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THE GO GREEN CEMENT INDUSTRY PROJECT

Options for energy saving and neutral CO_2 balance

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GO GREEN PROJECT
A MULTI SUBJECT APPROACH

- **This presentation is a part of a series of presentations addressing the different options reduce CO_2 emissions and consequently result in a neutral green-house-gas balance in cement manufacturing:**


Limestone, the main raw material for clinker and cement production

- **PROJECT FUNDING BY ENERGY CONSERVATION, 2014**
- **ALTERNATIVE RAW MATERIALS (ARM) AND COMPOSITE CEMENTS, STRATEGIES IN ARCHIPELAGO COUNTRIES 2016**
- **COMPOSITE CEMENTS VS ORDINARY PORTLAND CEMENT 2023**
- **LC^3 A GIANT LEAP TO SUSTAINABILITY 2024**
- **Cement is a product of strategic nature for every country. There is no substitution for cement today.**
- **Manufacturing of cement is the second most energy consuming large scale industrial process.**
- **The major process of clinker manufacturing is the decarbonation of limestone combined with huge combustion of thermal fuels (approximately 750 kcal/kg of clinker) and high electrical energy demand (approximately 95 kWh/t of cement). In total combined approximately 840 kcal/kg clinker.**

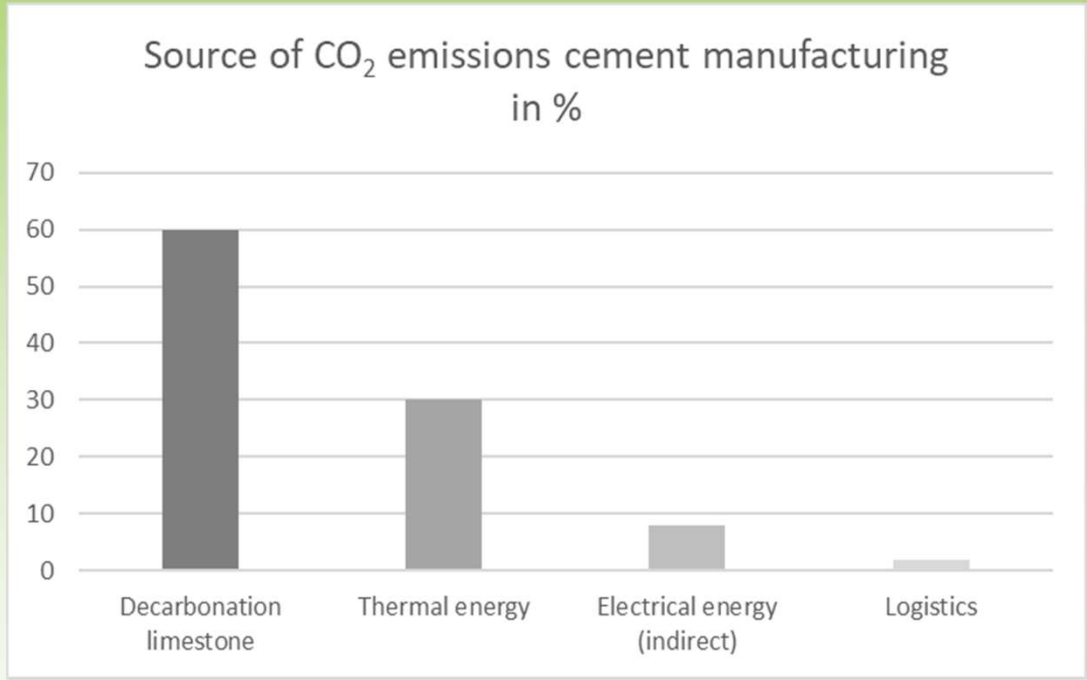
SOURCES OF CO_2 EMISSION

- **The main source of CO_2 emissions originates from the decarbonation of limestone. This is related to clinker production. The only feasible way to reduce this 60 %, CO_2 emission level is to decrease the clinker factor in the cement, meaning to eliminate OPC production and concentrate on various PCC (Portland composite cement) products, like Slag Cement, Fly Ash Cement, Pozzolan Cement or LC^3 Cement.**

- **Further 30 % of the total CO_2 emissions are related to thermal CO_2 from combustion of primary fuels such as coal, oil and gas. Sustainable or renewable fuels, like agricultural, industrial and municipal waste materials are secondary fuels or reflected as AFR (alternative fuels and raw materials) and are qualified to reduce the CO_2 emission balance.**

