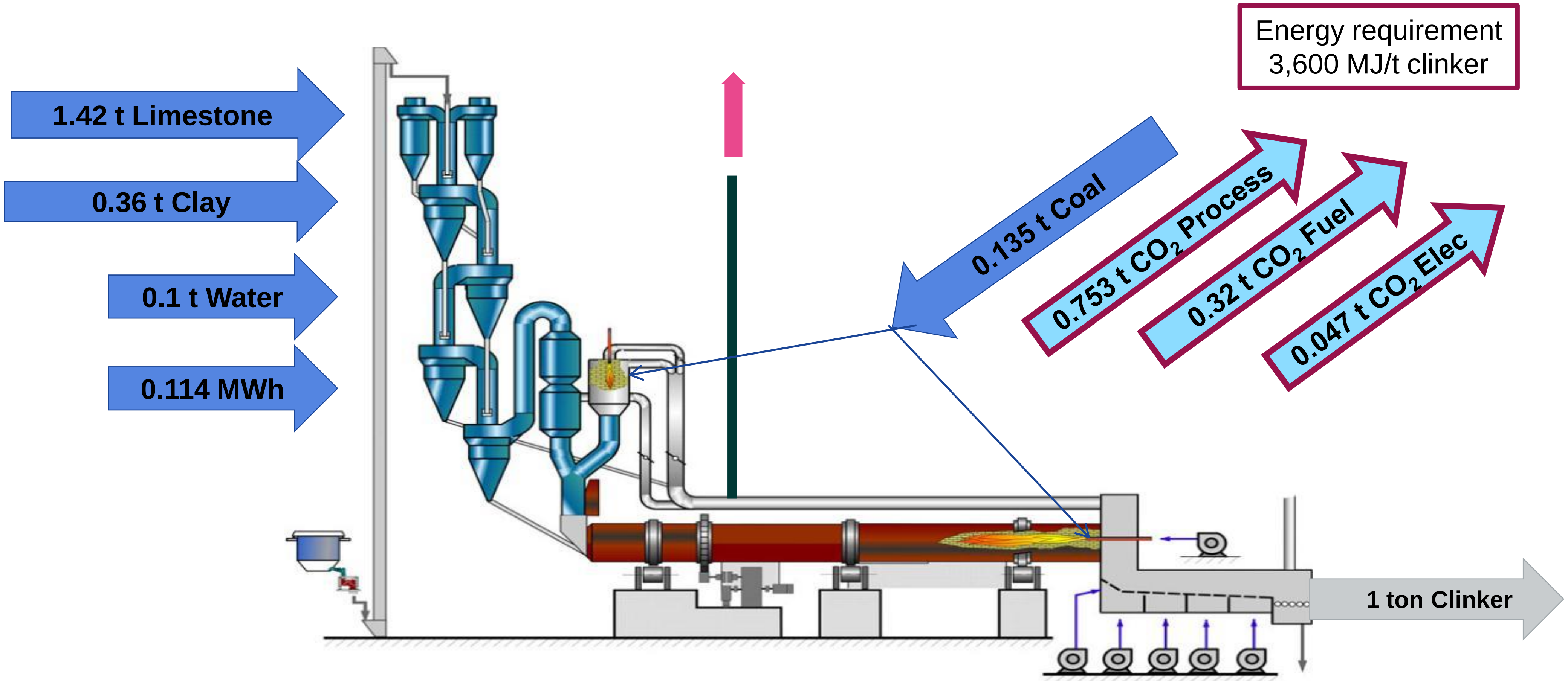
**Total embedded emissions = Scope 1 +2 + 3**



