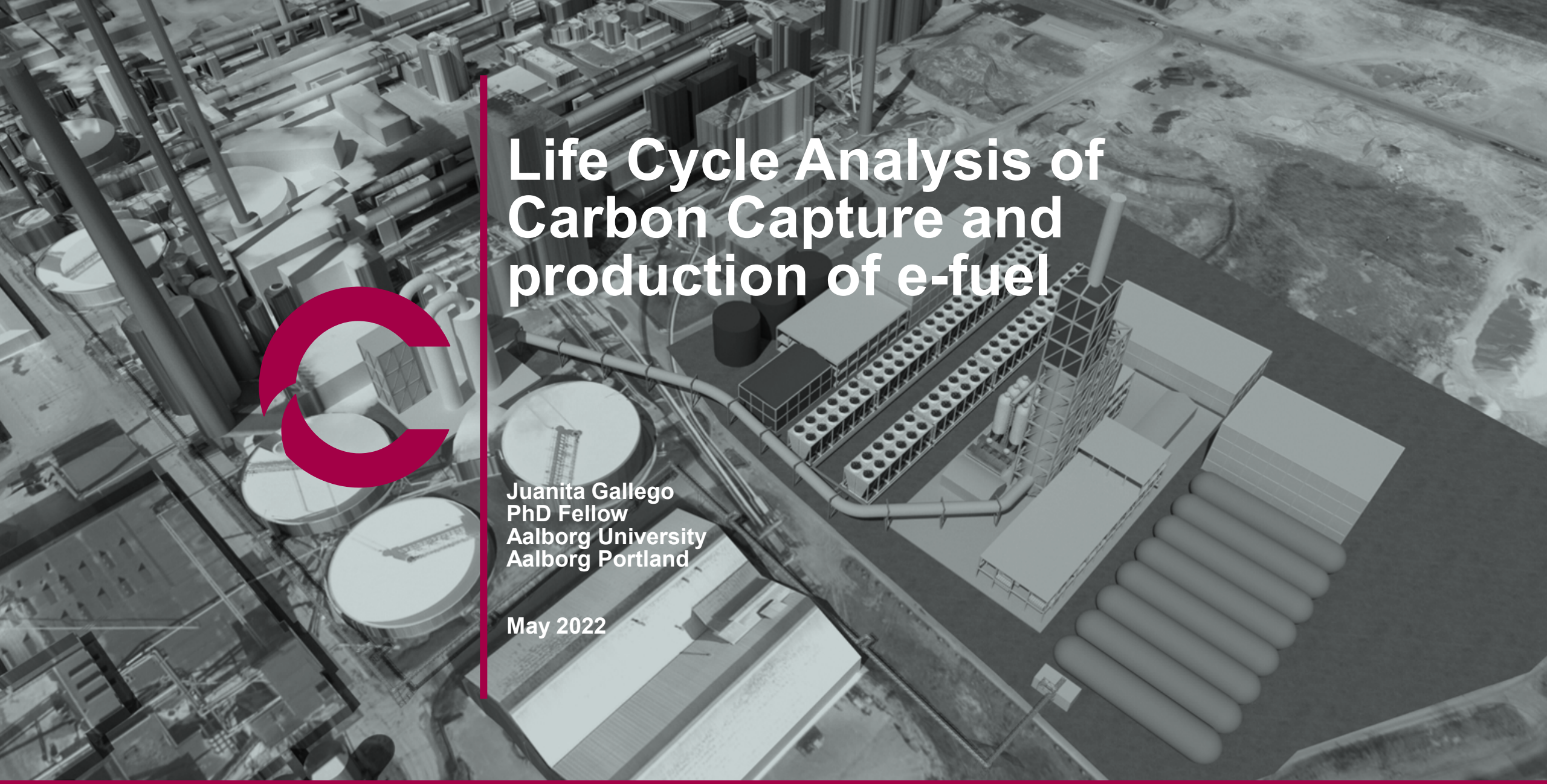

Life Cycle Analysis of Carbon Capture and production of e-fuel

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May 2022

The relevance of doing LCA for CCUS projects

CellPress

One Earth

Review

Limits to Paris compatibility of CO_2 capture and utilization

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De fleste metoder til at fange og genbruge CO2 lever ikke op til Parisaftalen

Flere af metoderne risikerer at udlede mere CO2, end de opsuger, viser et nyt studie, hvor forskerne har gennemgået 74 teknologier til at opsamle og anvende CO2.

