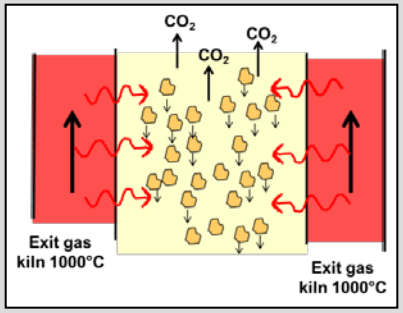
Turning CO_2 into a Valuable Asset

Studies and Projects at HeidelbergCement

Group Director Alternative Resources, Jan Theulen
21 May 2015



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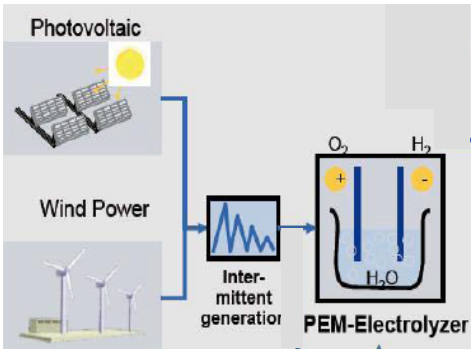
CCS and CCU

- **CCS is a solution with a large volume potential**
- **CCS**
  - well accepted in e.g. Norway, Canada and coming in UK
  - CCS to enhance oil production is an advanced model
- **CCS in Germany and other European countries still difficult**
- **CCU:**
  - Can contribute to end solution
  - Can bridge the gap until CCS is wider accepted

Overview CCU technologies



Direct Use

<30% CO_2

ponds/tubes

bacteria

algae

ethanol

microbes

chemicals

H_2

Carbon Capture

90% CO_2

Methanation

methane

Process CO_2 separation

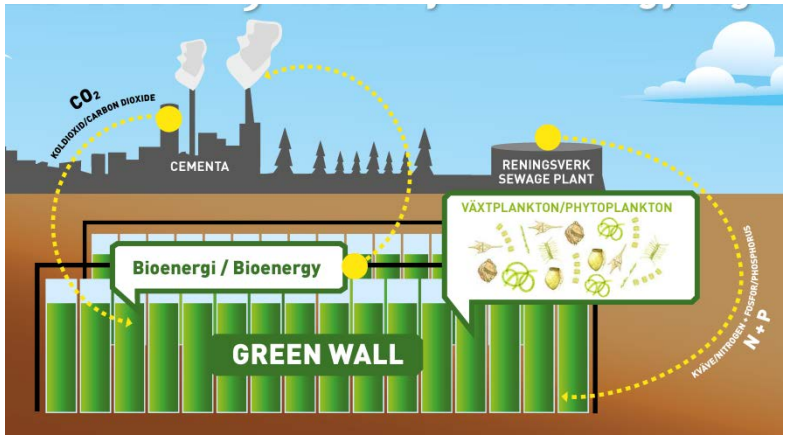
95% CO_2

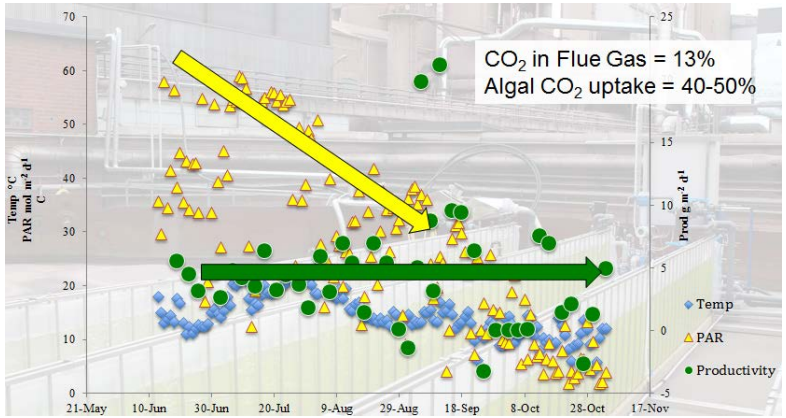
Enhanced Carbonation

building materials

(waste) minerals

Degerhamn micro-algae project with Linné University





- **Lab experiments**
  - Flue gas Degerhamn not harmful for micro-algae
  - High growth rate
  - Natural community less sensitive than mono-culture
- **Pilot plant construction (Algoland)**

