# Lime industry innovation projects & priorities

Round table 3 on Finance for innovation, cement and lime

06 April 2017

# Innovation in Lime sector

**Quarry:**
Innovation in extraction
Reduce waste
Improve biodiversity
Water footprint
…

**Process emission pilot projects:**
SCARLET;
LEILAC;
ECO & $ECO_2$;
$CaO_2$;
Chemical Looping;
Anaerobic Digestion renewables;
…

**Transport:**
Desulphurization in sea vessels
…

**Use:**
Phosphorous
Water purification
Mineral reaction as slag former
Renaturation using lime
Use of lime in HMA
Flue Gas Treatment
…

**Carbonation:**
Mortars
Soil Stabilisation
…

# SCARLET*

- Combines the advantages of a small efficiency penalty of 5 to 7 % points and a low $CO_2$ capture cost compared to competing technologies currently under development.
- One objective of the proposed project is to **perform long-term tests with different fuels in an upgraded 1 MWth pilot plant, aiming mainly at optimization of operating conditions & reliability.** First tests performed have confirmed the feasibility of the technology.
- **Construction of a demonstration unit** in the order of 20 MWth is the next step in the development of this technology.

TRL: 6
Status: Ongoing (2014-2017)
Funding: EU, FP7
Project link: http://www.project-scarlet.eu
Lime partner: Lhoist


* Scale-up of Calcium Carbonate Looping Technology for Efficient $CO_2$ Capture from Power Plants

# CARINA*

- The main objective of the project is **to achieve a technological proof-of-concept and a detailed economical evaluation for the retrofit of an existing coal fired power plant** with an indirectly heated carbon looping process.

- The process should yield higher plant efficiency and lower $CO_2$ avoidance costs than other $CO_2$ capture technologies which are currently under investigation.

TRL: 6

Status: Finalised (2010-2014)

Funding: EU FP7

Project link: https://www.proj\\SBS\Public\a.DOC\11

Lime partner: Lhoist


* **Car**bon Capture by **In**directly Heated c**A**rbonate Looping Process

# LEILAC*

- LEILAC will develop, build and operate 240 tonnes/day pilot plant to demonstrate that Direct Separation Reactor (DSR) **breakthrough technology that has the potential to capture unavoidable process emissions** and enable both Europe's cement and lime industries to reduce emissions by around 60%.

- Direct Separation Reactor (DSR) was used to produce niche 'extremely caustic MgO' since 2012, while trapping the plant's process $CO_2$ emissions, without additional chemicals or processes.

TRL: 7-8
Status: Ongoing (2016-2020)
Funding: H2020
Project link: https://www.project-leilac.eu
Lime partners: Lhoist & Tarmac
EuLA** part of the Advisory Board

* Low Emissions Intensity Lime and Cement (LEILAC); ** European Lime Association

# ULCOS*

- ULCOS is a major RTD program, which plans to assess **innovative and breakthrough solutions to decrease the $CO_2$ emissions of the Steel industry.** The target is an expected reduction of specific $CO_2$ emissions of 50% as compared to a modern Blast Furnace.

- ULCOS has identified and tested four process concepts that could lead to a reduction of Carbon dioxide($CO_2$) emissions by more than half compared to current best practice.

TRL: 6

Status: Finalised (2004-2010)

Funding: EU, FP6

Project link: http://www.ulcos.org/en/index.php

Lime partners: Lhoist

**Leader**: Arcelor Mittal (France). All steel producers in EU have partnered.

47 partners in total from 15 EU countries.

* **U**ltra **L**ow **$CO_2$** **S**teelmaking

# BiOxySorb*

- Assess experimentally and techno-economically of **1st and 2nd generation biomass co-combustion** under both air- and oxy-fuel conditions at various co-combustion ratios in combination with flexible, low cost SOx, HCl and Hg emission control by sorbent injection

- **Economic low carbon power production and emissions control** for future and flexible biomass co-fired power stations

- Assess necessary plant modifications for high thermal share biomass co-milling and co-combustion and for injection of sorbents

TRL: 6-7

Status: Finalised (2013-2016)