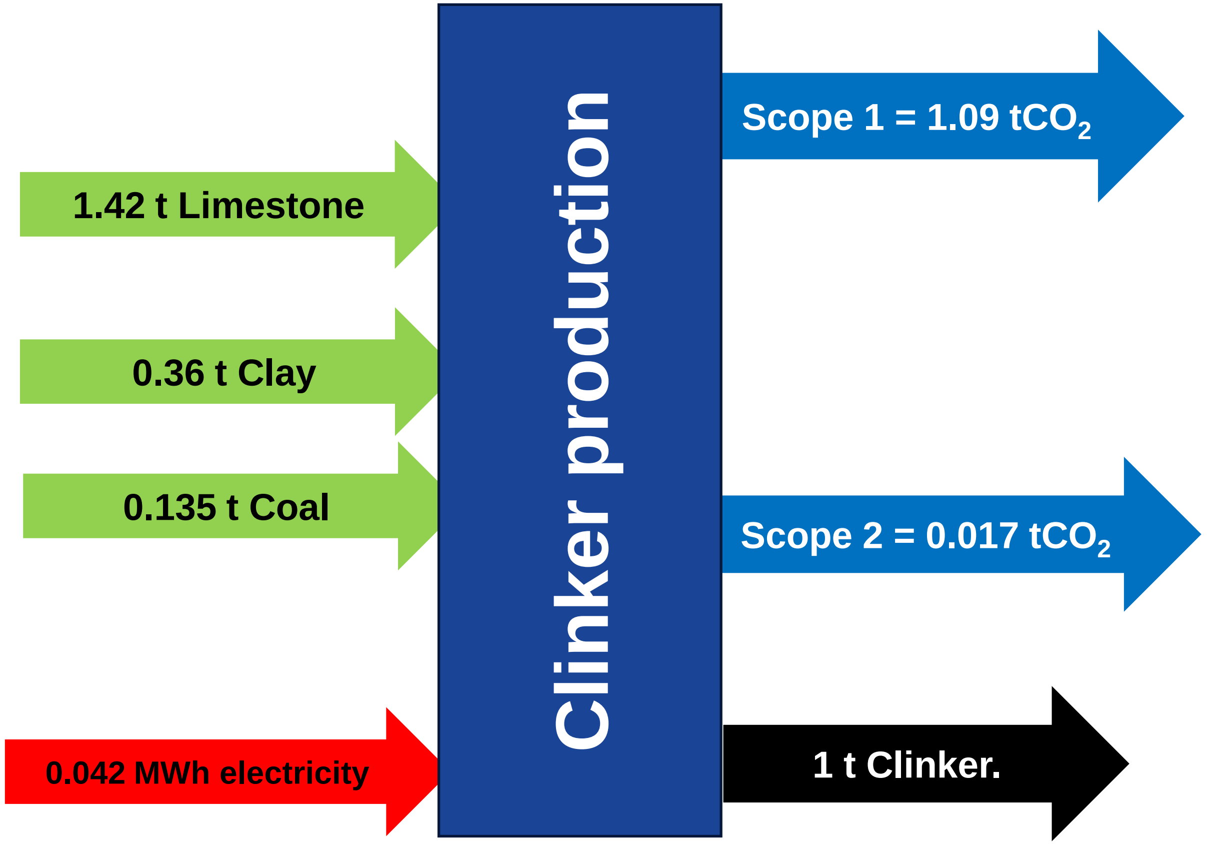
# SETTING THE BOUNDARY FOR ESTIMATING EMBEDDED EMISSIONS IN CLINKER AND CEMENT



# MASS BALANCE ON CLINKER PRODUCTION



# CALCULATING EMBEDDED EMISSIONS IN CLINKER




## Scope 1 emissions:

- **Process** = t limestone * EF of limestone = 1.42 * 0.525 = 0.745 t $CO_2$
- **Fuel (coal) emissions** = t of coal * Coal calorific value * EF for coal

= 0.135 * 0.027 TJ/t * 94.6 tCO2/TJ = 0.345 $tCO_2$

$CO_2$ EF coal = 94.6 $tCO_2$/TJ

Coal Calorific value = 0.027 TJ/t

**Total Scope 1 = 1.09 $tCO_2$**

## Scope 2 emissions:

- Electricity = Consumed electriciy * Grid EF

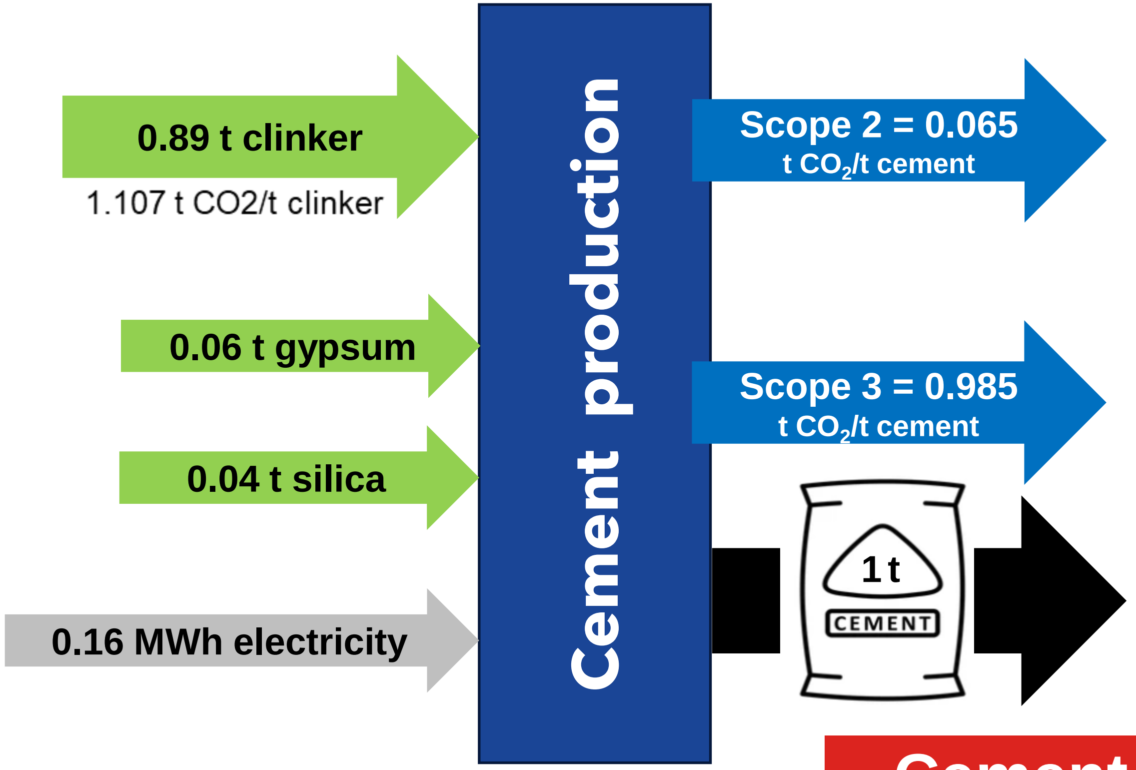
= 0.042 MWh* 0.411 $tCO_2$/MWh = **0.017 t $CO_2$**