Linnéuniversitetet Kalmar Växjö
CEMENTA HEIDELBERGCEMENT Group
KK-stiftelsen
FORSK
sma mineral

- **Inauguration attracted 600 visitors**
- **First season:**
  - CO_2 in Flue Gas = 13%,
  - Algal CO_2 uptake = 40-50%,
  - Potential for high production in late season
  - Potential for higher uptake with panels in series

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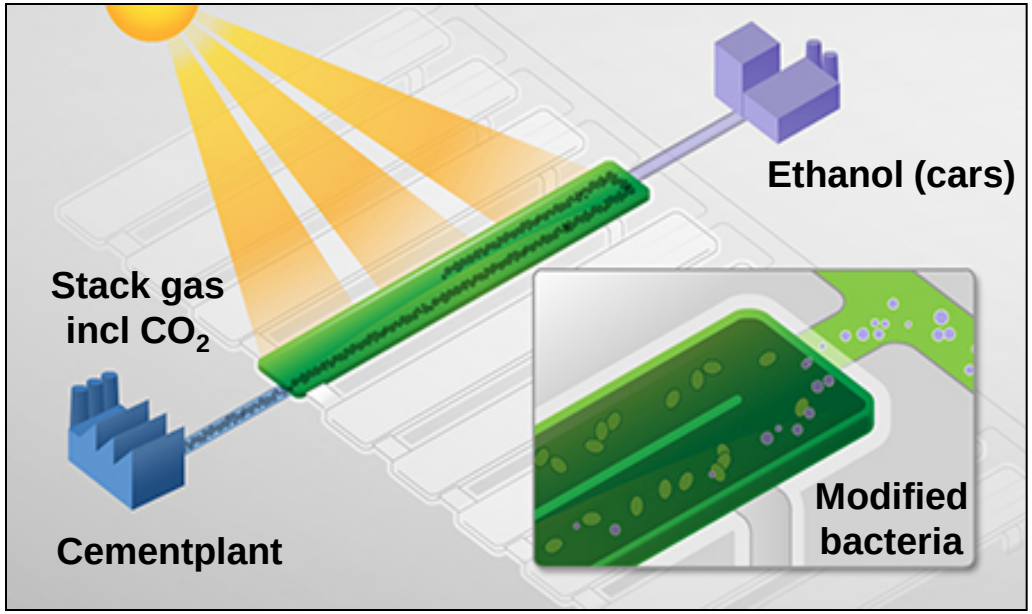
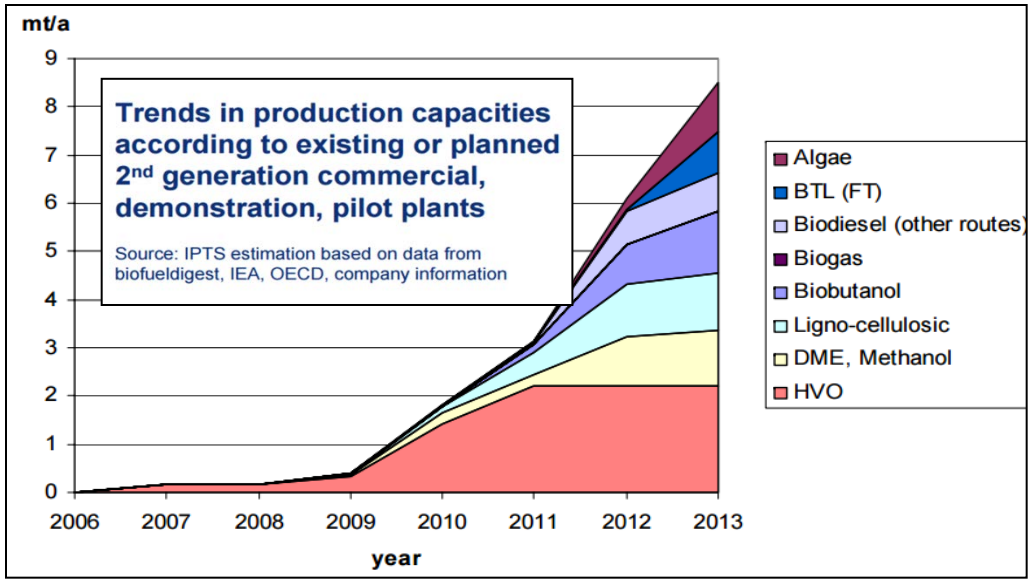
From CO_2 to ethanol by modified bacteria