Energy penalty

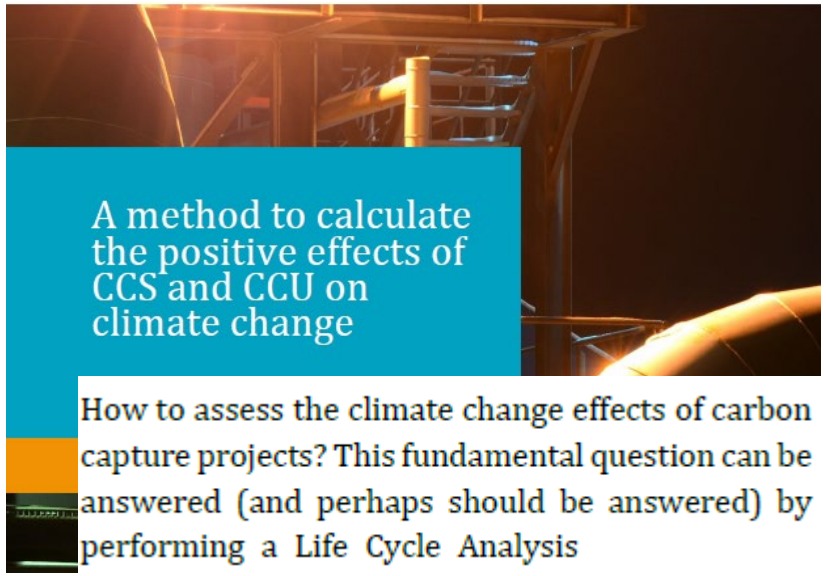
← Tweet

Mark Z. Jacobson
@mzjacobson

Why carbon capture is a "boondoggle" that increases air pollution and mining while hardly reducing CO2 on @Cheddar TV with @jd_durkin

cheddar.com/media/white-ho... @Stanford @StanfordWoods @cee_stanford @elonmusk @ssteingraber1 @howarth_cornell @ProfStrachan @BrianVad @ChristianOnRE

The relevance of doing LCA for CCUS projects



"more research on the environmental impacts of CCUS is required to provide the theoretical basis for the implementation of carbon capture and storage in cement production" An et al. (2019)

"Net emission reductions must be determined specifically for each technology through life cycle assessments" Naims (2020)

Proper life-cycle assessments or analyses (LCAs) that are inclusive to all aspects of sustainability are a necessary tool for quantifying risk and feasibility of large-scale implementation of CCS. Widder et al. (2011)

