SUSTAINABLE RECYCLING INDUSTRIES

Evaluation of the Buipe Cement Kiln of Savanna Diamond Ltd. (Ghana) for co-processing of TDF and WEEE-plastics

Venue: World Resources Forum 2023

By: Letitia Nyaaba, Selina Amoah, Dr. Sampson Atiemo, Ed Verhamme, Tobias Schleicher

Time: 5th September 2023, 11am (GMT+2)

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Agenda

1 Introduction

2 Outcomes of the technical full-assessment

3 Economics of co-processing

4 Policy roadmap and next steps

Co-processing of waste tires in Ghana

- A joint activity by Savannah Diamond Ltd., Environmental Protection Agency (EPA) Ghana, Alternate Resource Partners under the Sustainable Recycling Industries Project in Ghana

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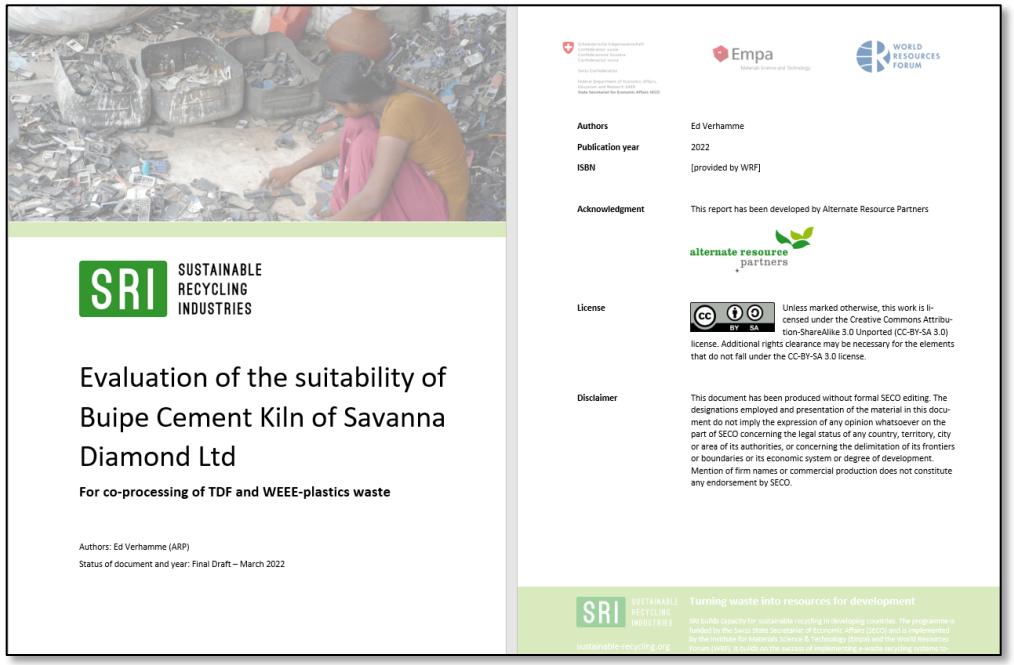
Full Assessment of Co-Processing of Waste Tyres in 2022

- After a **successful pre-assessment in 2021**, a **full assessment of the cement kiln** of Savannah Diamond Ltd. was carried out with EPA and experts from Alternative Resource Partners (ARP, joining online)
- We conducted an **online workshop with Ghana EPA in December 2021**
- The Savanna Diamond Buipe cement plant is a modern kiln with good heat consumption per ton clinker located in a rural area with a **properly organized plant** and management team with a very good team spirit.
- We had a follow-up policy workshop on Emission Monitoring Standards (EMS) in **September 2022**
- Study was finalized in **2022.**
- **Ongoing support of Savannah Diamond Ltd. On co-processing (economic scenarios, continuous monitoring system, trial burn)**

Full Assessment of Co-Processing (2)

- Waste materials considered: **Tyre Derived Fuels** (=TDF, shredded tires, size 50x50 mm) and WEEE-plastics waste.
- The installed main burner (designed for coal combustion) cannot burn the amount of alternative fuel in question.
- **A feeding system needs to be designed, engineered, and installed**, this could require an additional investment.
- Also, for co-processing a **Continuous Emission Monitoring System (CEMS)** needs to be installed.
- A **performance test** is recommended to confirm the non or negligible impact of co-processing of TDF and WEEE-plastics waste on the kiln process, emissions and clinker quality.
- Once a **performance test** has been successfully executed, other similar (hazardous) waste could be co-processed in the same feeding system as well.

Full Assessment Report of the Co-Processing of the Savannah Diamond Ltd. cement kiln in close cooperation with Ed Verhamme of Alternate Resource Partners (ARP)



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Evaluation of the suitability of Buipe Cement Kiln of Savanna Diamond Ltd

For co-processing of TDF and WEEE-plastics waste

Authors: Ed Verhamme (ARP)

Status of document and year: Final Draft – March 2022

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Authors	Ed Verhamme
Publication year	2022
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Acknowledgment	This report has been developed by Alternate Resource Partners

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Conclusion: If some the company realises necessary investments, co-processing of waste tyres is possible at Savannah Diamond Ltd.

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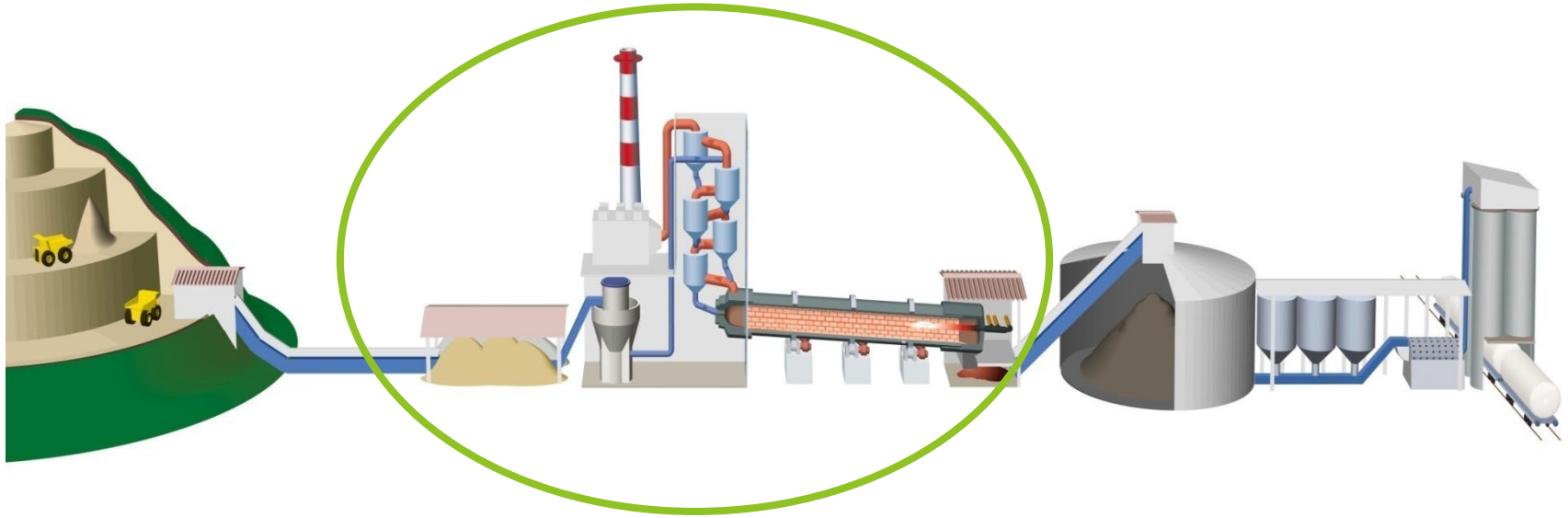
CEMENT MANUFACTURING – 3 MAIN PHASES