EF for Egyptian grid electricity = 0.411 $tCO_2$/MWh

**Embedded emissions = 1.09 tCO2 + 0.017 tCO2**

**Clinker embedded emissions = 1.107 tCO2 / t Clinker**

# CALCULATING EMBEDDED EMISSIONS IN PORTLAND CEMENT




**Scope 1:** No process CO2, No fuel = 0

**Scope 2:**

Electricity = Electricity consumption * EF = 0.16 MWh * 0.411 t$CO_2$/MWh = **0.065 t $CO_2$**

EF for Egyptian grid electricity = 0.411 t$CO_2$/MWh

**Scope 3 =** 1.107 t $CO_2$/t clinker * 0.89 t clinker

= **0.985 t $CO_2$/t cement**

**Embedded CO2** = 0.065 + 0.985 (t$CO_2$/t cement)

**Cement embedded emissions = 1.05 CO2/t Cement**



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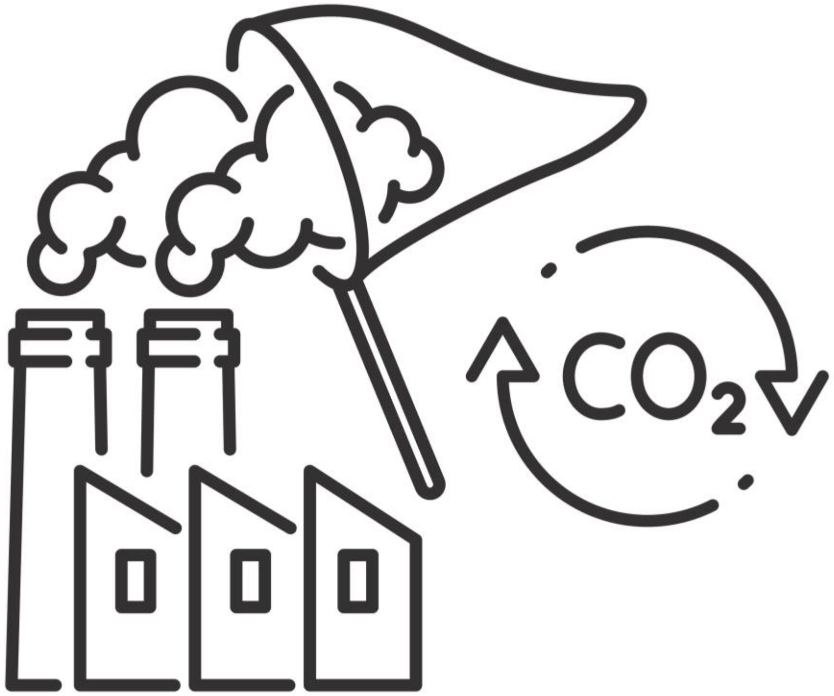
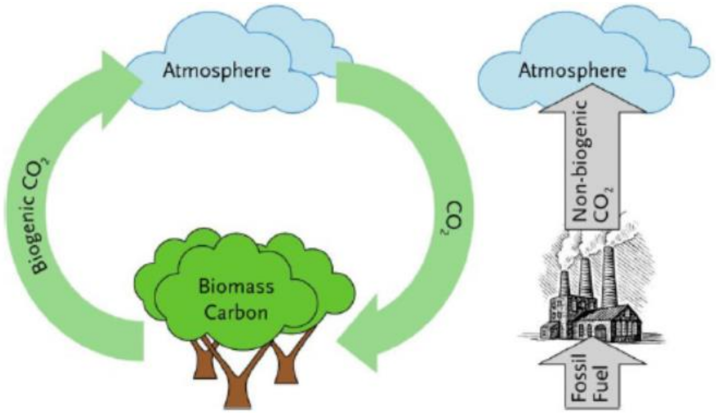