- Joule Ltd USA
- Direct use of exhaust gas
- Large space required and solar radiation
- Pilot in California or Texas in preparation
- Interests from VW/Audi
- Joule Plant Overview.mp4

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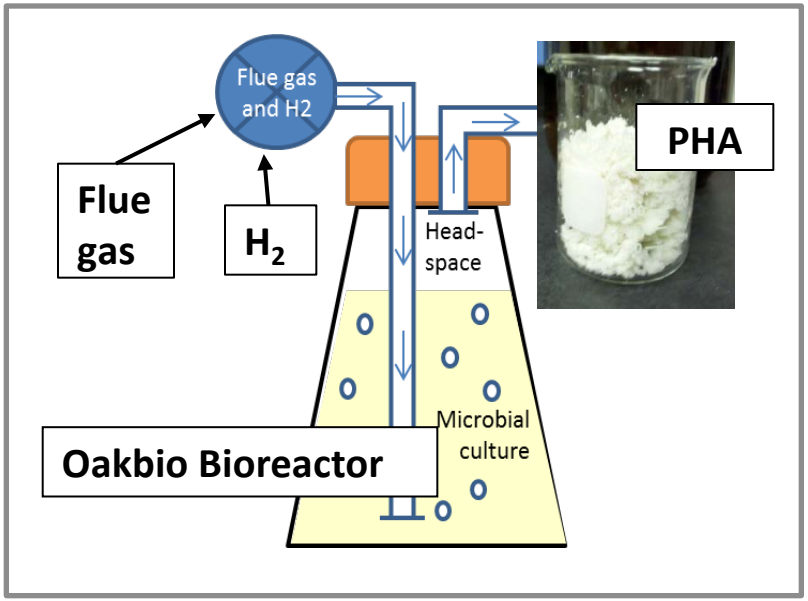
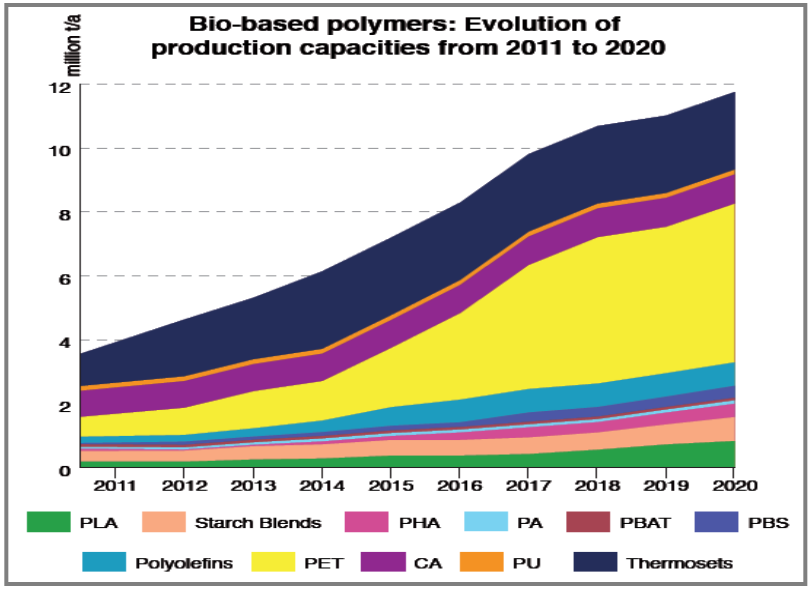
Oakbio – results trials 2012 in Lehigh-Permanente





- Trial successful at Lehigh plant
- PHA biopolymer good quality
- Process efficient with kiln flue gas
- Oakbio is scaling up technology (secured 0,5 mio $ fund in Canada)
- High costs H_2 to be compensated by high market value per ton of PHA (market constraints)
- Further next steps under discussion with Oakbio