1) Preparation of raw materials into raw meal (Extraction – Crushing – Pre-homogenisation - Dosing – Grinding – Homogenisation)

2) Clinker production – pyro-processing of raw materials (calcination of the raw meal into the rotary kiln – energy supplied by burning fuels)

3) Cement production - grinding of clinker and mineral components to obtain cement

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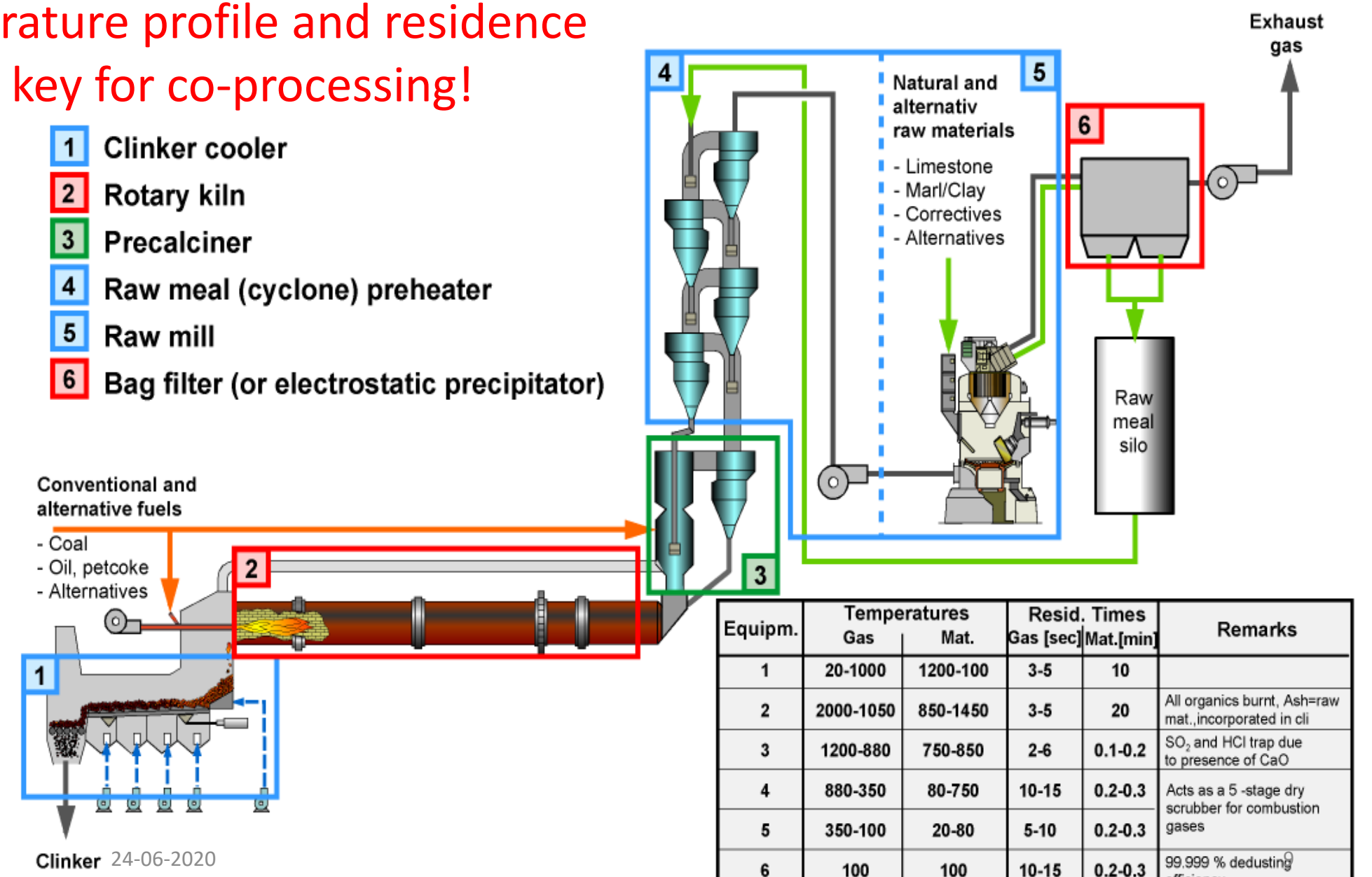
The (Cement) Clinker Process and its Special Characteristics (Example: Precalciner Kiln)

Temperature profile and residence time is key for co-processing!

1. Clinker cooler
2. Rotary kiln
3. Precalciner
4. Raw meal (cyclone) preheater
5. Raw mill
6. Bag filter (or electrostatic precipitator)



Equipm.	Temperatures Gas	Mat.	Resid. Times Gas [sec]	Mat.[min]	Remarks
1	20-1000	1200-100	3-5	10	
2	2000-1050	850-1450	3-5	20	All organics burnt, Ash=raw mat.,incorporated in cli
3	1200-880	750-850	2-6	0.1-0.2	SO_2 and HCl trap due to presence of CaO
4	880-350	80-750	10-15	0.2-0.3	Acts as a 5 -stage dry scrubber for combustion gases
5	350-100	20-80	5-10	0.2-0.3	
6	100	100	10-15	0.2-0.3	99.999 % dedusting efficiency

Dp-062.dsf / Kma 17.12.04

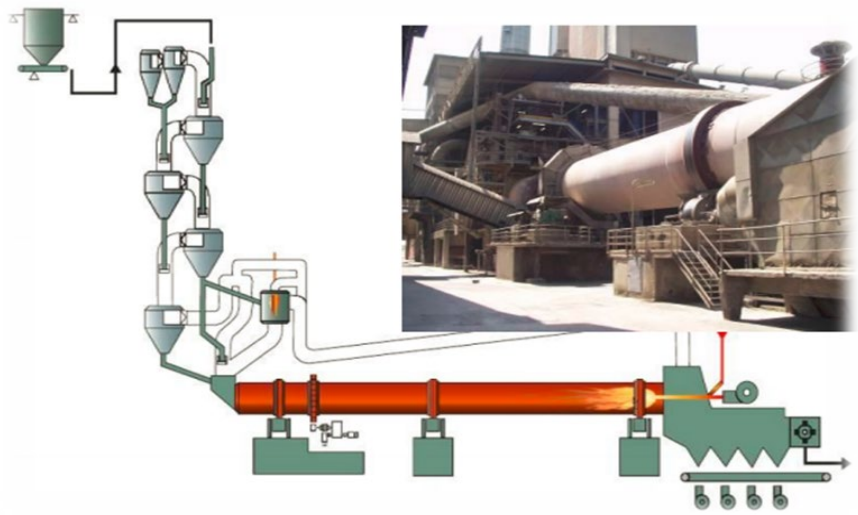
Co-processing – what is it ?

