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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654465

LEILAC Project Overview

March, 2016

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A technology solution to capture CO_2 emissions from the vital cement and lime industries…

Leilac

The Context:

- Cement and lime are two critical European industries
  - Directly employ more than 388,000 people in Europe.
  - **Cement** is one of the most widely used substances on the planet, fulfilling an essential role in providing society's need for housing and infrastructure.
  - **Lime** is used in a variety of applications including the iron & steel, chemical, paper and pharmaceutical industries.

- The EU has set an ambitious CO_2 emissions target: cutting emissions to 80% below 1990 levels by 2050.

- Both industries must play a major role in meeting the EU's CO_2 emission reduction target
  - Cement accounts for up to 5% of global anthropogenic emissions of CO_2.
  - Lime, while being the smallest sector within the European Emissions Trading System, has the highest CO_2 intensity related to its turnover.

A technology solution to capture CO_2 emissions from the vital cement and lime industries…

The Challenge:

- Around 60% of their total CO_2 emissions are released directly, and unavoidably, from the processing of limestone – not from the combustion of fossil fuels.

- CCS will need to be applied to 59% of European cement plant to meet the EU's emission reduction target

- The cement and lime industries are under intense competitive and cost pressures

LEILAC is uniquely placed to aid Europe in achieving its emissions target in a manner that allows the cement and lime industries to thrive.

The LEILAC (Low Emissions Intensity Lime And Cement) Project Vision is to future-proof the cement and lime industries without significant impact on operability, capital intensity or efficiency…

LEILAC summary

Planned pilot plant in Lixhe, Belgium

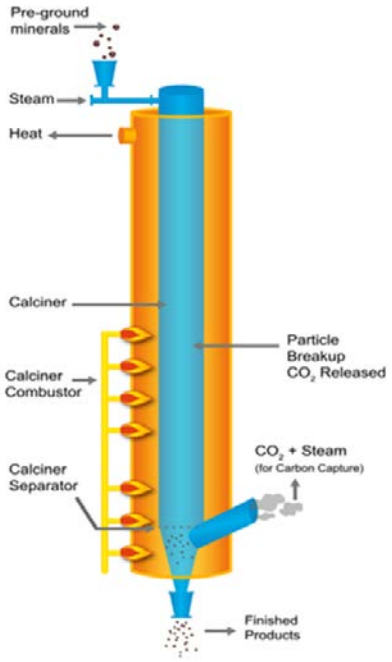
- Lime application 8tph
- Cement application 10tph

Indirect heating raw meal:

- Direct capture of process-related CO_2
- 95% capture rate of pure CO_2

€12m H2020 grant plus € 9m in-kind

- 5-year project, start in early 2016



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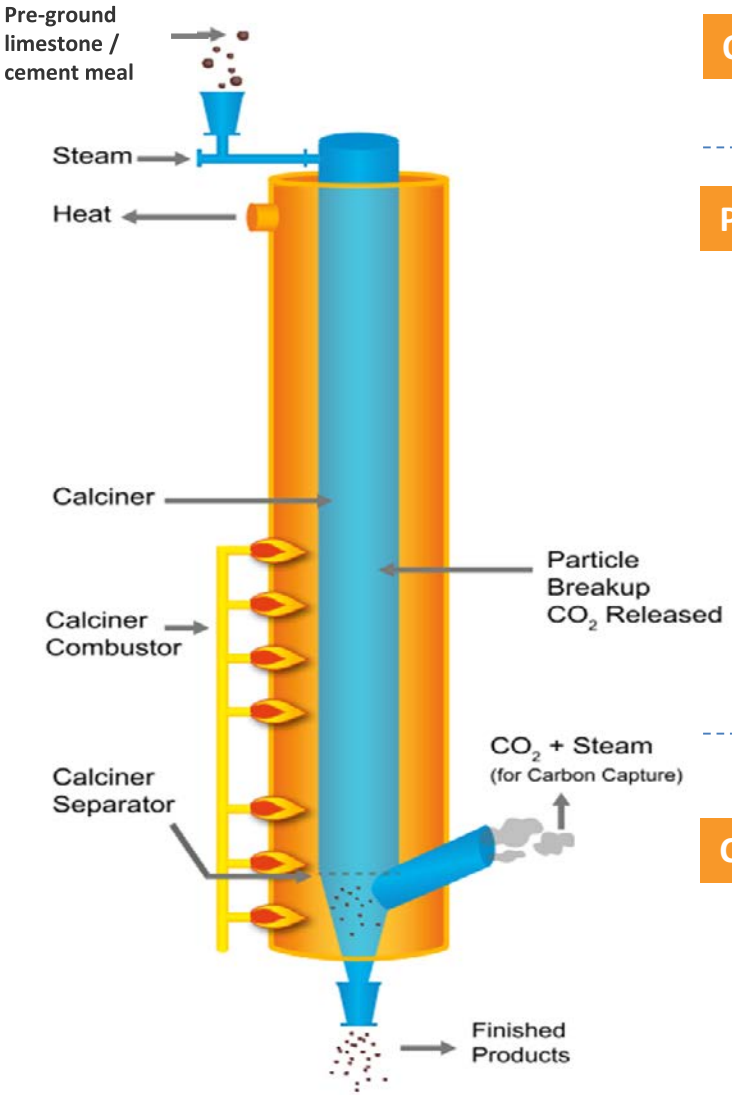
Calix' s Direct Separation Reactor ("DSR") …