# DECARBONISATION OPTIONS AND THEIR IMPACT

# CO-PROCESSING OF ALTERNATIVE FUELS




| MSW component | Total C content in % of dry weight | | Fossil C fraction in % of total carbon | |
|---|---|---|---|---|
| | Default | Range | Default | Range |
| Paper/cardboard | 46 | 42-50 | 1 | 0-5 |
| Textile | 50 | 25-50 | 20 | 0-50 |
| Food waste | 38 | 20-50 | - | 0 |
| Wood | 50 | 46-54 | - | 0 |
| Garden/park waste | 49 | 45-55 | 0 | 0 |
| Nappies | 70 | 54-90 | 10 | 10 |
| Rubber and leather | 67 | 67 | 20 | 20 |
| Plastics | 75 | 67-85 | 100 | 95-100 |

## Replace coal with Alternative Fuel

Energy requirement 857 kcal/kg = 3,600 kJ/kg clinker

Main barrier is availability of biomass. To reach 40% substitution 0.094 t biomass/ t clinker are required. Assuming an overall clinker production of 45 million ton, an amount of 4.23 million tons of biomass would be required per year.

CO2 emissions are calculated from fossil carbon content, for biomass it is zero.

| % substitution | Energy from coal kJ/kg clinker | Fuel emissions tCO2/t cl |
|---|---|---|
| 10% | 3,240 | 0.306 |
| 40% | 2,160 | 0.204 |

# Estimation of CO2 reduction by co-processing of biomass

Embedded emissions before substitution = **1.107 tCO2/t clinker**

Replacing coal with Alternative Fuel will impact fuel emissions as follows:

- Process emissions (from limestone **0.745** tCO2/t Clinker) remains the same.
- Fuel emissions (**0.345** tCO2/t clinker) will decrease by an amount proportional to the % substitution).
- Scope 2 emissions (from electricity **0.017** tCO2/t Clinker) remains the same.

For 10% substitution Embedded emissions in clinker = 0.745 + 0.345 * 0.9 + 0.017 = **1.07 tCO2/t clinker**

For 40% substitution Embedded emissions = 0.745 + 0.345 * 0.6 + 0.017 = **0.97 tCO2/t clinker**

**Embedded Emissions = 1.07 t $CO_2$/t clinker with a reduction of 12.4%**

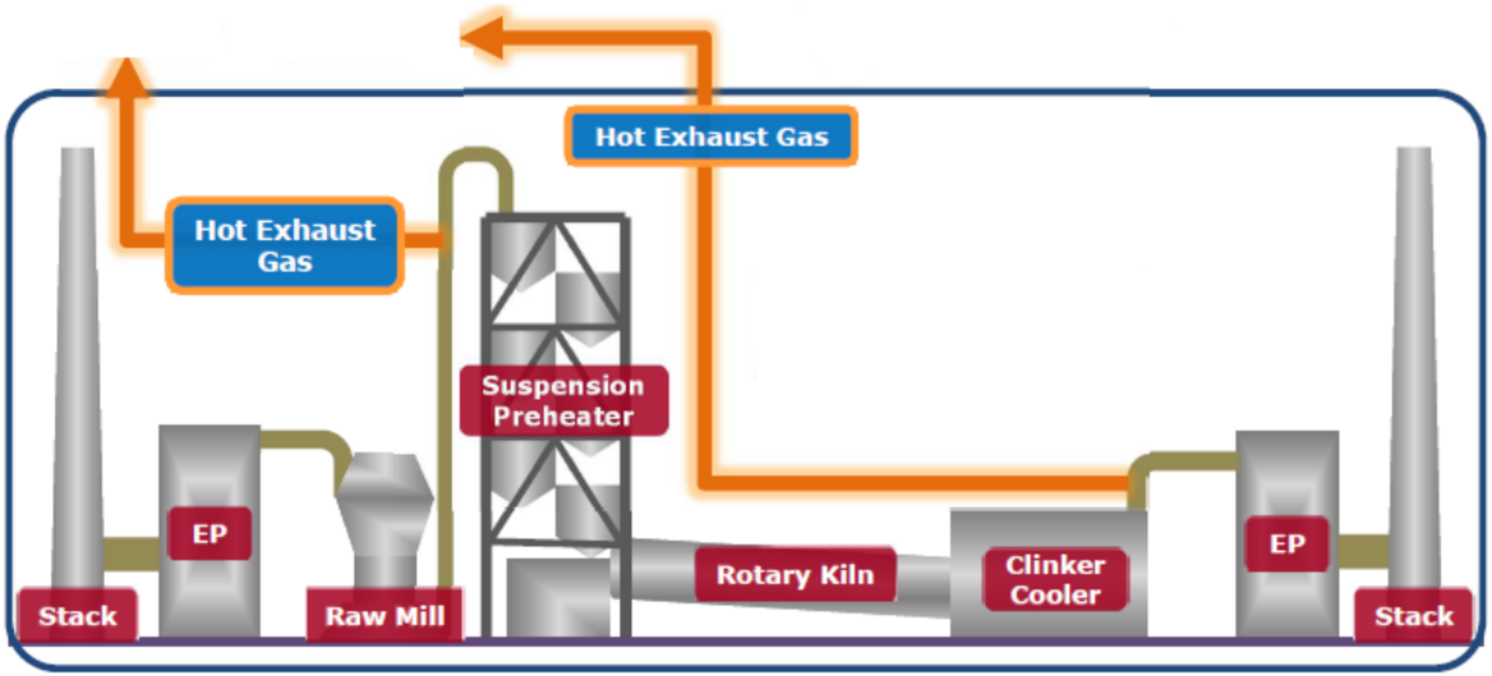
**Free allowance = 0.693 t CO2/t clinker**