Co-Processing is…

…the use of waste materials in resources intensive industrial processes such as cement, lime, steel, glass, power generation, etc.

..instead of fossil fuels & natural resources

Co-processing is a main alternative to improve the environment and improve the industry ecological footprint



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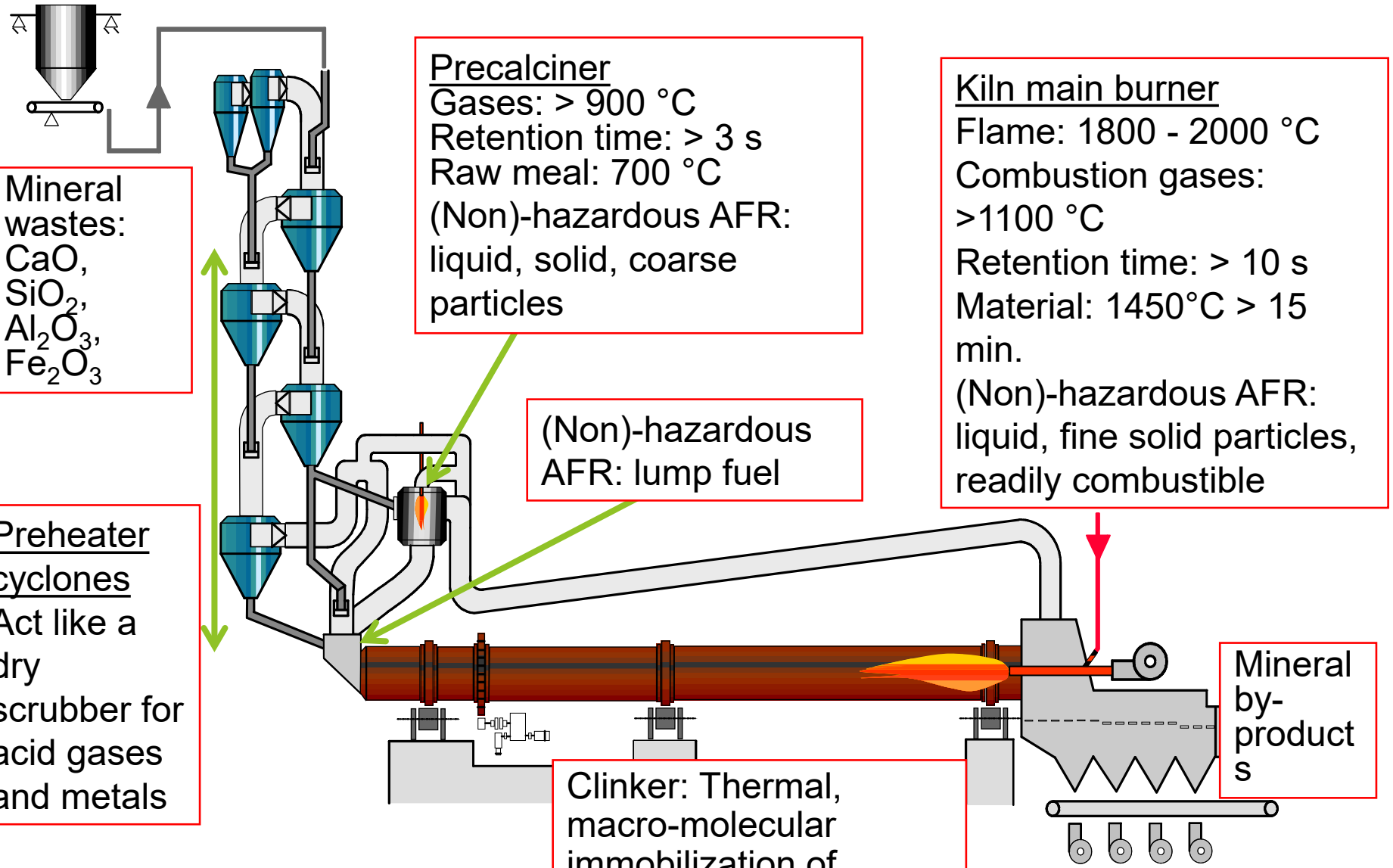
Technical characteristics cement kiln



Mineral wastes: CaO, SiO_2, Al_2O_3, Fe_2O_3

Precalciner
Gases: > 900 °C
Retention time: > 3 s
Raw meal: 700 °C
(Non)-hazardous AFR: liquid, solid, coarse particles

(Non)-hazardous AFR: lump fuel

Kiln main burner
Flame: 1800 - 2000 °C
Combustion gases: >1100 °C
Retention time: > 10 s
Material: 1450°C > 15 min.
(Non)-hazardous AFR: liquid, fine solid particles, readily combustible