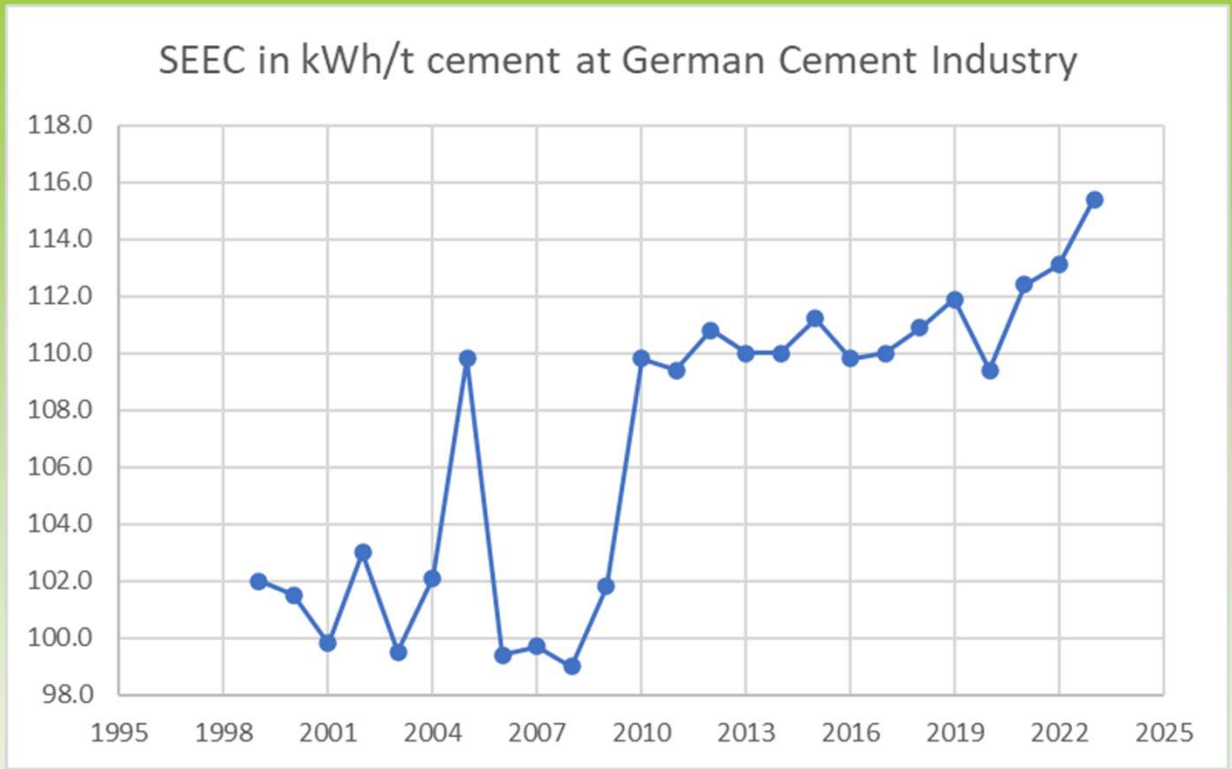
- **Consumption of electrical energy contributes to 10 % of the CO_2 emissions. Electrical energy is particularly easy to replace by CO_2 neutral technology.**

- **Logistics and other minor sources are causing up only 2 % of the CO_2 emissions. Also, this minor part should be subject new eco friendly technological replacement.**



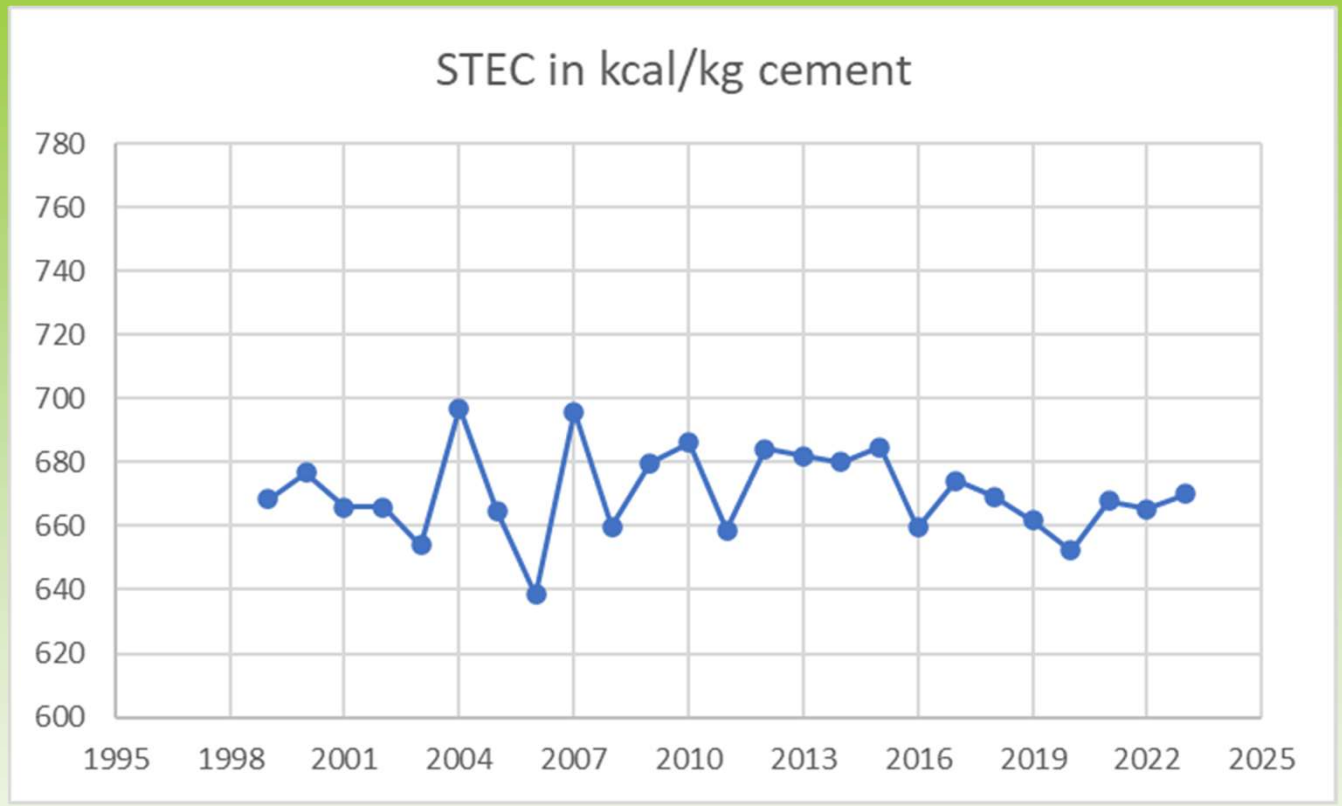
This presentation concentrates on the options to convert thermal-, electrical energy and logistics.