Current literature on CCUS

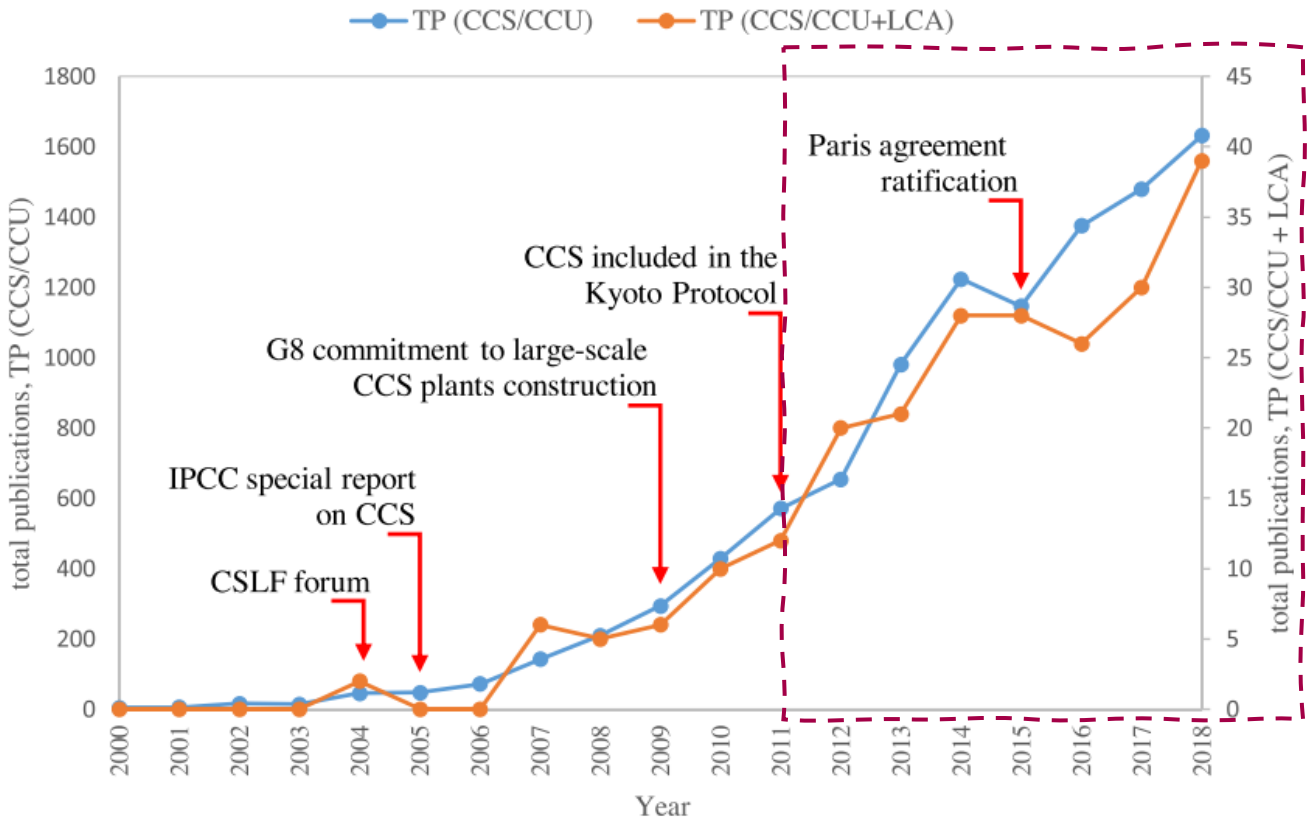


Fig. 3. The growth trends in carbon capture and LCA of carbon capture.

Source: Cruz et al (2021)

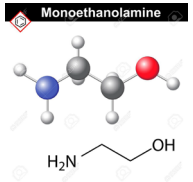
Search criteria

- ✓ Articles published between 2011 and 2021
- ✓ Articles looking specifically into the amine-based capture technology
- ✓ Articles including capture and storage activities
- ✓ Articles about production of methanol with captured CO_2
- ✓ Articles looking simultaneously into utilization and storage

Current literature on CCUS: key findings from 117 articles

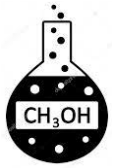
Most of studies analyze CCUS implementation in the power sector generation

<u>Only four in the cement sector</u>



The majority of articles model the chemical absorption process using MEA

3.8GJ/tonCO_2
2.6kg/ton CO_2



The production of methanol from recycled CO_2 has the greatest potential for a short-term deployment from other utilization options

Only makes sense when using green energy

Only two studies assess the life cycle environmental impacts of <u>all the CCUS</u> value chain