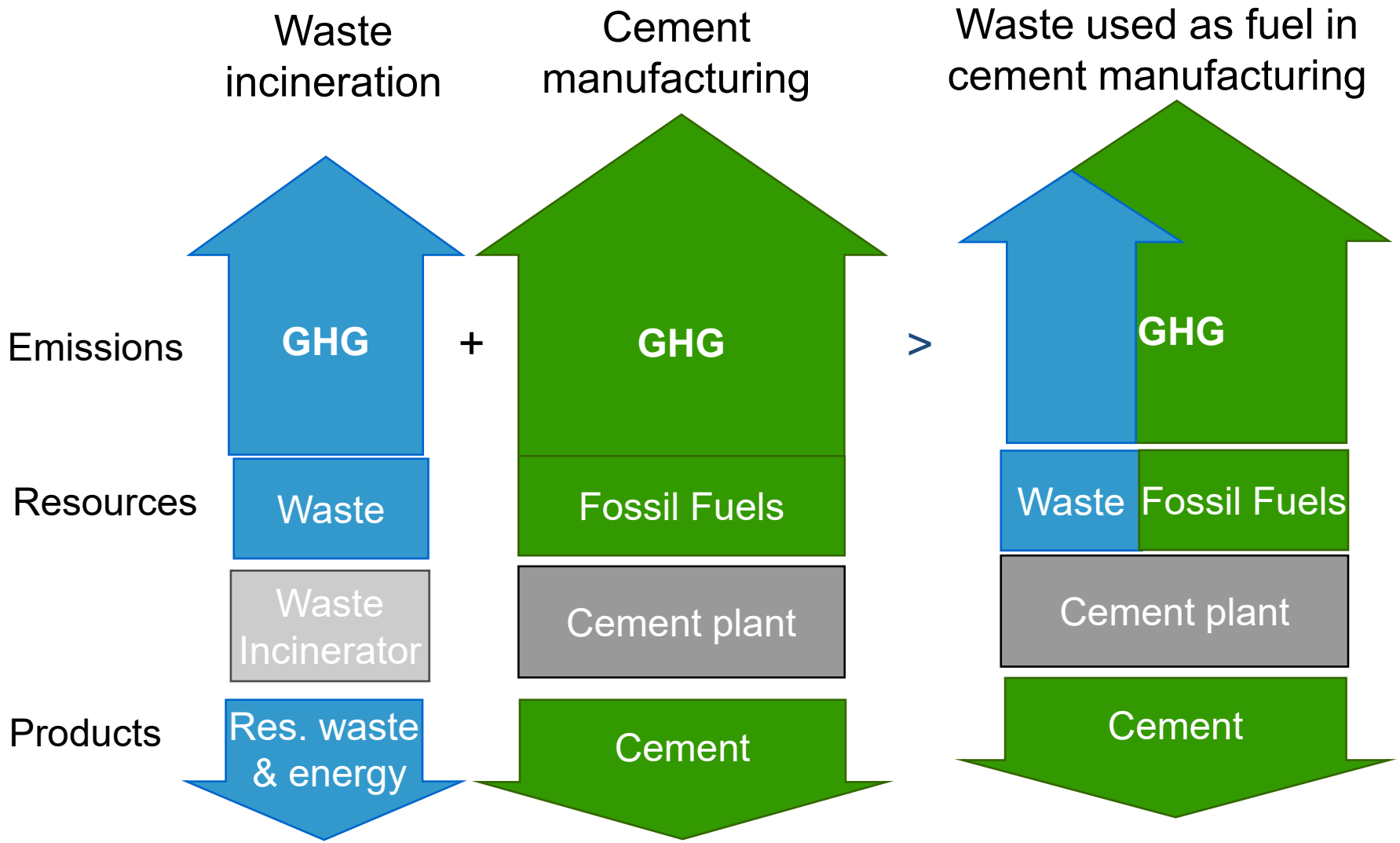
Preheater cyclones
Act like a dry scrubber for acid gases and metals

Clinker: Thermal, macro-molecular immobilization of metals

Mineral by-products

Roles of different parts of the killn in the cement manufacturing process and feeding of alternative fules and raw materials (AFR).

Overall, Green House Gas (GHG) emissions are reduced when replacing fossil fuels by wastes



Co-processing saves CO2 as compared to seperately incinerating waste!

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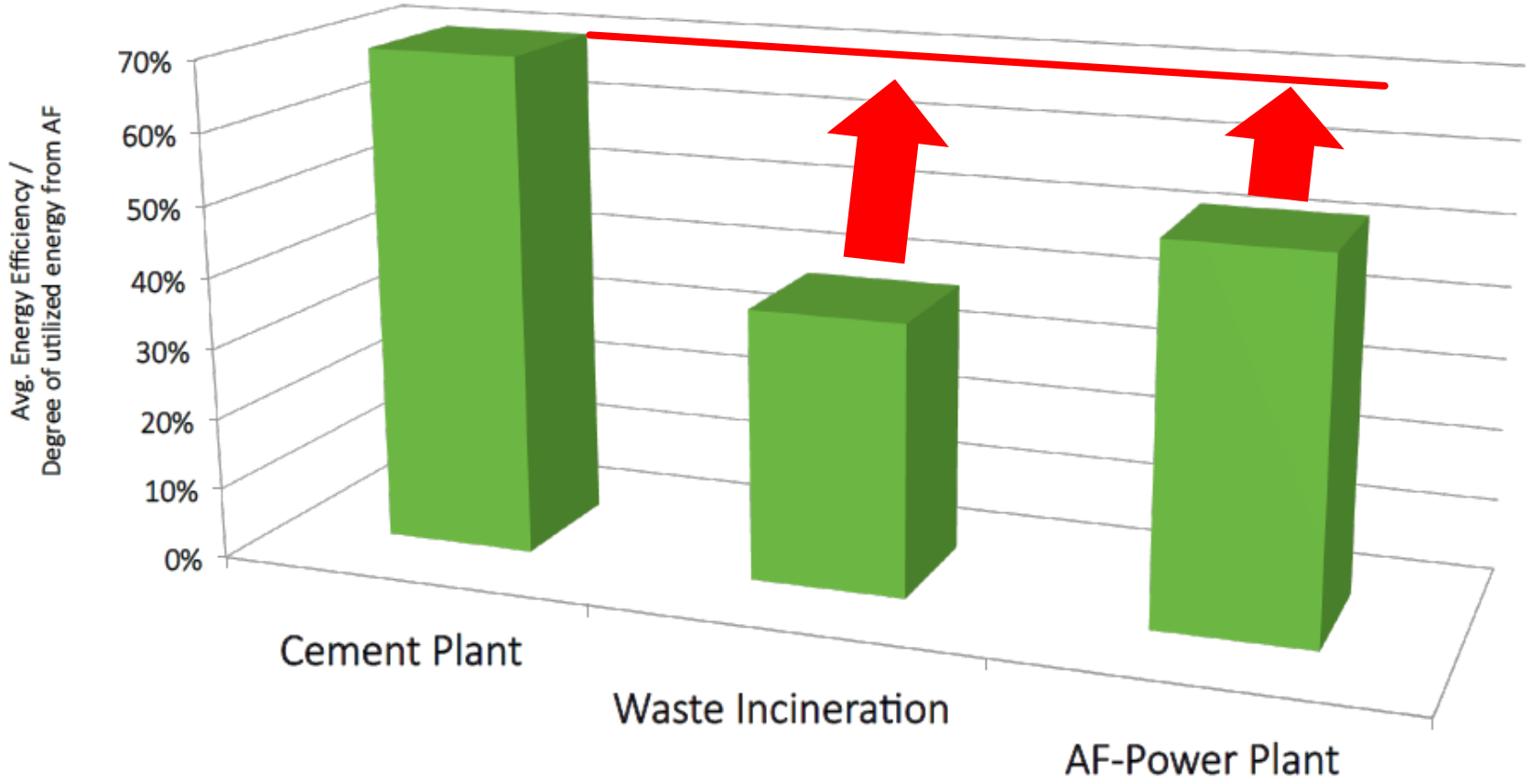
Co-processing, economical advantages

Comparison of waste disposal technologies



Energy recovery rate is higher in a cement plant!