DEVELOPMENT OF ELECTRICAL SEEC



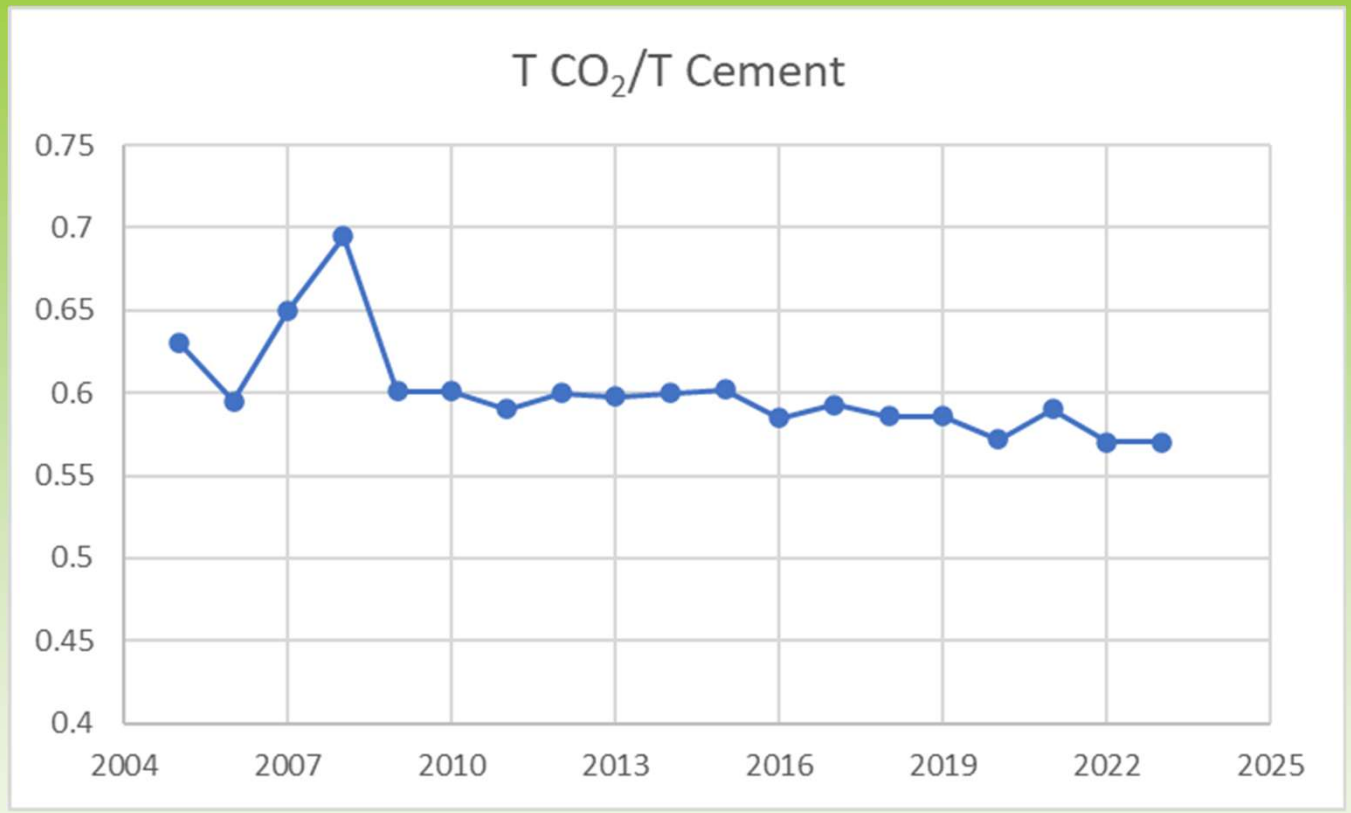
- **Data are reflecting the situation of German Cement Industry. Data have been taken because of reliability and constant availability.**
- **In spite of application of new grinding technology, e.g. VRM or RP based grinding systems, SEEC was significantly rising since 2010. This increase of approximately 10 kWh/t is attributed to the production of composite cement types mainly containing GBFS, which has a higher grindability compared to clinker and requires a higher fineness of the cement.**

DEVELOPMENT OF THERMAL STEC



- **Data are reflecting the situation of German Cement Industry. Data have been taken because of reliability and constant availability.**
- **The very low STEC is again attributed to the utilization of additives in cement and the practical elimination of OPC from the product portfolio.**
- **The fluctuations in the early 2000 years are caused by the learning curve in utilization of high amounts of AFR.**

DEVELOPMENT OF CO_2 EMISSIONS



- **In Germany and other European countries specific emissions of CO_2 are now constantly below 0.6 T CO_2/T cement.**
- **In Asia specific CO_2 emissions are far above this level in the range of 0.75 T CO_2/T cement. This is mainly due to low level of composite cements, low level of AFR utilization (< 20 % TSR) and low generation of regeneratable electrical energy.**

• There is a lot to do!!!