Output

- A pure CO_2 stream
- 5 to 10 times more reactive product

Principle

- Retrofit (replaces existing calciner) or new-build
- Can be built to handle variable mineral input streams, as well as biomass and waste coal fuels
- Pre-heating combined with accurately controlled temperature and reactor residence time minimises sintering (loss of activity)
- Can handle fines that cannot be processed by conventional lime kilns, but appropriate for cement meal and limestone fines.
- Enhances other CO_2 abatement technologies (e.g. oxyfuel firing) and alternative fuels.

Cost

- Captures CO_2 for no energy penalty (just compression).
- Comparable capital costs + potentially lower operating and maintenance costs to conventional kilns

Direct Separation is a key element in a plant's wider CO_2 reduction system…

Direct Separation captures all of the process emissions i.e. 60% of a plant's total emissions:

1. Those 60% process CO_2 are captured for 'free' (new build or scheduled retrofit) as there is no energy penalty (just compression).
2. It can be immediately used with alternative fuels, immediately reducing total plant emissions to 85%.
3. Compared to a "previous generation capture concepts" such as amines for 90% of a plant's total emissions, the net CO_2 emissions are only around 0.14kg higher per 1kg of cement produced.
4. It can be used with existing capture technology such as oxyfuel or calcium looping to capture the majority of the remaining heating emissions. If biofuel is also used then a plant would operate with negative emissions.
5. This 'free' carbon capture should become the industry's Best Available Technology – creating a "no-regrets" investment option for the cement and lime industry.

Direct Separation is proven at commercial scale for magnesite processing…

CALIX DIRECT SEPARATION REACTOR FOR MAGNESITE ($MgCO_3$)

LEILAC will test scale-up of temperature and throughput, and demonstrate integration to production processes…

- The scale-up of temperature from 780ºC, proven for magnesite calcination, to 905ºC for limestone. The key issue is the durability of the steel reactor structure operating at a wall temperature of 1040ºC in the radiative heating zone.

- Scale-up of throughput of lime and cement by investigating the limits to throughput per reactor tube, minimising the requirements for a modular array reaching 5,000 tonnes/day (for cement).

- The pathway for integration of the Direct Separation reactor to industrial production processes for lime and cement. The pathway includes the transition from natural gas combustion to powdered fuel combustion as well as plant integration and product quality assessment.

LEILAC is a first step towards wider technology roll-out…

1

LEILAC pilot plant

TECHNICAL OBJECTIVES

- Input feed capacity of 10 tph of cement meal, or 8 tph limestone.
- Efficiently capture over 95% of CO_2 process emissions, and verify that pure CO_2 can be captured.
- Evaluate and mitigate the major scale-up technical risks.
- Confirm that the end cement and lime products are not negatively impacted.
- Life Cycle Analysis
- Techno-economic analysis

DISSEMINATION

- Disseminate data and findings which support the anticipated performance and cost of full-scale application.
- Share knowledge with public, industry, policy-makers, peer projects, scientific community.
- Establish a roadmap for the cement and lime industry.