Source: Study from BVSE (2016) – German Association for Secondary Raw Materials and Waste Management

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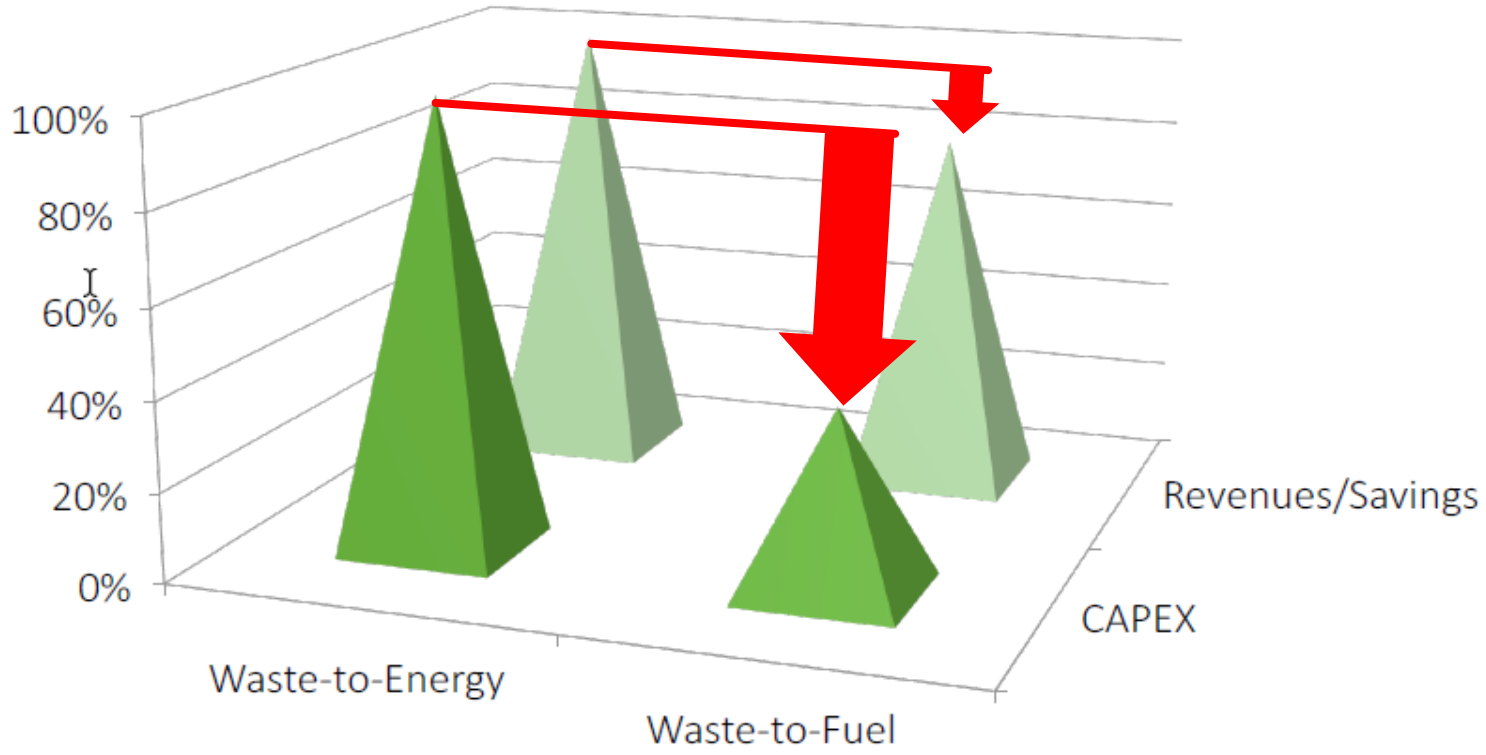
Co-processing, economical advantages

Comparison waste-to-energy versus waste-to-fuel (co-processing)



Compared to a waste to energy plant, co-processing needs less CAPital EXpenditure (CAPEX)!

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Source: Study from BVSE (2016) – German Association for Secondary Raw Materials and Waste Management

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Several AFR waste samples

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Requirements and prerequisites for co-processing (Hazardous) waste in cement kilns I

- ✓ Compliance with Basel and Stockholm Conventions;
- ✓ Co-processing as waste treatment (including destruction) included in **national waste management legislation**;
- ✓ Regular stakeholder dialogues with local community and authorities for responding to comments and complaints; stakeholders, especially government agencies need to address local political and community concerns;
- ✓ An approved Environmental Impact Assessment and all necessary national/local licences meeting international standards;
- ✓ An approved location, technical infrastructure and processing equipment;
- ✓ Reliable power and water supply;
- ✓ Adequate air pollution control devices (APPCD) and continuous emission monitoring ensuring compliance with regulation and permits;
- ✓ Exit gas conditioning/cooling and low temperatures in the APCD to avoid dioxin and furan formation;
- ✓ Clear management and organisational structure with unambiguous responsibilities, reporting lines and feedback mechanism;

Co-processing is only environmentally-sound and safe operation if these requirements are all covered!

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Requirements and prerequisites for co-processing (Hazardous) waste in cement kilns II

- ✓ An error reporting system for employees and penalties for non-compliance;
- ✓ Qualified and skilled employees to manage AFR and Health, Safety and Environment;
- ✓ Adequate emergency & safety equipment, procedures; regular training;
- ✓ Authorised and licensed collection, transport and handling of AFRs;
- ✓ Safe and sound receiving, storage, preparation and feeding of AFRs;
- ✓ Adequate laboratory facilities and equipment for AFR control;
- ✓ Demonstration of AFR destruction performance through test burns;
- ✓ Adequate record keeping of AFRs and emissions;
- ✓ Adequate product quality control routines;
- ✓ An OH&S & Environmental management and continuous improvement system certified according to ISO 14001 & 45001 or similar;
- ✓ Regular independent audits, emission monitoring and reporting;
- ✓ Open disclosure of performance reports.

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Main results & observations of (virtual) Field Visit

- Successful field visit with full participation of all stakeholders
- Presented information and tour of cement plant allowed for a good understanding of cement kiln hardware, performance and operation by Savannah Diamond
- Small list of outstanding topics was compiled and shared with all stakeholders
- All details on the full assessment were shared in a full report

The cement plant following some limited technical upgrades, organizational training adapting relevant operating procedures, a successful trial burn, updated EIA and receipt of an extended permit **should be able to co-process TDF (Tyre derived fuel) & WEEE plastic waste**.