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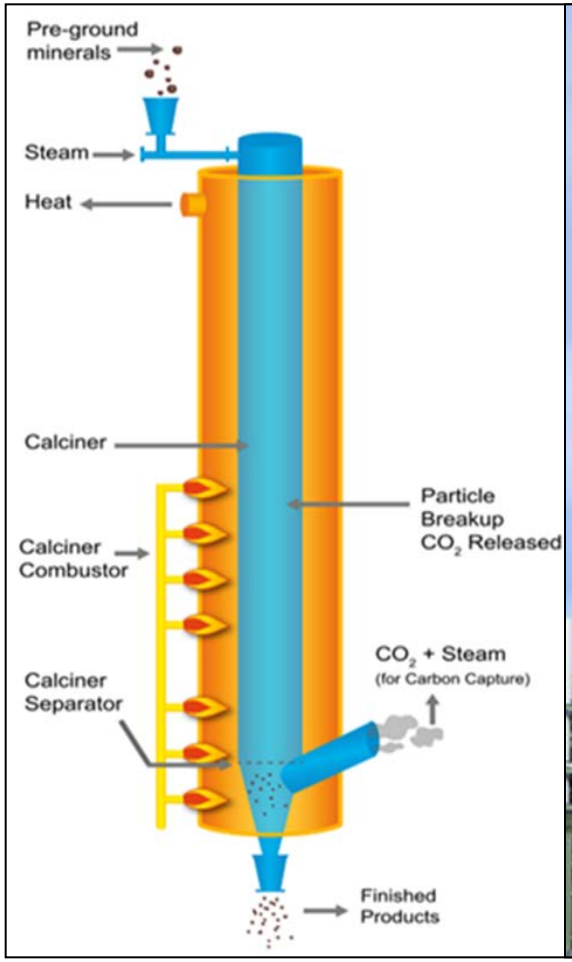
CO_2 separation during calcining; target EU fund

- **CALIX Australia**
  - HeidelbergCement
  - Lhoist, L-Tarmac
  - Cemex
  - Foster Wheeler
- **Indirect heating raw meal:**
  - process related CO_2
  - 99% pure CO_2
- **MgO-facility in Australia**
- **Lime + Cement demo plant 10 tph in Lixhe**
- **EU-Horizon 2020**
  5 May 2015 applied