Only one study considers the temporal dimension

Life Cycle Assessment for the Greencem project

System under assessment

Capture capacity: 1.1-1.3 MtonCO_2/year

Energy requirement for amine regeneration: 2.5GJ/ tonCO_2

Amine make-up: 0.5Kg/tonCO_2

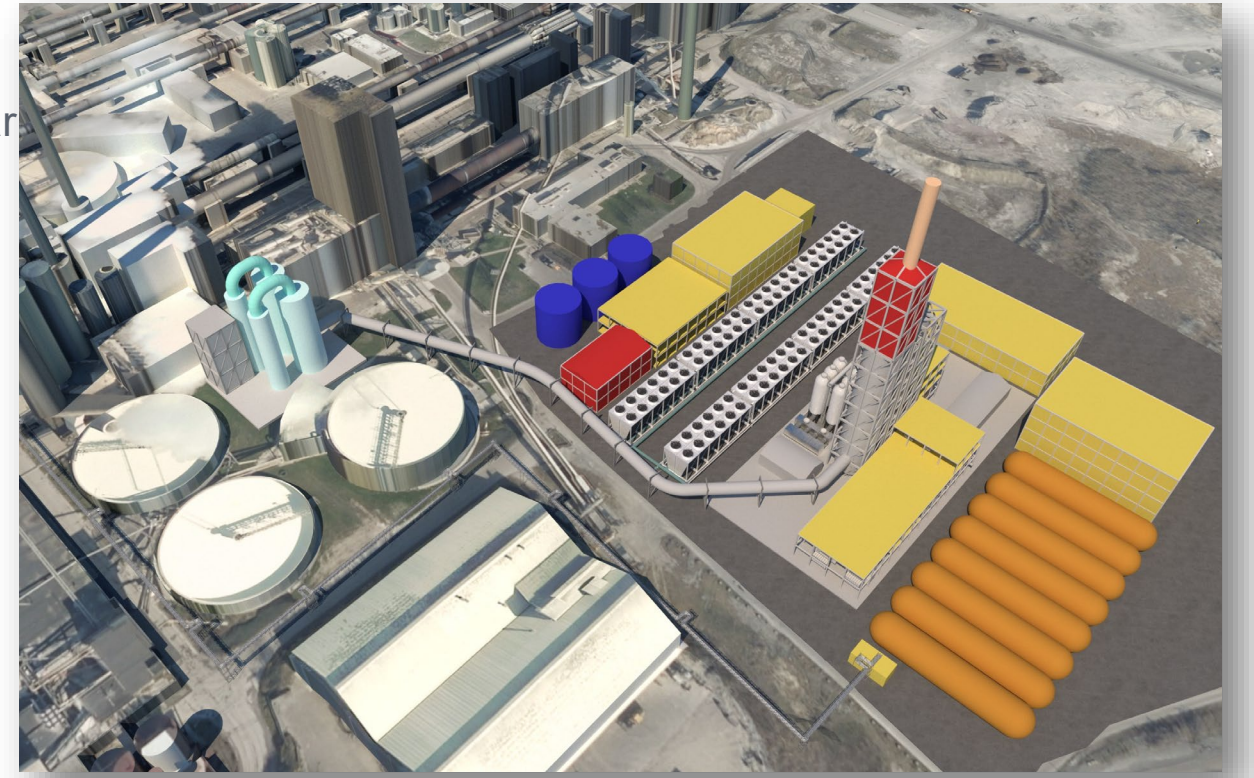
3 steam sources: El-boiler, gas boiler, Heat Pump

Transport by ship

Injection in a depleted oil gas located in the North Sea, at 480Km

Deliver of **biogenic** CO_2 to PtX and methanol production

Deliver of excess heat to DH (Max 100MW)



Production and combustion of kerosene

Production of heat with electrical boiler

Scenarios

Years: 2020, 2030 and 2050

BAU and PA 1.5

CCS and CCUS

Type of LCA: cradle to gate

Functional unit: One ton of grey clinker

Results: When does CCS or CCUS deliver PA reduction goals?

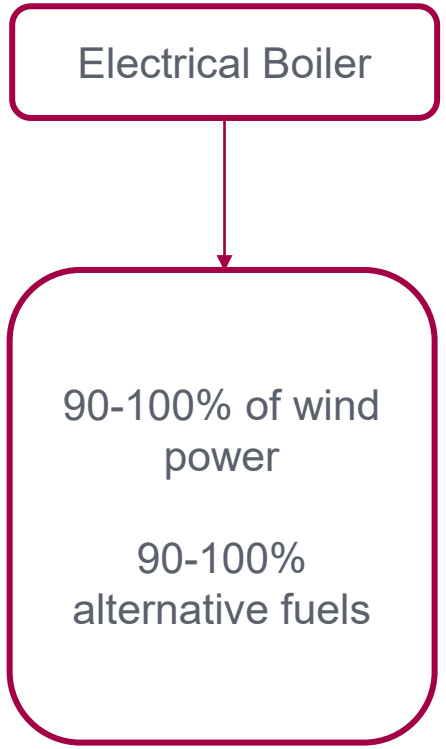
Reduction on Global Warming for one ton of clinker

	Paris Agreement (<1.5°C)					
	CCS			CCUS		
Year	El boiler	Gas boiler	Heat Pump	El boiler	Gas boiler	Heat Pump
2030	84%	85%	85%	83%	84%	83%
2050	89%	89%	89%	88%	88%	88%

2030: 75% of wind power and 75% alternative fuels
2050: 100% of wind power and 75% alternative fuels

30% biogenic

Pre-conditions for reaching neutrality



Key messages

- CCUS cannot deliver the climate targets without renewable energy sources, therefore, it is not a “competing” technology but a complementary one

> CCUS will be the third most important measure, after electrification and renewables, to achieve net zero emissions. IEA, 2020

- The condition of neutrality can be delivered on the conditions of a high share of biogenic sources for fuels in the clinker production. Nevertheless, the availability of biogenic sources is limited and constrained

- There are not great differences between CCS and CCUS as long as the methanol is produced with biogenic CO_2 and it replaces kerosene or fossil fuels

Thank you

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