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3 Economics of co-processing

1

First you can see data used from the assessment as well as assumptions regarding energy input

			Calculation			Clarification
Coal	27.2	MJ/kg coal	=	27.2	GJ/t coal	MJ>GJ/kg>t
Clinker	3.5	GJ/t	=	3.5	GJ/t clinker	
Coal needed/ tclinker				0.1287	t coal/ t clinker	Clinker M6/coal M5
Production	350’000	t clinker				
Coal needed	45’036.76	t coal				
Energy input	5	USD/GJ	=	136	USD/t coal	$5 assumed
Energy cost	6’125’000	USD				

2

The second part refers to the savings on coal by tyre derived fuels (TDF)

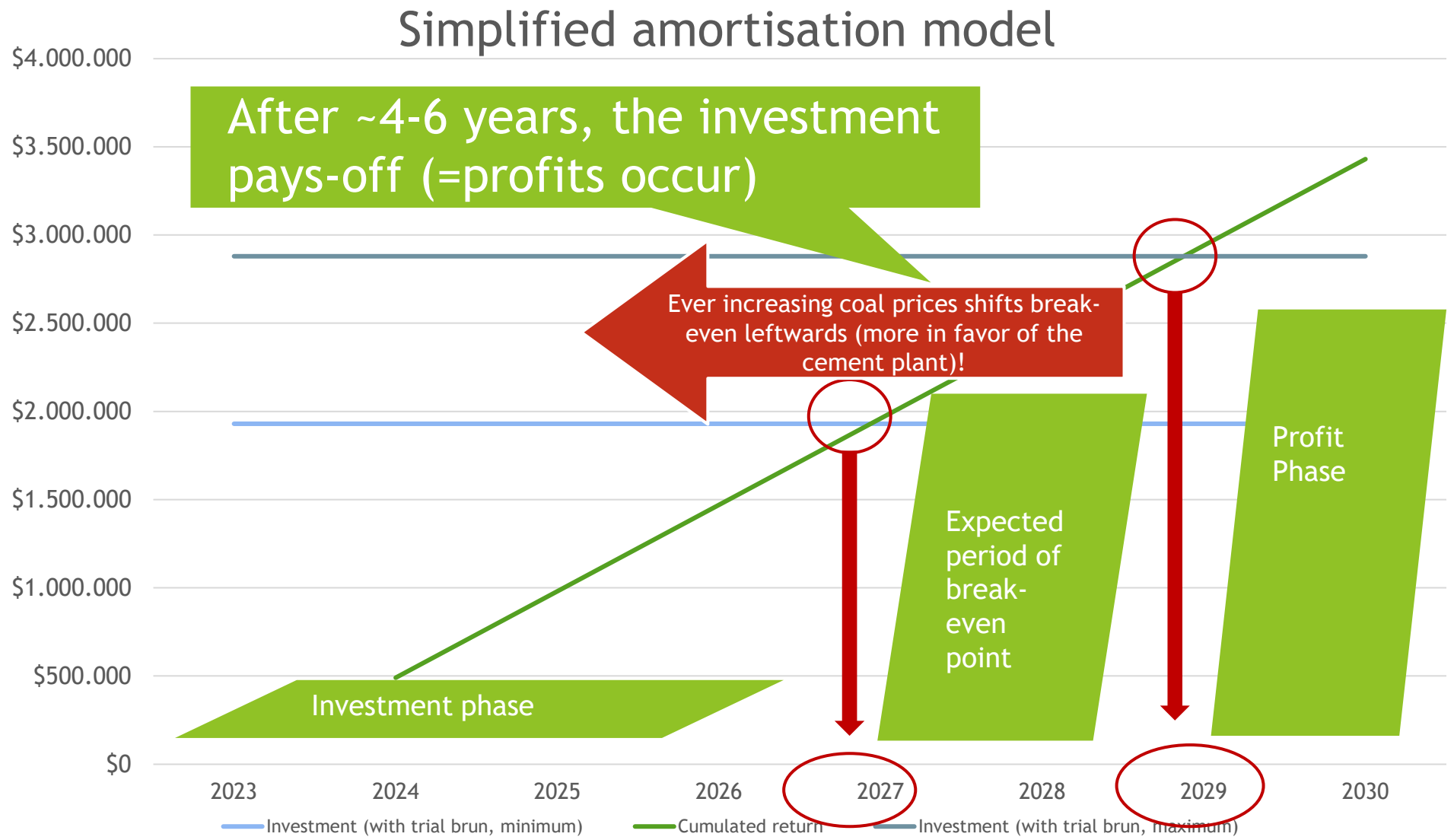
	TSR					
Saving on coal	10	%	=	612‘500	USD	10% assumed
Cost TDF	1	USD/GJ		122‘500		$1 assumed
Net benefit @ 10 % TSR TDF				490‘000	USD	

3 Economics of co-processing

Investments	Min	Max	Payback time	
Adaption of (C)EMS to include additional measurements	$150‘000	$200‘000		
Identify and implement solid waste feeding point and system	$1‘500‘000	$2‘200‘000		
Build suitable receiving and storage area (with roof and liquid-tight floor) for TDF and WEEE-plastics waste	$100‘000	$200‘000		
Carry out performance test (trial burn)	$150‘000	$250‘000		
Review together with local authorities which requirements for testing TDF and WEEE-plastics are needed	$30‘000	$30‘000	Minimum Investment	Maximum Investment
Total incl. performance test	$1‘930‘000	$2‘880‘000	3.94 y	5.88 y

3 Payback times of capital investment is between 3.94 – 5.88 years

3 Economics of co-processing



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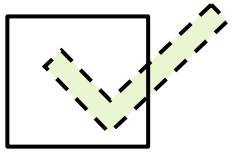
4 Policy roadmap to enable co-processing of waste tyres and e-waste plastics in Ghana

Outlook: What is needed to enable co-processing of waste tires in Ghana?

- Re-cap of guiding principles for pre- and co-processing by Holcim (biggest cement company of Switzerland) and GIZ GmbH (2020)

1

Step 1: Legal and Institutional Framework



Implications for EPA Ghana:

Clarification is needed if co-processing is formally allowed in Ghana (check permit of Savannah Diamond)

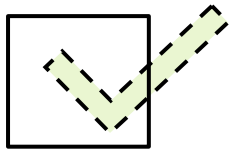
Implementation principles

Legal & Institutional Framework (I)	• Compliance with all relevant laws and regulations has to be assured. • Pre- and co-processing shall be in line with relevant international agreements (e.g. Basel and Stockholm Conventions). • Effective monitoring by an qualified environmental regulator, that has sufficient institutional capacity shall be ensured. • Country-specific requirements and needs shall be reflected in regulations and procedures. • If a local legal framework for pre- and co-processing is not existent and/or inconsistent, international best practices shall be applied and build-up of the required capacity as well as the set-up of institutional arrangements ensured.
Environment (II)	• Additional emissions and other negative effects on the environment from pre- and co-processing shall be prevented or kept at minimum. • Emissions to air and water from co-processing shall not be higher than from cement production without co-processing. • The cement products (concrete, mortar) shall not be used as a sink for potentially toxic elements (e.g. heavy metals).
Operation & Quality Control (III)	• Only appropriate waste streams shall be selected. These shall be pre-processed to ensure quality control, proper handling and stable kiln operation during co-processing. • Companies engaged in pre- and co-processing must be qualified. They shall ensure continuous control and monitoring of inputs and relevant parameters of their production processes. • The quality of the cement products (concrete, mortar) remain unchanged.