# IMPLEMENTING ENERGY EFFICIENCY PROJECTS

- **Minimizing False air:** False air increases energy consumption due to higher air volume, which also results in higher power consumption and electricity consumption for fan operation. The BAT (Best Available Technology) benchmark value for the volumetric flowrate of air is 2300 $m^3$/t clinker.
- **Reduction of by-pass:** By-pass increases as chlorides content in raw material increases.
- **Equipment maintenance and optimization**
- **Use of oxygen enriched air :** It will result in higher combustion efficiency leading to reduced amount of coal/t clinker.
- **Increase % capacity utilization**

**CO2 reduction from energy efficiency < 5%**

# INSTALLATION OF COMBINED HEAT AND POWER (CHP) PLANTS




JFE Engineering corporation, 2018

**Combined Heat and Power (CHP) generation**

- The maximum power generated from waste heat represents 9% of the power requirement.
- Grid power reduction
  = Power required * 0.09 = 0.042 * 0.09
  = 0.00378 kWh/t clinker
- Resulting decrease in CO2 emissions =
  0.00378 kWh/t * 0.411 kg CO2/kWh (Grid EF)
  = 0.0015 tCO2/t clinker
- Embedded Emissions will be reduced by this negligible amount to become 1.107- 0.0015 = 1.106
- For a production line of 13,500 t clinker/d, the annual reduction will only be 4,455 tCO2.
- The main benefit is financial.

**Embedded emissions = 1.106**

# USE OF GREEN HYDROGEN AS FUEL

Green Hydrogen using solar PV leads to a GHG footprint of 1.7– 4.4 tCO2/ tH2 ≈ 3 tCO2/t H2

Calorific value of Hydrogen = 120 - 142 MJ/kg

Hydrogen requirement to produce 1 t clinker = 3,465 MJ/ t clinker / 130,000 MJ/t H2 = 0.026 t H2/t clinker