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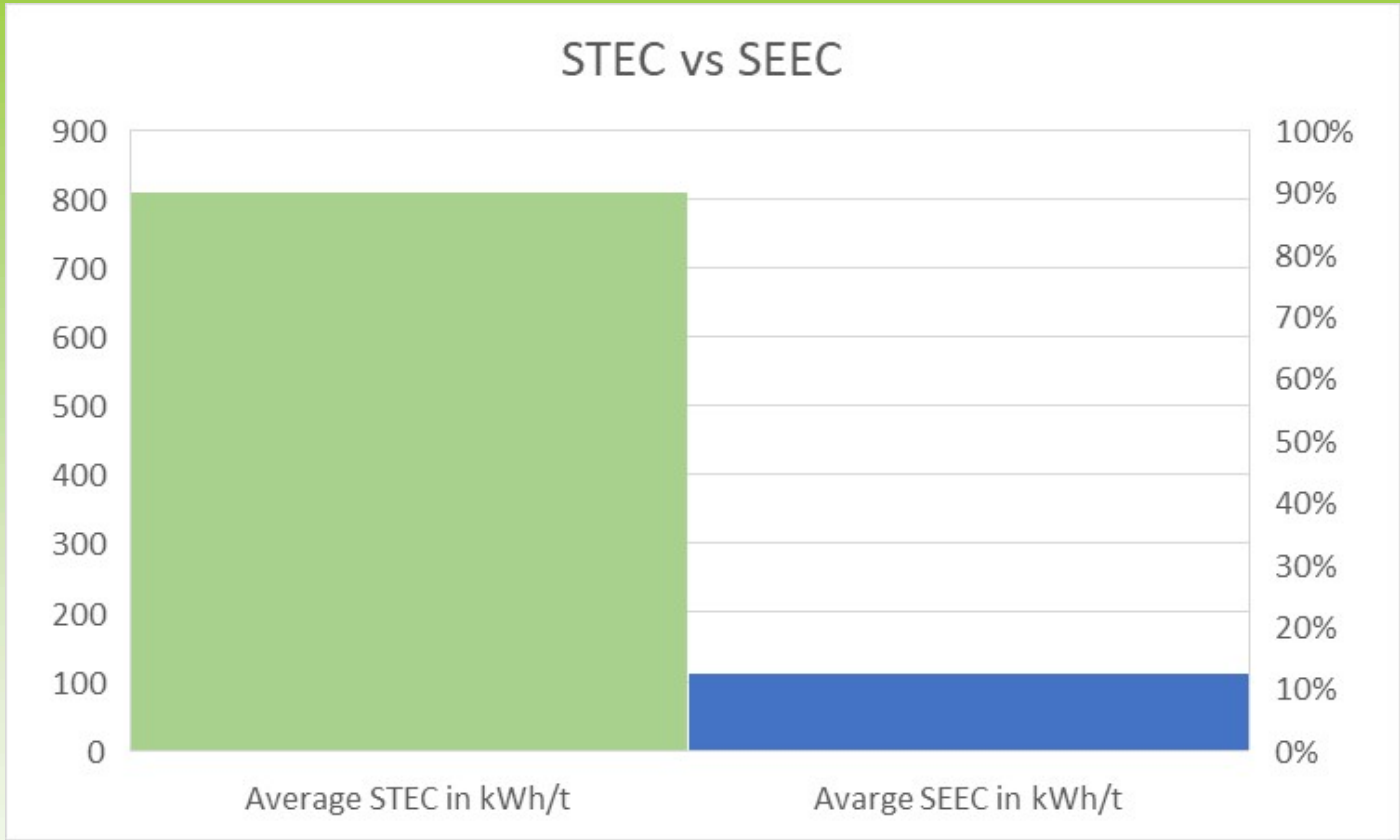
RELATION BETWEEN STEC vs SEEC