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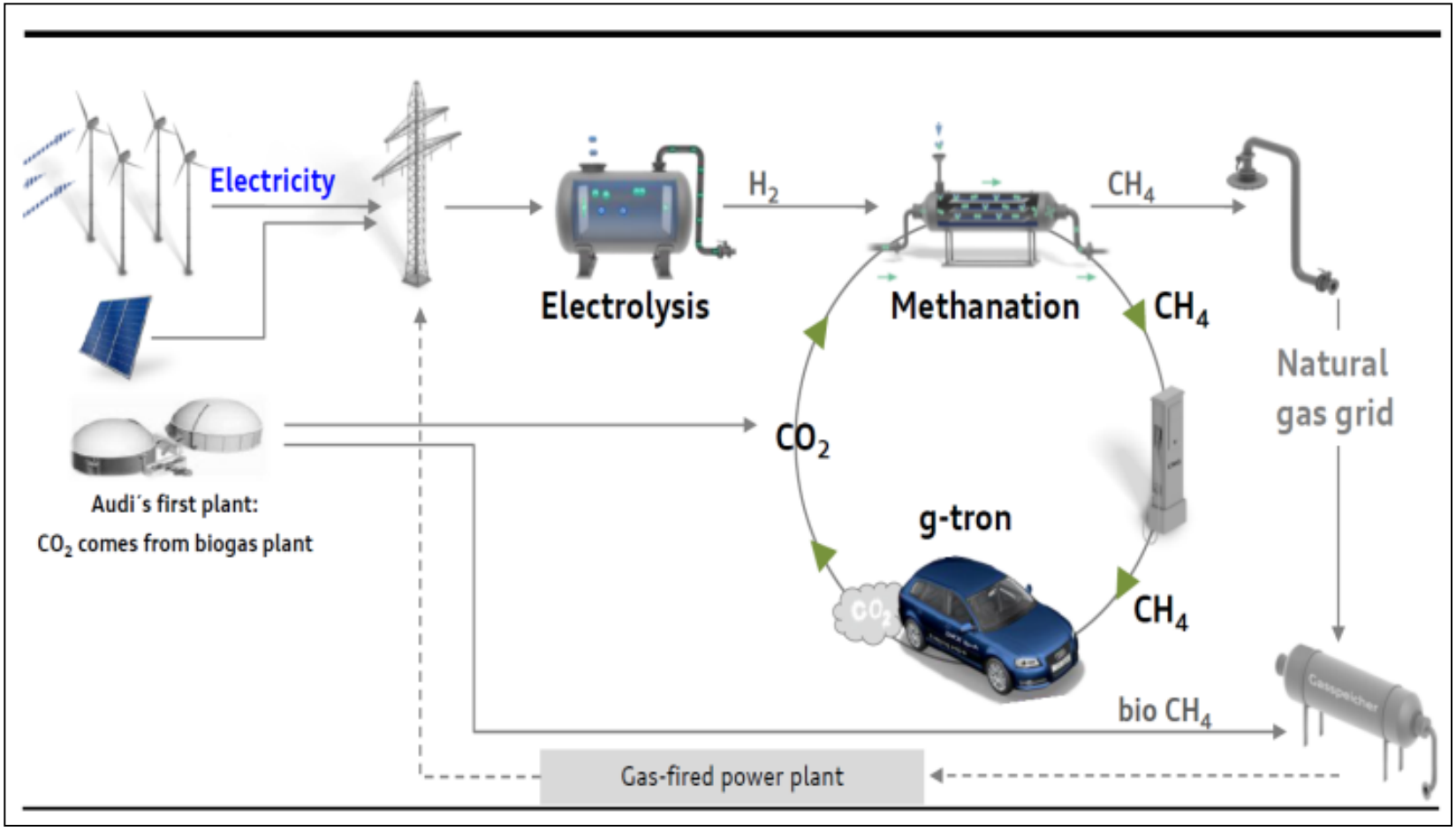
CO_2 to methane using H_2



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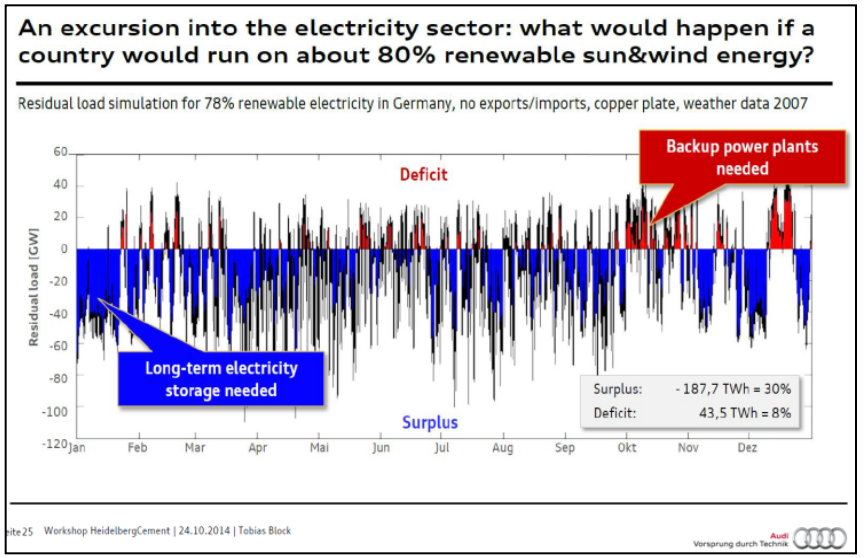
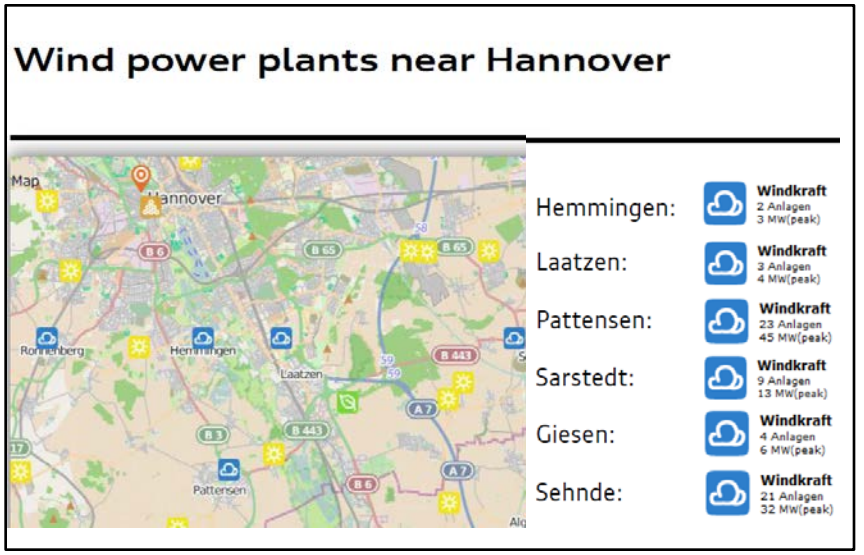
Study to potential in Hannover - Germany