Funding: EU, FP7

Project link: http://www.ulcos.org/en/index.php

Lime partner: Lhoist

* **Bio**mass co-combustion under both air- and **Oxy**-fuel conditions

# ECO* & ECO2**

- Objective was to **investigate the recycling of anthropogenic $CO_2$ into the natural carbon cycle using lime.** In practice, the capture of $CO_2$ from flue gases with the help of a limestone-$CO_2$-washing process similar to the naturally occurring carbonate weathering process.
- The **$CO_2$ scrubbing process with limestone powder in solution was successfully demonstrated at the waste water facility** in Bad Orb. During performance tests a reduction of $CO_2$ within the flue gas by up to 13 % was achieved. A four-five stage cleaning system could lead to a $CO_2$ reduction of up to 80%, as modelling and calculations revealed
- Pre-trial finished; **Pilot plant build**; Tests at IUTA (Duisburg)
- Bio- and ecological modelling to test the harmlessness of process water discharge and biochemical effects are ongoing

TRL: ECO= 5-6; ECO2 = 7
Status: * Finalised (2010-2012); ** ECO2 Ongoing (2013-2017)
Funding: National (Germany)
Project link: http://www.fg-kalk-moertel.de/forschungsberichte.html
Lime partner: FG

* **Eco**nomical $CO_2$ scrubbing; ****Eco**nomical $CO_2$ scrubbing (follow up project)

# CaO2*

- Calcium Carbonate Looping (CCL) is a technology tested for low-cost post combustion CO2 capture for fossil fuels using limestone based solid sorbents.
- The CaO2 project intends to demonstrate in a large pilot (2-3 MWth) a process optimisation of the CO2 capture post combustion calcium looping system for coal based power plants.
- This process scheme is intended to minimize or even avoid the need of a $CO_2$ recycle to the oxyfired circulating fluidized bed calciner, by exploiting the endothermic nature of the calcination reaction and the large solid flow circulating from the carbonator.
- Basic mass and heat balance calculations reveal that the standard CaL system can **reduce about 20-30% the energy requirements in the calciner** by switching to a configuration as proposed in the CaO2 project.

**TRL**: 6
**Status**: Ongoing (2014-2017)
**Funding**: EU, FP7
**Project link**: http://cao2.eu
**Lime partners**: Carmeuse

** Carbon Looping Technology*

# AGICAL+

- Reduce process emissions and consumption of fossil fuel linked to glass (high gas temperatures) and lime production (low temperatures).
- **Capture $CO_2$ in the flue gases using microalgae cultures**, and then processing these microalgae to extract biofuel, to be used again in the product process to reduce the consumption of fossil fuels.
- **The goal was to demonstrate that it is possible to capture 360 tonnes of $CO_2$ per year** and per hectare of microalgae, thus producing 200 tonnes of biomass, and extracting up to 2460 GJ of biofuel.
- The evaluation of the pilot results led the partners to discontinue the project since the yields were lower and economic unviability results

**TRL**: 4

**Status**: Planed to run from 2011 to 2016; terminated in 2013

**Funding**: EU, LIFE+

**Project link**: http://www.agical.eu/

**Lime partner**: Carmeuse

# ADiREN4Lime*

- **To reduce energy costs and reliance on grid electricity and gas, a project was developed to use Anaerobic Digester** (AD) for kiln operations

- The methane can be used to produce electricity or upgraded to Biomethane for injection into the gas grid and can be used as a fuel for lime kilns

- Built in 2 phases: 1: **1.25MW Combined Heat and Power (CHP); Phase 2: 2MW CHP plus 1.5MW drier in the restored quarry operations**

- Uses 45,000 tonnes of feedstock annually

- Combined output of the 3 AD plants is 110% of kiln electricity demand

- Dryer using waste heat from the CHP engines to dry digestate used as a high value fertiliser

**TRL**: 9

**Status**: Operating since 2015

**Funding**: Own initiative (UK)

**Lime partner**: Singleton

* **A**naerobic **Di**gestion as a **R**enewable **En**ergy for **Lime** Industry

EuLA 25 years

# Ideas for Innovation calls

# Lime industry R&D priority

- Small sector but enabling nature, consideration of value chains
- Major priority for the lime sector is $CO_2$ mitigation