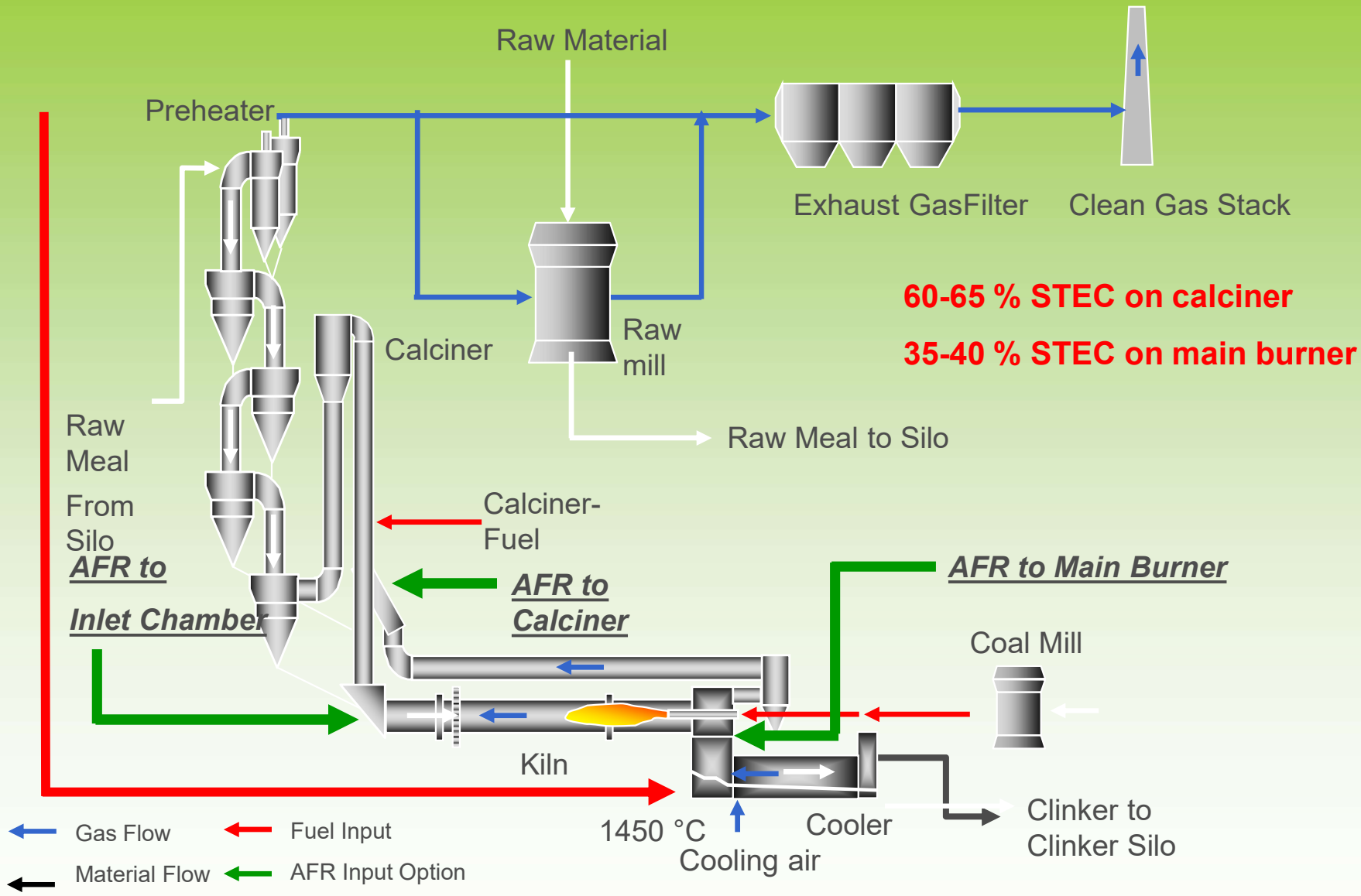


- **The graphics concludes the situation of the cement industry. Approximately 90 % of the total production energy for cement is related to thermal energy consumption. Only 10 % of the consumption is related to electrical energy.**

- **Consequence: Significant improvements in energy replacement or conservation can only be achieved if STEC is reduced. Change in SEEC is also important but does not significantly improve general balance.**

CO_2 REDUCTION BY MAXIMUM TSR
(Thermal Substitution Rate)

WHAT ARE THE TECHNICAL PRECONDITIONS FOR MAXIMUM TSR FLEXIBILITY?

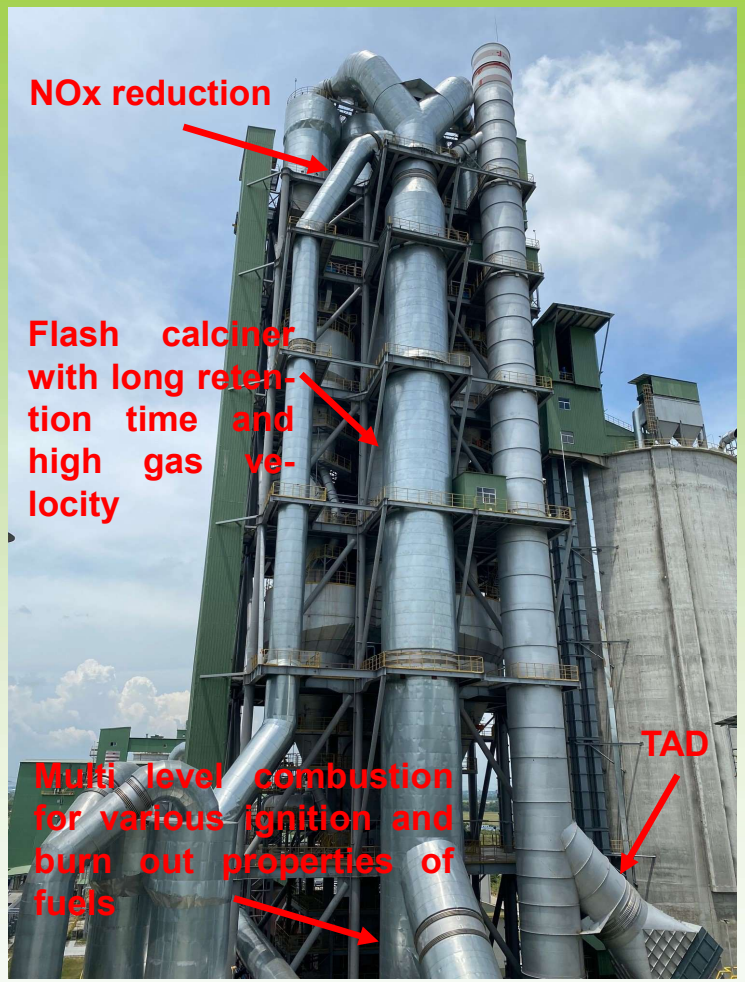


WHAT ARE THE TECHNICAL PRECONDITIONS FOR MAXIMUM TSR FLEXIBILITY?

Successful maximization of TSR today mainly consists of a mixture of different AFR materials. Process, ecological, availability and mainly economical reasons are the drivers for an optimum AFR mixture.

Modern cement plant with maximum flexibility on technical as well as economical fuel flexibility need the have following features:

- **Plants need to have preheater and calciner technology.**
- **Plants need to have a tertiary air duct (separate calciner line)**
- **Calciner should have maximum retention time, e.g. 3.5 - 4 sec.**
- **Calciner should have a gas velocity of 20-22 m/s and split of tertiary air (multi combustion) for NOx reduction.**
- **Installation of low grade AFR material combustion facility, e.g. hot disc, pyrorotor, combustion chamber, gasifier.**
- **Plants should include a 10 % bypass system with option to route the bypass dust to the cement mill.**



- **Plants need suitable, hygienic and safe storage areas for agricultural and/or industrial and/or municipal AFR in liquid and solid state.**

AFR MATERIALS FOR TSR

TSR (Thermal Substitution Rate) is mainly depending on availability of AFR materials in the required quality and quantity as well as commercial profitability. In the cement industry TSR is mainly/only accepted, if substitution of primary fuels like coal, oil or gas is of commercial benefit.

Within the last decade the demand for AFR materials exploded and many easy to burn and combust AFRs became expensive or unavailable. To increase TSR many cement manufacturers accept low quality AFR with a low or no, expensive processing level. At the same time CAPEX into AFR feeding and combustion systems rose and requires sustainable long-time supply of AFR.

MUNICIPAL WASTE THE KEY TO SUCCESS?

In reality a mix of various and varying AFR materials is used in cement plants and introduced in different suitable locations to the pyro-system. However, reality is that usually only municipal waste is available in the required quantity. According to experience the raw municipal waste in Asia includes only 35-40 % of combustibles which have to be separated from the compostable faction. Moreover, the combustible fraction need to be shredded into a suspend able size to used in conventional calciner/kiln systems.