Fuel emissions = 0.026 t H2/ t clinker * 3 tCO2/t H2 = 0.08 t $CO_2$/t clinker

Clinker Embedded Emissions become

**Scope 1 = 0.745 (process emissions) + 0.08 (emissions from fuel Hydrogen)**

**= 0.833 t CO2/t clinker**

**Scope 2 = 0.017 t CO2/t clinker**

**Embedded Emissions = 0.85 t $CO_2$/t clinker with a reduction of 20.8%**

**Free allowance = 0.693 t CO2/tclinker**

# ALTERNATIVE RAW MATERIALS TO REDUCE PROCESS EMISSIONS

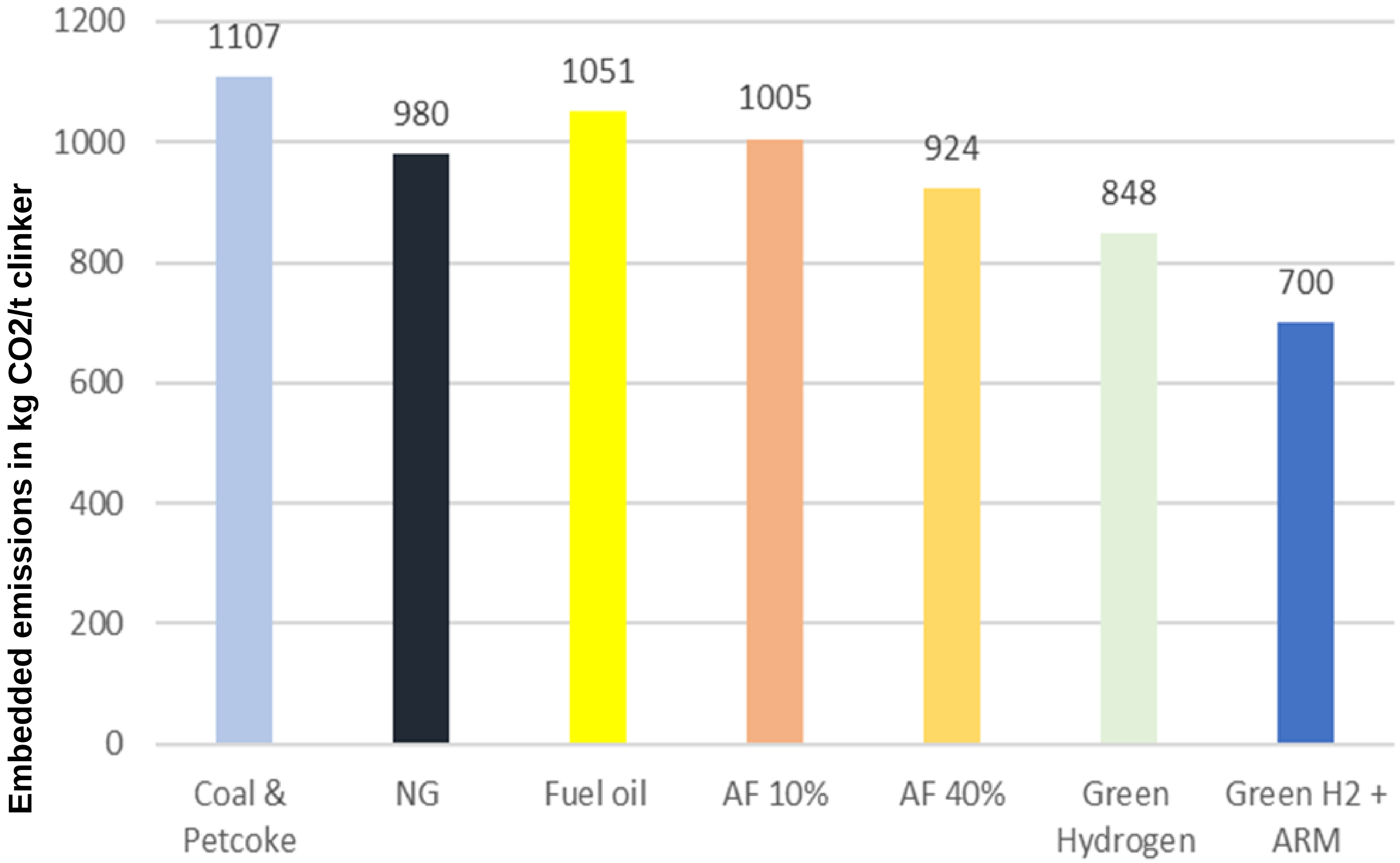
- The largest source of CO2 comes from RM calcination. The use of alternative decarbonated materials will significantly reduce CO2 emissions. Waste materials and by-products from other industries can be used.
  - recycled cement paste from demolition waste
  - air-cooled slag
  - waste lime
- CEMBUREAU expects up to a 3.5% reduction of process CO2 using decarbonated materials by 2030 and up to 8% reduction by 2050.
- Using green hydrogen as fuel and alternative RM resulting in 3.5% reduction of CO2 emissions PCF = 0.745 * 0.965 + 0.017 = 0.735 t CO2/ t Clinker

**Embedded Emissions = 0.735 t CO2/t clinker with a reduction of 33.6%**

↓

**Free allowance = 0.693 tCO2/t clinker**

# IMPACT OF DECARBONIZATION OPTIONS ON CLINKER EMBEDDED EMISSIONS



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# FREE ALLOWANCE PHASE OUT

# FREE ALLOWANCE PHASE OUT FOR CEMENT SECTOR

Impact of phase out on deviation from free allowance for the various decarbonization projects, **$tCO_2$/t clinker**