- Focus of the lime industry on innovation around CCS/CCU
- Short to middle term R&D priority:

**Get the $CO_2$ in some form of fuel and make it part of the fuel chain:**

- Bioethanol
- Biomass
- Oxyfuel

# Project ideas

- Increase CO2 e.g. by looping
- Indirect calcination
- Methanisation
- Low concentration CO2 -> Direct use for e.g. plant/algae/bacteria growth/feeding or flue gas cleaning
- Combination with Oxyfuel process
- Carbonation
- Carbon dioxide Storage by Mineralisation (CSM)

# Storage of renewable energy by combination of Lime "Oxyfuel Process" with $CO_2$ -looping and methanization

**Background:** ▪ usage of ~70´MWh electricity/day (working day) in Germany
▪ available capacity: 80´MWh (incl sun & wind)->target 150´MWh/day
=> however capacity not fully available (volatility)
Cost in Germany > 1 bn. € for shutdown of not usable wind energy

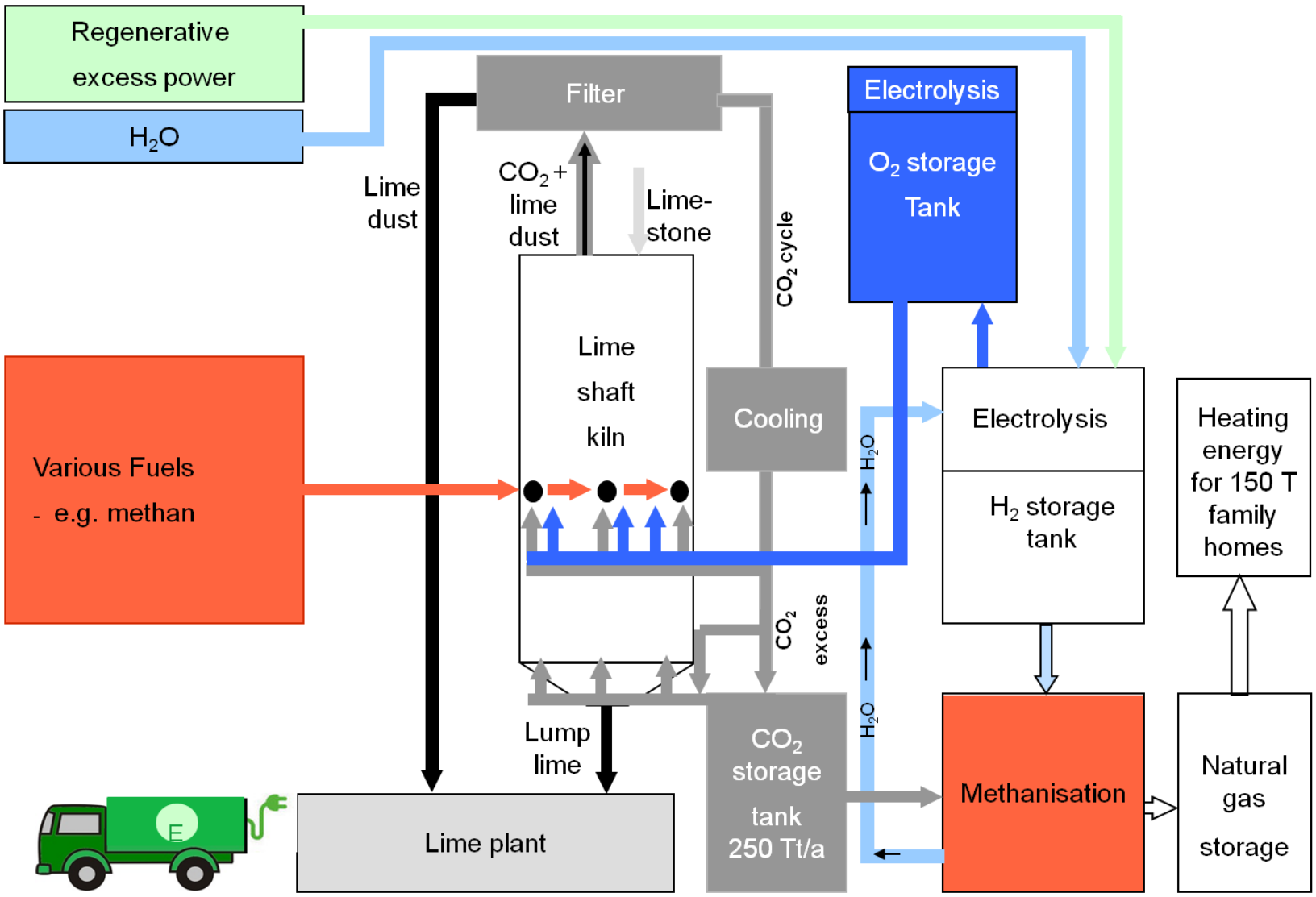
**Detail:** Construction of hydrogen electrolysis sites (usage above mentioned 1 bn€)