Above separation and shredding process requires high CAPEX and high OPEX and deteriorated profitability. Hence it is of utmost importance to reduce/avoid preparation processes of municipal waste.

CONSEQUENTLY, PYRO SYSTEMS NEED TO BE MODIFIED/ADJUSTED TO RECEIVE AND PROCESS RDF 2 MATERIAL.

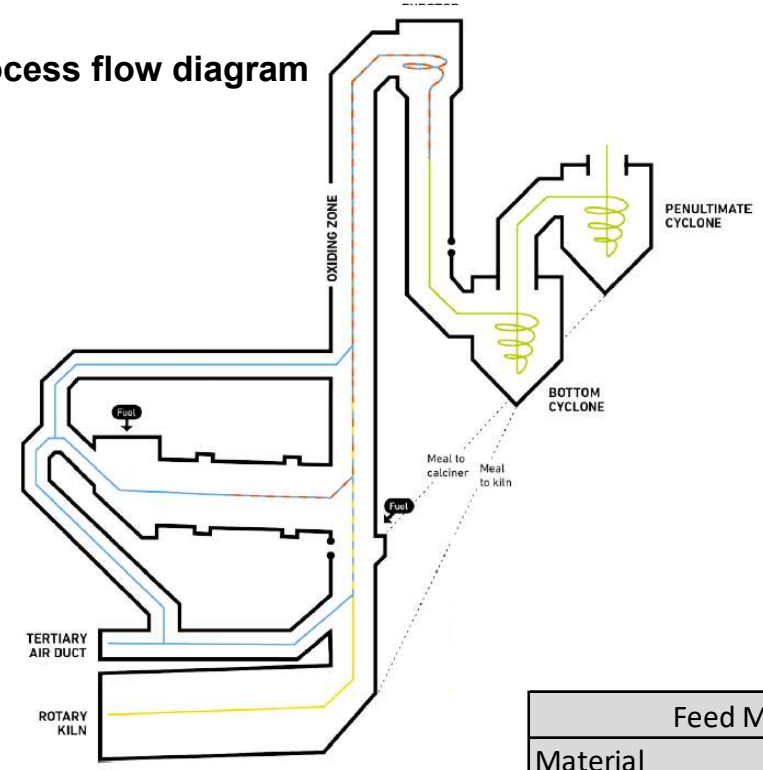
Raw Waste **RDF 2** not suspend able in air **RDF 1** suspend able in air

TECHNICAL OPTIONS TO PROCESS LOW GRADE MUNICIPAL WASTE (1/3)

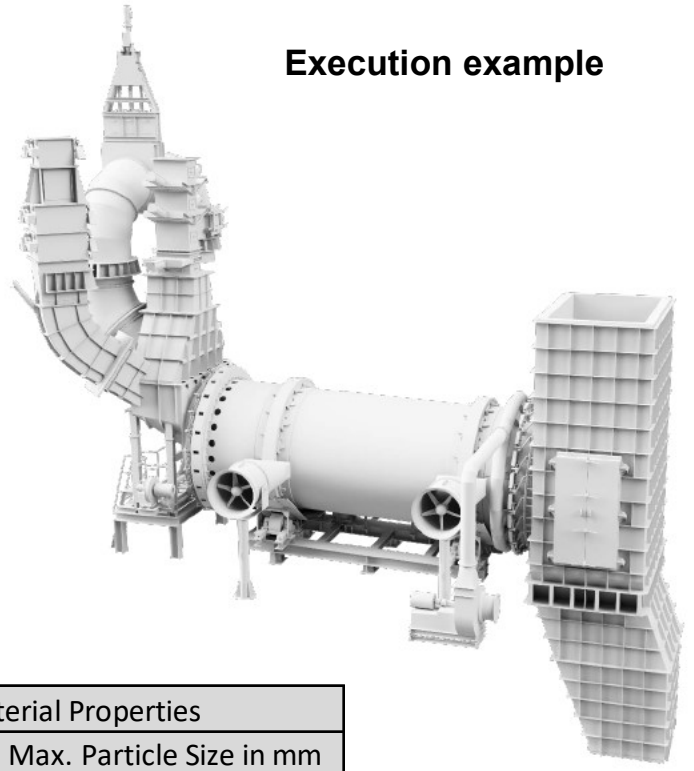
THE PYRO-ROTOR

- **The following selection of technology are just examples and are not complete or exclusive.**

Process flow diagram



Execution example



- **Independent system.**

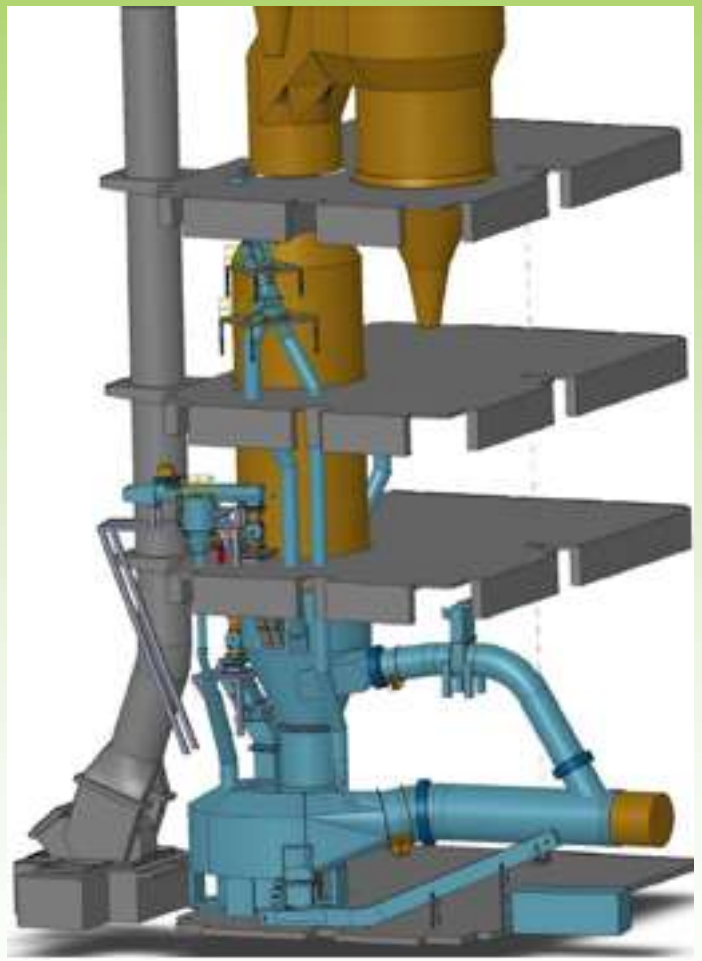
Feed Material Properties	
Material	Max. Particle Size in mm
Biomass	100*100*15 (3D)
Plastics	300*300*100 (3D)
RDF/Fluff	300*300 (2D)
Tire Chips	300*300*25 (3D)
Whole tires	complete