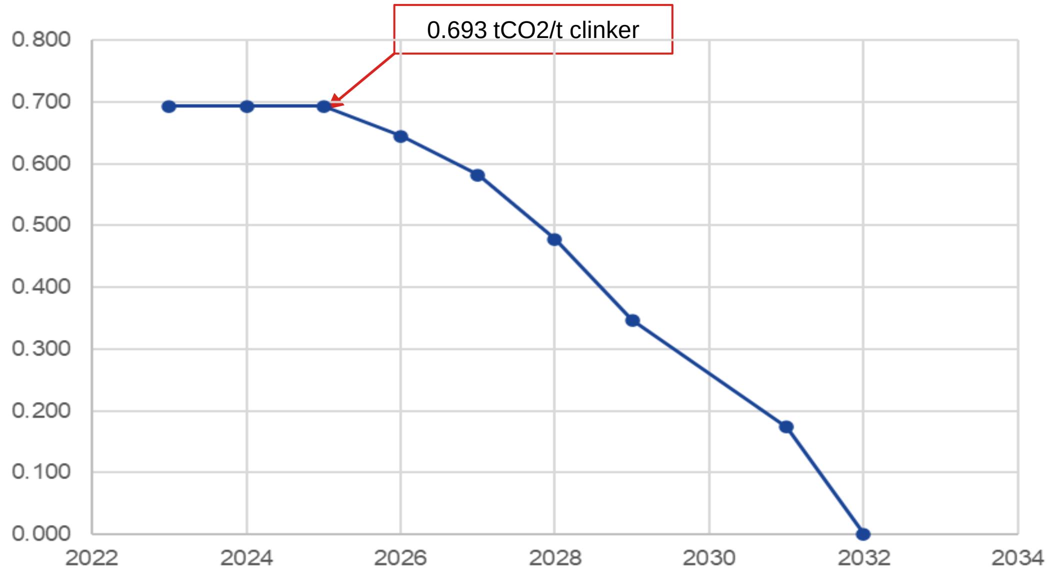
***Case 1:*** *40% substitution of thermal energy by RDF energy*

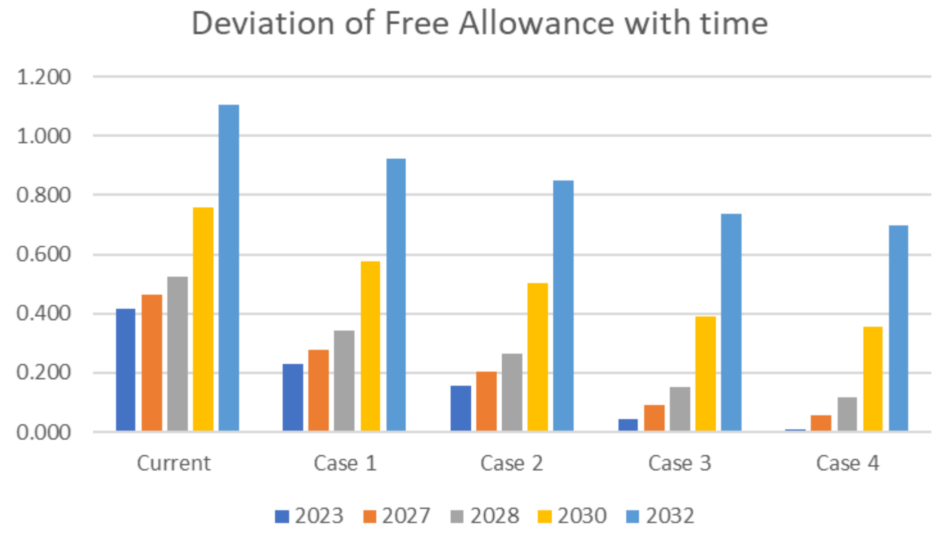
***Case 2:*** *Use of green hydrogen as fuel*

***Case 3:*** *Use of Alternative Raw Material 3.5% reduction in process emissions*

***Case 4:*** *Green H2 + ARM*

| Impact of decarbonization on deviation from free allowance | | | | | |
|---|---|---|---|---|---|
| | Current | Case 1 | Case 2 | Case 3 | Case 4 |
| **2023** | 0.414 | 0.231 | 0.155 | 0.042 | 0.007 |
| **2027** | 0.463 | 0.280 | 0.204 | 0.091 | 0.056 |
| **2028** | 0.525 | 0.342 | 0.266 | 0.153 | 0.118 |
| **2030** | 0.761 | 0.578 | 0.502 | 0.389 | 0.354 |
| **2032** | 1.107 | 0.924 | 0.848 | 0.735 | 0.700 |



# IMPACT OF CBAM AND CONCLUDING REMARKS

# IMPACTS OF CBAM - CEMENT SECTOR

Only precursors have ETS free allowances. CBAM cost on a complex good such as cement will depend on the amount of precursor clinker in the complex good. In the case of cement, each type of cement has a different range of clinker ratio.

Because of the free allowance phase out, deviation from free allowance will increase with phase out and decrease with implementation of decarbonization project (Table 1).

CBAM cost in €/ t Cement = deviation * Clinker ratio * (80 €/t CO2).

CBAM cost per ton of different types of cement before and after implementing proposed projects is given in Table 2.

The table shows that exporting Low clinker ratio cement will increase competitiveness of Egyptian cement companies in the European market.