- Split up of water into hydrogen (H) and oxygen (O) -> 2 gases -> " oxyfuel "
- Inject oxygen into kiln for burning process – no air supply!
- Burning process: methane with oxygen from electrolysis
  - However very high flame temperature (2.000C) -> cooling necessary /
  - => dilution of O2 by CO2 from loop / insert pure $CO_2$ into cooling zone of the kiln
- $CO_2$ for cooling and firing => $CO_2$ loop
- The entire $CO_2$ is concentrated, pure $CO_2$ in exhaust gas => optimized CCU-process
- No energy intensive stripping is needed
- $CO_2$ usage with hydrogen => Methane ($CH_4$)-Methanisation -> e.g. gas for burning process and storage of renewables

Support is needed for development of the process:
- hydrogen electrolysis / recuperator / optimization dedusting CO2

**Required financial support ~ 40 Mio. €**

# Lime Oxyfuel process with $CO_2$ loop

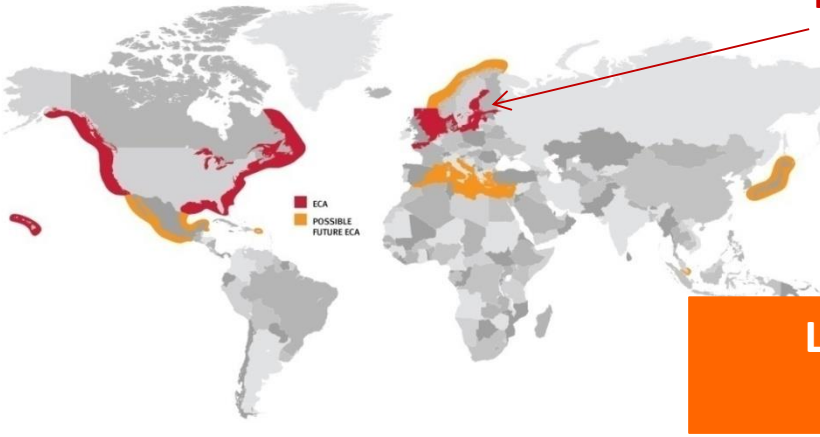


EuLA 25 years

# Lime answers to
## Marine diesel desulphurisation

# International shipping is one of the main sources of sulphur emissions

- 55,000 merchant ships
  -> 90% of global trade volume
- Fuel consumption: 370 mn tonnes of heavy oil p.a.
- Emission: soot, $NO_x$, $CO_2$ plus approx. 22 mn tonnes $SO_2$ p.a.
- Sulphur emission corresponds to approx. 400 large coal-fired power stations




**New legal regulation as of 1 January 2015**

- Limits in emission control areas (ECA):
  - 1.0% -> 0.1% as of 2015
  - 500 Tt $SO_2$ emissions in North Sea and Baltic Sea

**Lime hydrate pellets have significant potential**

# High efficiency absorption for dry exhaust gas desulphurisation in packed bed filter


- Reliable $S0_2$ abatement of > 95%
- No reheating of $NO_x$ filtration
- Catalytic oxidation of soot on alkaline lime hydrate pellets
- Re-use of cost-effective heavy oil possible
- Highly efficient and economical
- Ecologically friendly recycling of REA products
- **Successful large-scale industrial trials**

sulfur absorption to core

**25 Mio. € to establish technology**