TECHNICAL OPTIONS TO PROCESS LOW GRADE MUNICIPAL WASTE (2/3)

THE HOT DISC

- **The following selection of technology are just examples and are not complete or exclusive.**

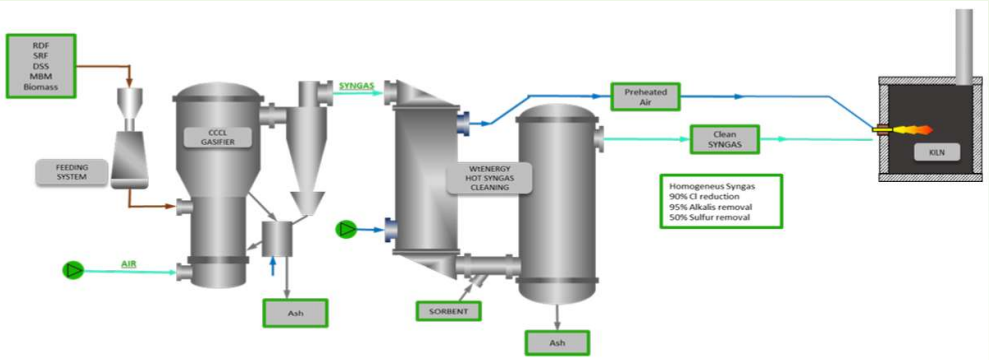
- Enables the use of non-shredded RDF and other bulky fuels.
- Solution for the SLC calciner.
- Gas retention time +0.5 sec.
- Material retention time, HOTDISC table speed from 2 RPH (22.5 min) to 20 RPH (2.25 min).
- Fuel and combustion air are mixing.
- Integrated system, cannot work independently.



TECHNICAL OPTIONS TO PROCESS LOW GRADE MUNICIPAL WASTE (3/3)

THE GASIFIER

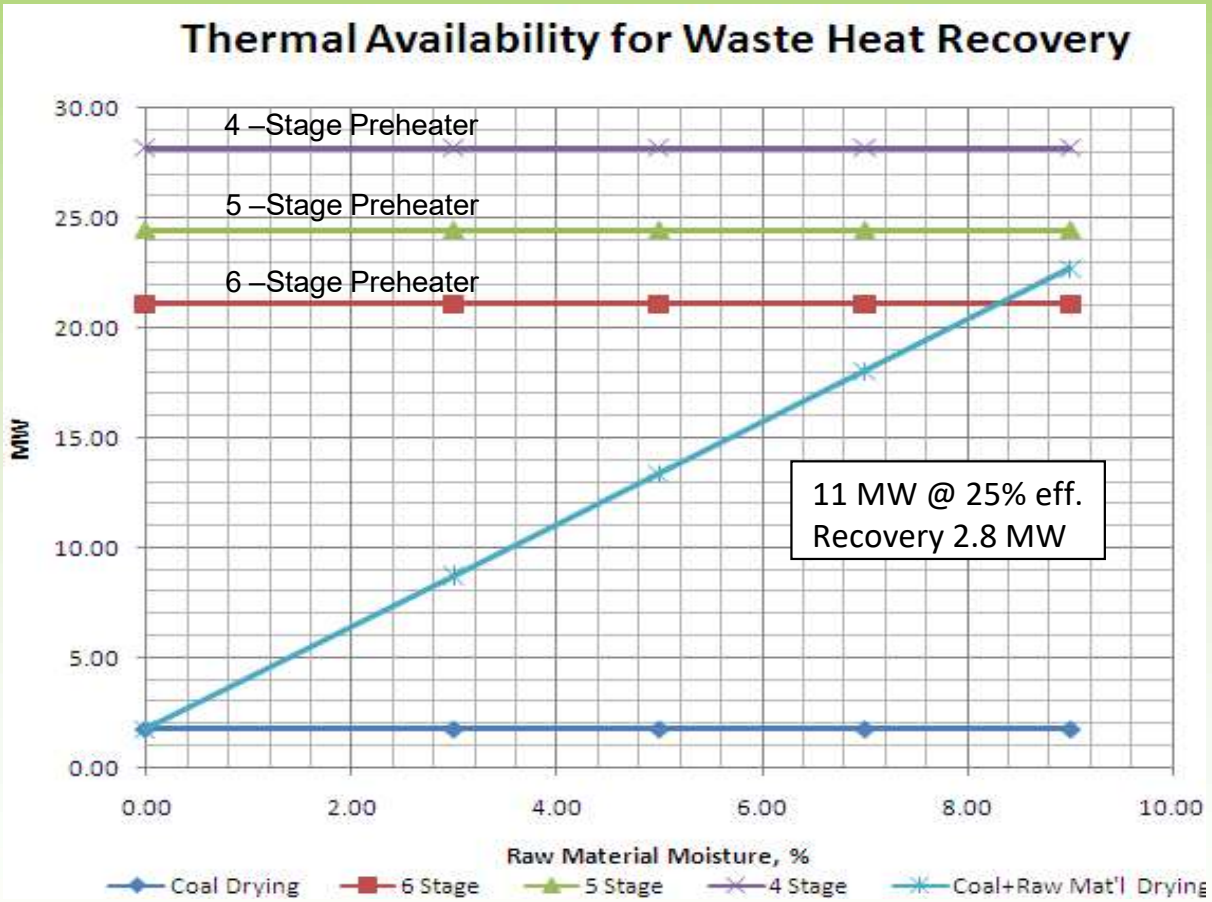
- **The following selection of technology are just examples and are not complete or exclusive.**
- AFR heated to 800°C in a reducing atmosphere.
- The AFR is pyrolized and gasified.
- Ash is introduced as raw material into the calciner/inlet chamber.
- The “syngas” produced can be used at main and calciner burner like primary fuel.
- Typically, up to 20 % TSR with existing models achieved.
- Low modification of existing clinkerization plant.
- Different types of gasifiers available, e.g. fluidized bed or rotary gasifiers.
- **Independent system. Stand alone unit.**