Step 2: Environment

- **Adequate air control**: emission standards very carefully studied and compared.
- EPA signaled adoption of emission standards

2



Implications for EPA Ghana:

If Savannah Diamond invests into co-processing new emission standards would have to be included into the **new permit** of the facility and the **Environmental Impact Assessment (EIA)**

Implementation principles

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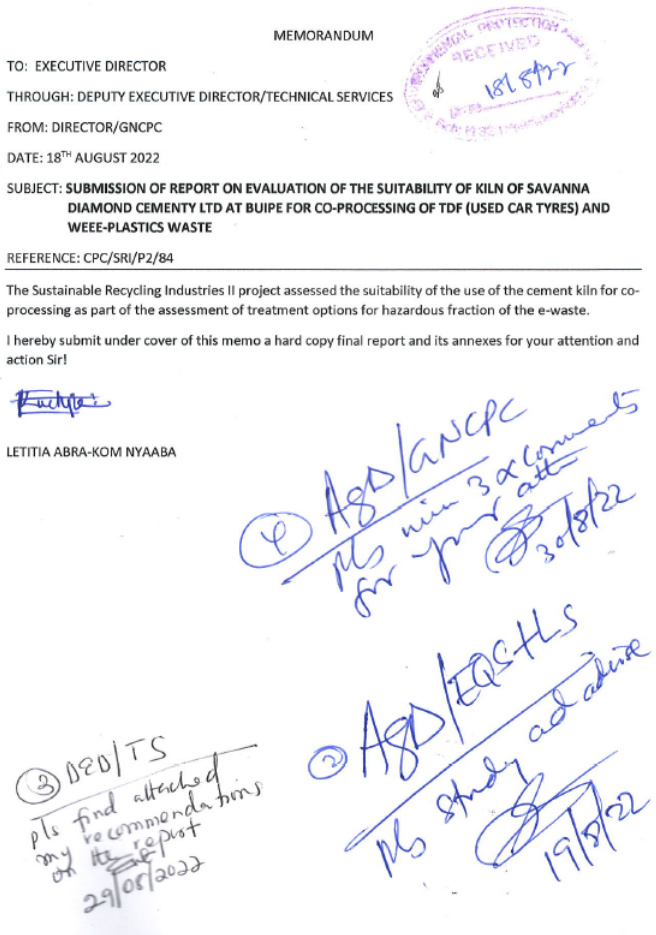
4 Policy roadmap to enable co-processing of waste tyres and e-waste plastics in Ghana



MEMORANDUM

TO: EXECUTIVE DIRECTOR

THROUGH: DEPUTY EXECUTIVE DIRECTOR/TECHNICAL SERVICES

FROM: DIRECTOR/GNCPC

DATE: 18TH AUGUST 2022

SUBJECT: **SUBMISSION OF REPORT ON EVALUATION OF THE SUITABILITY OF KILN OF SAVANNA DIAMOND CEMENTY LTD AT BUIPE FOR CO-PROCESSING OF TDF (USED CAR TYRES) AND WEEE-PLASTICS WASTE**

REFERENCE: CPC/SRI/P2/84

The Sustainable Recycling Industries II project assessed the suitability of the use of the cement kiln for co-processing as part of the assessment of treatment options for hazardous fraction of the e-waste.

I hereby submit under cover of this memo a hard copy final report and its annexes for your attention and action Sir!

LETITIA ABRA-KOM NYAABA

The Recommendations made by Sustainable Recycling Industries (SRI) are relevant and should be implemented.

Savanna Diamond per their permit schedule is required to comply with Stack Emissions Limits including Total Particulate Matter (TPM), Oxides of Nitrogen (NOx), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Hydrogen Chloride (HCl), Mercury (Hg) and Lead (Pb).

In reference to the recommendations made by Sustainable Recycling Industries (SRI) the following pollutants should be added to the list of parameters monitored by the company: Hydrogen Fluoride (HF), Total Organic Compounds (TOC), Cadmium (Cd)+ Titanium (TI), heavy metals (Antimony (Sb), Arsenic (As), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), Vanadium (V)) and Dioxins and Furans.

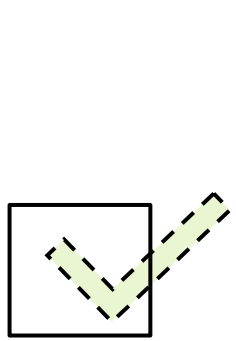
The EQ&LS Department will work with the Ghana Standard Authority to include other pollutants currently not included in the Ghana Standard (Stack Emissions Limits). These parameters includes;

i. Total Organic Compounds (TOC)
ii. Arsenic (As)
iii. Chromium (Cr)
iv. Copper (Cu)
v. Manganese (Mn)
vi. Nickel (Ni)
vii. Vanadium (V)
viii. Dioxins and Furans

Per the Conclusions and Recommendation in chapter 9, the Agency should initiate discussions with Savanna Diamond Company Limited on the outcome of the Suitability Assessment relating to the use of their Kiln for coprocessing of Tire Derived Fuel (TDF) and WEEE-Plastic waste. The discussion should cover the conclusions and recommendations on pages 21 and 22.

Step 3: Operation & Quality Control

- Pre-processing of selected waste streams is key
- Quality assessment also of pre-processing and storage needed



Implications for EPA Ghana:

Also, **operations and quality control** of pre-processing and storage is needed

3

Implementation principles

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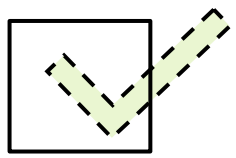
Step 4: Health & safety

- Savannah Diamond needs to show appropriate risk controls
- Also, safety compliance records are key!

4



Implications for EPA Ghana:

Review health & safety requirements in light of new risks (e.g. if tires are stored without a roof, water can accumulate in them being a breeding place for mosquitos)

Health & Safety (IV)	• Companies active in pre- and co-processing shall establish appropriate risk controls to provide healthy and safe working conditions for employees and contractors. • Companies shall have good safety compliance records as well as personnel, processes, and systems committed to protecting health and safety in place.
Inclusivity and Engagement (V)	• Companies active in pre- and co-processing shall engage regularly and communicate transparently with the public, relevant authorities and other stakeholders. • Country-specific and local needs as well as different cultural contexts shall be taken into account when implementing pre- and co-processing. • Companies engaged in pre- and co-processing shall consult and collaborate with actors in the existing local waste management value chain, including informal waste workers.
Economic & Financial (VI)	• Pre- and Co-processing projects shall be based on a financially sustainable business model, which brings value to all involved stakeholders and local communities. • Financing mechanisms shall be in place to ensure that interventions have financing covered in the medium to long term.
Implementation (VII)	• Monitoring and auditing systems need to be in place to enable successful implementation. • Capacity building and training at all levels is essential.