- **>80% of production costs is electricity**
- **Only feasible if:**
  - electricity for “nearly free”
  - produced methane is subsidized as renewable
  - Country will increase wind + PV to high levels (>> 30%)
- **Hannover hot spot of wind & solar panels**

  → frequent “grid overload”





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From CO_2 to light weight aggregates

- Incinerator ashes
- By-pass dust
- Quarry fines

http://www.c8s.co.uk/technology.php

+ CO_2 =

UK's Carbon8 wins permission to more than double production of carbon negative aggregates

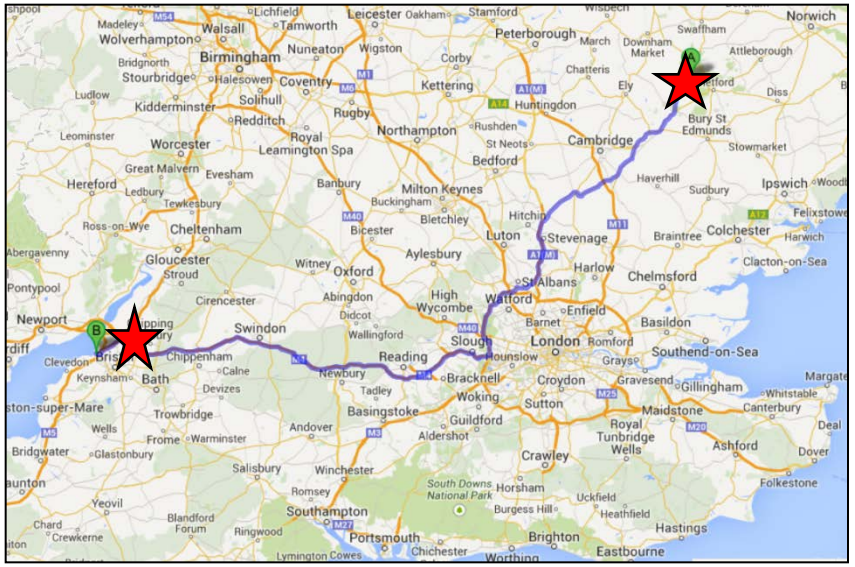
First published on www.AggBusiness.com

Pioneering carbon negative aggregate specialist Carbon8 Aggregates is set to more than double production after gaining planning permission to build a second manufacturing facility at Avonmouth, near Bristol, southwest England.