2

DSR large scale demonstration

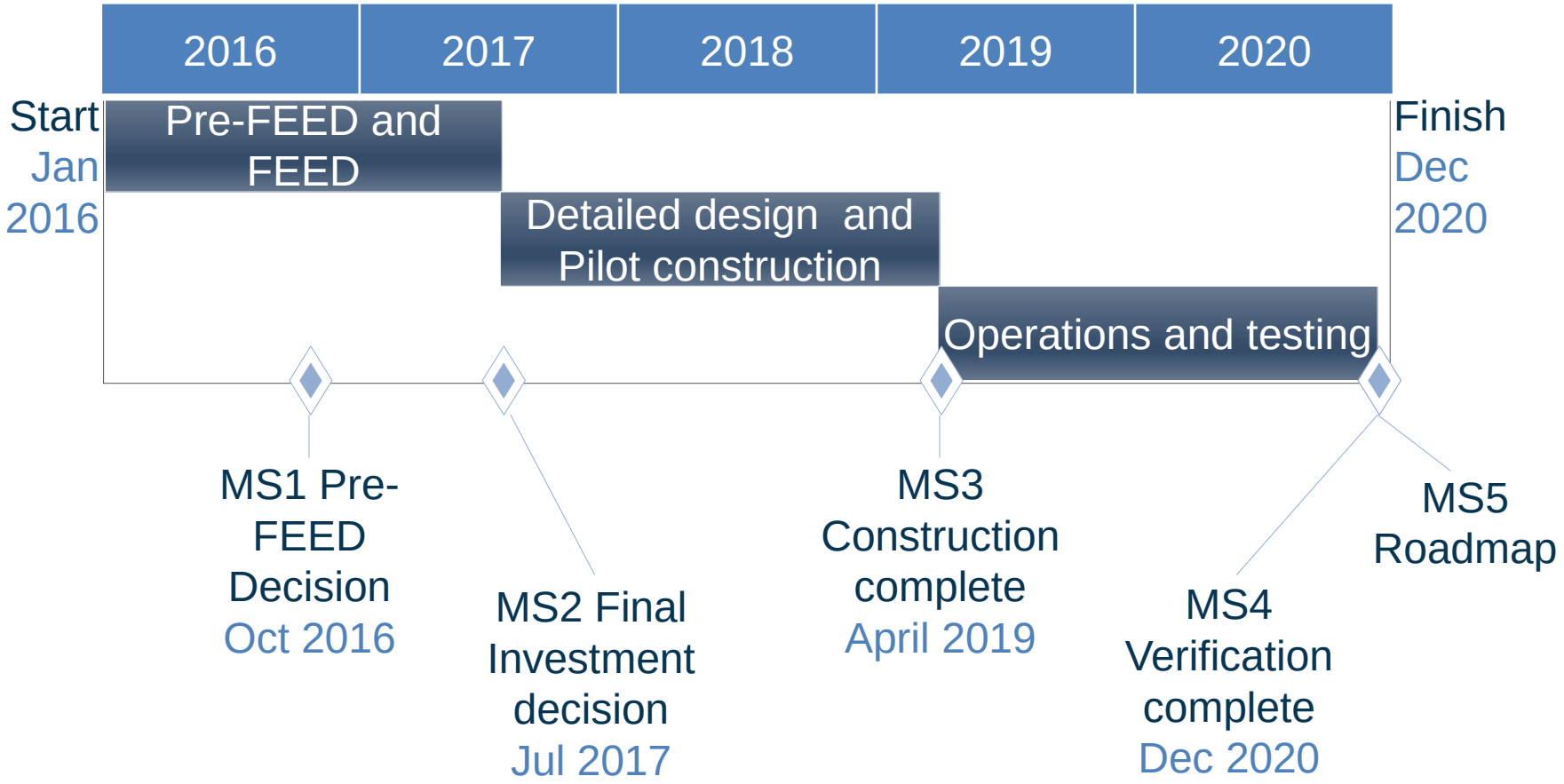
3

DSR international roll-out

LEILAC Pilot Plant is strategically located at CBE, Lixhe, Belgium…

Proposed site of the LEILAC pilot plant

We plan to start operations in Q2, 2019...



Follow LEILAC's progress…

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LEILAC Contact details

Adam Vincent
LEILAC Project Manager
Calix (Europe) Ltd
tel:
a.vincent@

Daniel Rennie
LEILAC Project Co-Ordinator
Calix Europe Limited
tel:
d.rennie@

Thank you