**Table 1 Deviations of embedded Emissions from free allowance**

| | Deviation 2023 | | Deviation 2032 | |
|---|---|---|---|---|
| | None | H2 + ARM | None | H2 + ARM |
| Clinker Embedded Emissions | 0.414 | 0.007 | 1.107 | 0.7 |

**Table 2**

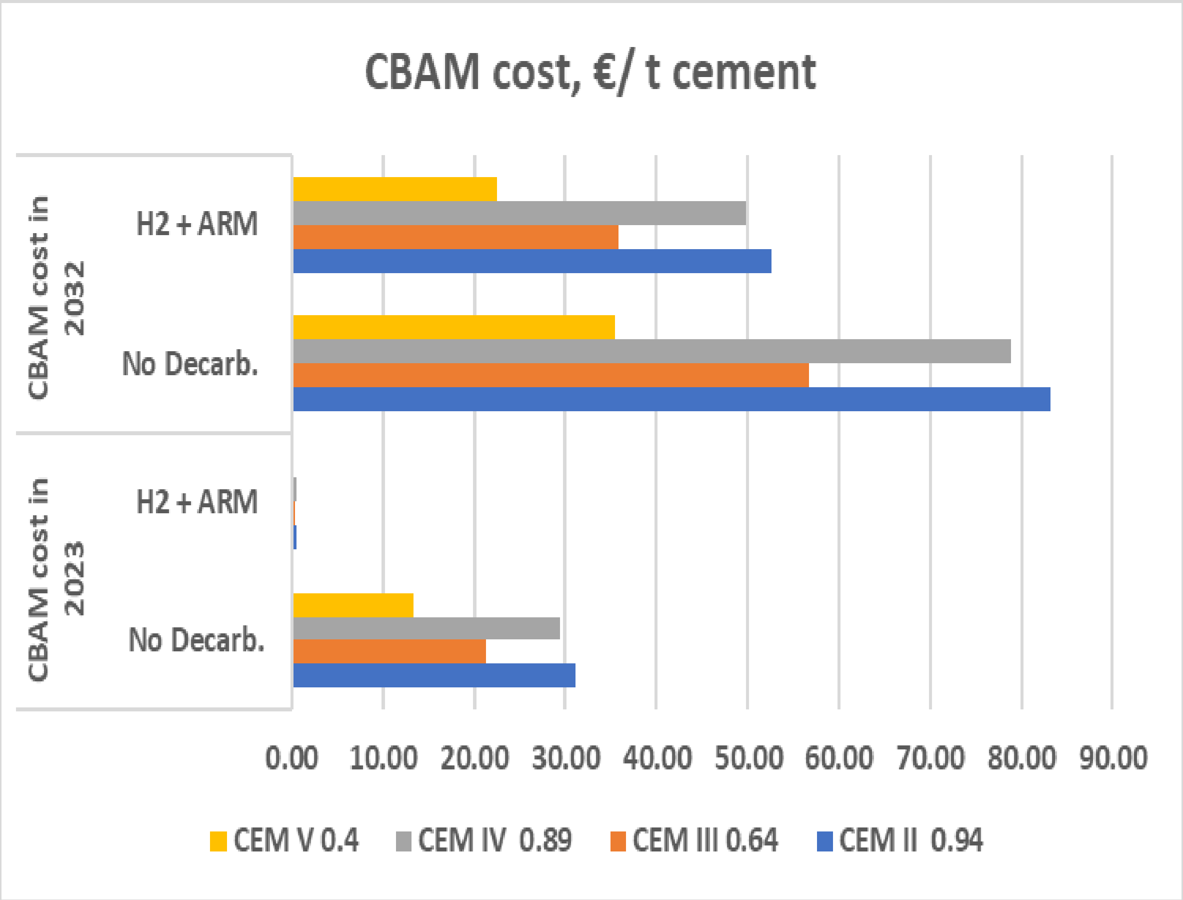
| | CBAM cost in 2023 | | CBAM cost in 2032 | |
|---|---|---|---|---|
| Cement type | No Decarb. | H2 + ARM | No Decarb. | H2 + ARM |
| CEM II | 31.13 | 0.53 | 83.25 | 52.64 |
| CEM III | 21.20 | 0.36 | 56.68 | 35.84 |
| CEM IV | 29.48 | 0.50 | 78.82 | 49.84 |
| CEM V | 13.25 | 0.22 | 35.42 | 22.40 |

# Concluding remarks

Process emissions are hard to abate as long as limestone substitutes have not been found. If Net Zero is to be targeted by International Cement Companies Carbon Capture Use and Storage will have to be considered.

Companies will have to weigh their options based on a financial feasibility that would take into consideration factors such as:

- Investment and operating costs of implemented decarbonization project
- Potential tapping into non-CBAM markets
- Current and future CBAM cost
- Change in ETS cost of CO2



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# THANK YOU!

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