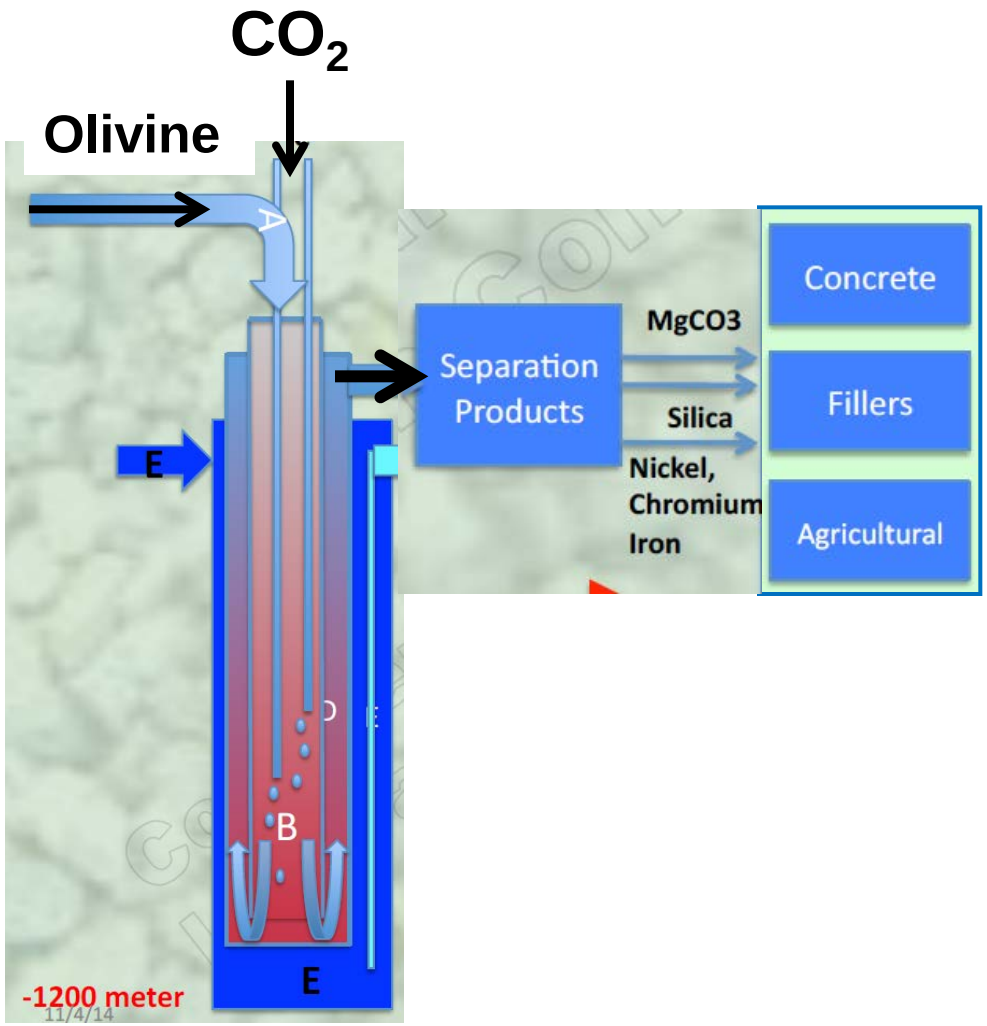
Work on the €5.1 million (£4 million) project will begin later this year and the plant is expected to be fully operational by early 2016, more than doubling Carbon8's ability to meet rising construction industry demand for its high quality, lightweight aggregates.

Using an award-winning patented technique known as Accelerated Carbonation Technology

The size of this Carbon8 ball, pictured beside the Severn Bridge in southwest England, shows the equivalent of capturing 4,000tonnes of CO2 a year – the amount Carbon8's new Avonmouth facility will capture annually



Olivine transformed by CO_2 to cement additives



- **R & D phase**
- **University of Leuven**
  - Sibelco (Olivine)
  - University Delft - NL
  - Innovation Concepts (small private company)
- **350 kg CO_2 / t product**
- **Value of products??**
- **Product could be within HC-business lines**
- **Horizon 2020 next step?**

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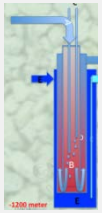
Benchmarking

0,06		Oakbio	Joule	Methanation	Carbon8	Olivine
						
CAPEX / t CO2	€/t CO2	++	++	-	+	+++
capture intensity	t CO2 / t product	+++	++	+++	-	+
land-intensity	m2 / t CO2	+++	-	++	++	+++
efficiency	%		+	++		
electricity cost @ 60 €	€/t CO2	-	0	-	+	++
product value / t CO2	€/t CO2	+++	++	++	++	+
size of market / availability raw materials		-	++	+	+	+
development stage		pilot	pilot	semi-comm	comm	R&D

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CO_2 will become a valuable asset…

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