Step 5: Inclusivity and engagement

- Savannah Diamond must engage in public hearings before they invest
- Neighboring communities must be included within a public stakeholder process

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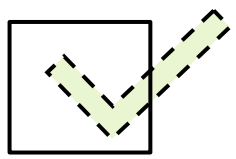

Implications for EPA Ghana:

EPA should also review the public stakeholder process by Savannah Diamond Ltd.

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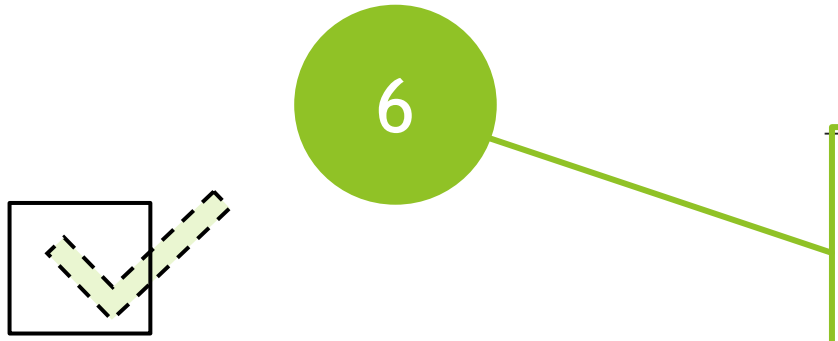
4 Policy roadmap to enable co-processing of waste tyres and e-waste plastics in Ghana

Step 6: Business model sustainability

- addresses Savannah Diamond Ltd.



Implications for EPA Ghana:

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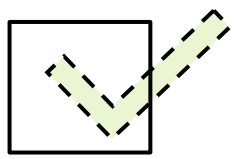
Implementation (VII)	• Monitoring and auditing systems need to be in place to enable successful implementation. • Capacity building and training at all levels is essential.

Step 7: Implementation

- Monitoring and auditing systems
- Further capacity building with Savannah Diamond Ltd.
- Training at all levels

7



Implications for EPA Ghana:

Coaching and supporting Savannah Diamond Ltd. in further implementation

Health & Safety (IV)	• Companies active in pre- and co-processing shall establish appropriate risk controls to provide healthy and safe working conditions for employees and contractors. • Companies shall have good safety compliance records as well as personnel, processes, and systems committed to protecting health and safety in place.
Inclusivity and Engagement (V)	• Companies active in pre- and co-processing shall engage regularly and communicate transparently with the public, relevant authorities and other stakeholders. • Country-specific and local needs as well as different cultural contexts shall be taken into account when implementing pre- and co-processing. • Companies engaged in pre- and co-processing shall consult and collaborate with actors in the existing local waste management value chain, including informal waste workers.
Economic & Financial (VI)	• Pre- and Co-processing projects shall be based on a financially sustainable business model, which brings value to all involved stakeholders and local communities. • Financing mechanisms shall be in place to ensure that interventions have financing covered in the medium to long term.
Implementation (VII)	• Monitoring and auditing systems need to be in place to enable successful implementation. • Capacity building and training at all levels is essential.

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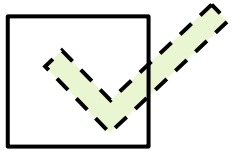
Step 7: Implementation - Outlook in a nutshell



- Compliance with Basel and Stockholm Conventions;
- Co-processing as waste treatment (including destruction) included in **national waste management legislation**;
- Regular **stakeholder dialogues** with local community and authorities for responding to comments and complaints; stakeholders, especially government agencies need to address local political and community concerns;
- An approved **Environmental Impact Assessment** and all necessary national/local licences meeting international standards;
- An approved location, technical infrastructure and processing equipment;
- Reliable power and water supply;
- Adequate air **pollution control devices (APPCD)** and **continuous emission monitoring ensuring compliance with regulation and permits**;
- Exit gas conditioning/cooling and low temperatures in the APCD to avoid dioxin and furan formation;
- Clear management and organisational structure with unambiguous responsibilities, reporting lines and feedback mechanism;

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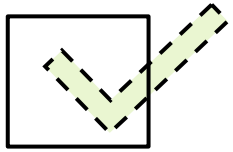
Step 7: Implementation - Outlook in a nutshell



- An **error reporting system** for employees and penalties for non-compliance;
- **Qualified and skilled employees** to manage AFR and Health, Safety and Environment;
- Adequate **emergency & safety equipment**, procedures; regular training;
- Authorised and licensed collection, transport and handling of AFRs;
- Safe and sound receiving, storage, preparation and feeding of AFRs;
- Adequate laboratory facilities and equipment for AFR control;
- Demonstration of AFR destruction performance through test burns;
- Adequate record keeping of AFRs and emissions;
- Adequate product quality control routines;
- An OH&S & Environmental management and continuous improvement system certified according to ISO 14001 & 45001 or similar;
- Regular independent audits, emission monitoring and reporting;
- Open disclosure of performance reports.

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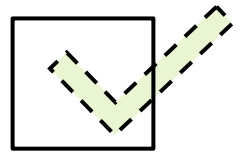
Step 7: Implementation - Outlook in a nutshell (2)

- An **error reporting system** for employees and penalties for non-compliance;
- **Qualified and skilled employees** to manage AFR and Health, Safety and Environment;
- Adequate **emergency & safety equipment**, procedures; regular training;
- Authorised and licensed **collection, transport and handling** of AFRs;
- Safe and sound **receiving, storage, preparation and feeding** of AFRs;
- Adequate **laboratory facilities** and equipment for AFR control;
- Demonstration of AFR destruction performance through **test burns**;
- Adequate **record keeping** of AFRs and emissions;
- Adequate **product quality control routines**;
- An OH&S & Environmental management and continuous improvement system certified according to ISO 14001 & 45001 or similar;
- Regular independent audits, emission monitoring and reporting;
- Open disclosure of performance reports.



Furter guidenace

- “UNEP/BC technical guidelines” (2012)
- “EU co-incineration directive” (2010),
- “GIZ-LafargeHolcim-FHNW Guidelines on pre- and co-processing of waste in cement production” (2020)
- National legislation of Ghana

DIRECTIVE 2000/76/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 4 December 2000
on the incineration of waste
(OJ L 332, 28.12.2000, p. 91)

Questions & Answers

On behalf of the whole SRI Ghana team

THANK YOU VERY MUCH FOR YOUR KIND PARTICIPATION

Main estimated additional equipment and cost for co-processing of (Hazardous) Waste

- Cement plants will **expect a service fee** for disposal by co-processing. This is due to:
  - Unstable supply of these wastes
  - Extra health, safety and environmental requirements
  - Giving little advantages on clinker production, etc.
- Next slide shows a **typical generic cost estimate** for the adjustments required for these waste streams
- Compared to the alternatives of building High Temperature Incinerator (HTI) in Ghana or exporting to such incinerators abroad**, the cement kiln co-processing option is economically more viable and lowers the risk of long-distance transport** of these hazardous waste streams and no or neglectable difference in environmental performance

alternate resource partners

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