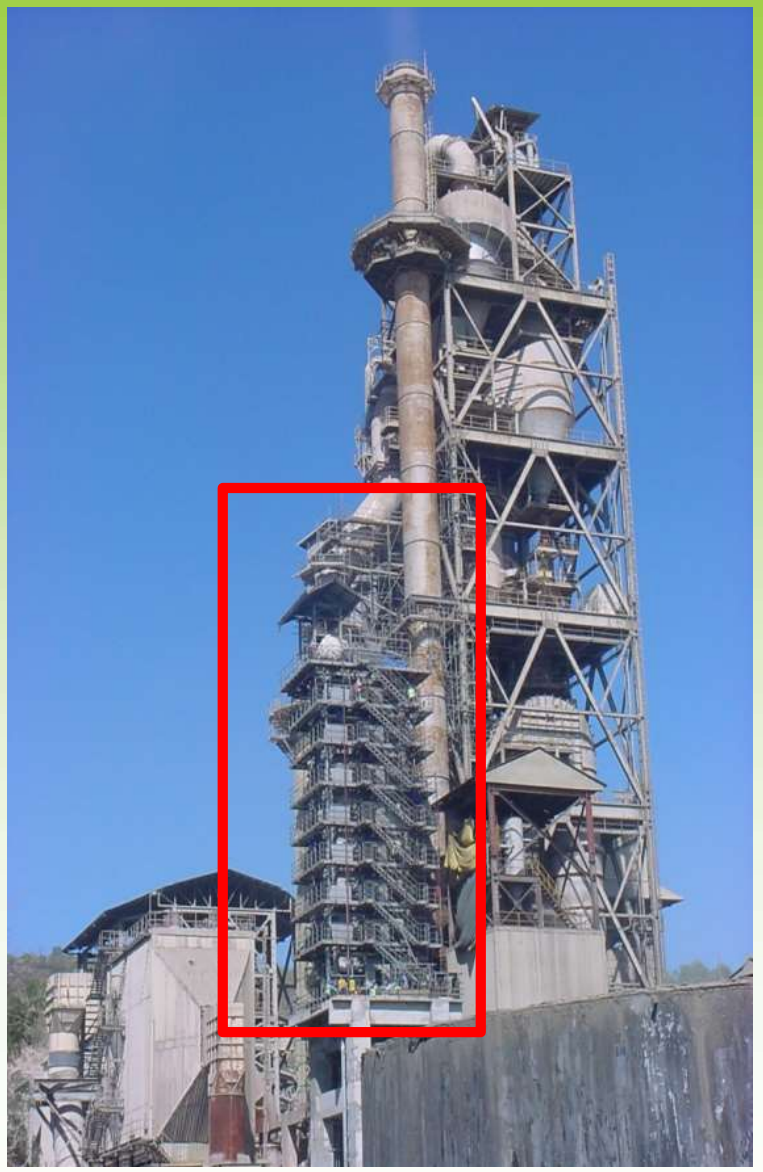


CO_2 REDUCTION BY GENERATION OF REGENERATABLE POWER

POWER GENERATION BY WHR SYSTEMS

- Typically for a 5000 TPD clinker production line with 5 stage PH system at 4 % moisture a WHR the recovery power is about 2.8 MW.
- This is sufficient to operate the kiln line even at power brown outs.
- **Please note: WHR systems should not be abused as power plants.**





POWER GENERATION BY SOLAR ENERGY

- **Installation of solar power farms is becoming more and more popular, particularly in countries on the southern hemisphere.**
- **Typically, are sizes of 20 MW or a multiple of it.**
- **The major disadvantage of solar power is its availability only during day time. Storage of electrical energy is economically excluded at such capacities.**
- **A solution to maximize utilization of solar power is the upgradation of cement mills, the main electrical consumers of the cement plant.**
- **This means, grinding operation is reduced to daylight hours.**
- **Also modern, energy efficient grinding technology like Roller Presses and Vertical Roller Mills should be applied.**
- **In case of a new cement mill project, CAPEX for upgradation of mill capacity will be easily recovered by complete independence form public grid and cheap solar power.**


Installation of a 20 MW solar farm at a cement plant in Thailand

POWER GENERATION BY WIND ENERGY

- **Wind energy is hardly used in cement plants today, also that space requirement is much lower compared to solar energy and a modern wind mill generates up to 4.2 MW of energy.**
- **Carefully investigation of the optimum location would provide energy almost 24 hours.**
- **Wind mills could be installed in quarry areas or at external land.**

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THANK YOU FOR YOUR KIND ATTENTION

I AM LOOKING FORWARD TO ANSWER YOUR QUESTIONS