

ECCSTAZE

Publieke samenvatting / Public summary

Aanleiding

The EU and the Netherlands want to operate fully sustainable and CO₂ neutral by 2050. Amine-based CO₂ absorption technology is well established but usually designed to capture only 90-95% of the CO₂, while operating at high energy requirements in the range of 2.4 to 4.2 GJ/tCO₂. Moreover, CO₂ is produced at low pressure (1.6 to 1.8 bar), requiring expensive compression for transportation and reuse or storage. To reach 99+% capture, costs increase exponentially. Therefore, achieving zero or even negative emissions with conventional amine technologies is not cost-effective. In this project, ECCSTAZE, we will develop a circular, sustainable and green CO₂ capture process that only uses electricity as energy input, and an aqueous hydroxide solution, in situ produced in a membrane, as solvent. As only product, clean CO₂ at higher pressure (10 bar) is obtained that can be directly used for CO₂ storage and utilization. Deep CO₂ removal and a final CO₂ concentration in the flue gas stream lower than 50 ppmv can be achieved, which for post combustion capture implies a capture rate above 99.9% – greatly minimizing residual (non-captured) CO₂ emissions.

Doelstelling

ECCSTAZE will develop a green, fully sustainable innovative electro-membrane (EM) based CO₂ capture process: CO₂ is captured in a hydroxide solution forming carbonates. Next a novel regeneration step is performed combining neutralization and an EM process: first, the CO₂-loaded carbonate solution is neutralized with a green organic acid obtained from bio-fermentation,

Projectinformatie / Project information

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Algemene informatie / General information

Penvoerder / Secretariat
Technische Universiteit Eindhoven

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releasing the CO₂ at higher pressure, avoiding expensive compression steps. Next, the remaining, CO₂-free salt solution is sent to an EM process regenerating the hydroxide and the acid such that both can be recycled and reused in the next CO₂-absorption cycle. The bipolar, anion and cation exchange membrane used in the EM process and used for the proof of concept are commercially available membranes not designed and not at all optimized for this process. Also, their production requires petroleum-derived organic solvents restricted by the EU (REACH legislation). The focus thus is on development of membranes using fully sustainable water-based layer-by-layer membrane modification and electrospinning with green solvents and their performance evaluation in a bench scale absorption-regeneration process.

Korte omschrijving

The project consists of four work packages. A bipolar, anion and cation exchange membrane are developed and produced using fully sustainable water-based layer-by-layer membrane modification and electrospinning with green solvents. Developed membranes will be characterized and subsequently built in the EM stack to test their performance with model and real solutions. During the experiments, not only the membrane composition and EM module configuration will be studied, but also the optimal hydroxide and organic acid concentrations will be identified as well as membrane fouling and control. Ultimately, the developed tailored EM stack will be integrated in a bench scale setup to evaluate the total process performance. The project will also include an LCA and cost estimation of the EM device and process. Furthermore, a business case will be developed for application in the flue gas stream of a waste-to-energy plant and compared to amine-based absorption. This will include process modelling for scale-up, detailed engineering of the CO₂ capture process, a technical economic analysis and cost calculation. Finally, a market survey will be performed.

Resultaat

ECCSTAZE develops a technology allowing a wide

range of industries to become carbon neutral or even carbon negative, leading to significant reduction in cost to achieve Dutch (and EU) carbon neutrality goals. More specifically, ECCSTAZE will develop a green, fully sustainable innovative EM regeneration device at cost-effective operation to be integrated in the circular CO₂ capture process. To reach that, the focus is on the development and production of a bipolar, an anion and a cation exchange membrane including performance evaluation in a bench scale absorption-regeneration process. Finally a large scale process will be designed and a techno-economic evaluation, an LCA, business case and market study will be performed. In 2022, the industry and power sector in The Netherlands emitted 79.1 MtCO₂-eq. With amine-based technology, still 7.9 MtCO₂ (10%) not captured CO₂ would be released to the air each year and carbon neutrality is not obtained. With current prices this represent of €1.6-4.7 billion. Oppositely, ECCSTAZE's technology is designed for deep removal: the process will capture 99.9+%, so the energy requirements will be significantly lower targeting 35-45 €/tCO₂ only.

De data in deze applicatie is afkomstig van de Rijksdienst voor Ondernemend Nederland (RVO) en wordt in samenwerking met de Topsector Energie ontsloten.

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