Electric Decade Workshop 17.01.2024

ēQATOR: Electrically heated catalytic reforming reactor

Richard H. Heyn, Project Coordinator

Chief Research Scientist, SINTEF Industry, Oslo Norway

rhh@sintef.no

Funded by the European Union

ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.

Project information

- June 2022 – November 2025
- Project budget 8.544 M€
- Project grant 7.536 M€

SINTEF
Coordinator

NextChem
Maire Tecnimont for Energy Transition

MCI
THE ENTREPRENEURIAL SCHOOL

University of Stuttgart
Germany

MEΔM

Steinbeis
Europa Zentrum

PSTd'A
Parco Scientifico e Tecnologico d'Abruzzo

walter tosto

cnrs

KERAMIK INNOVATION
BERTHOLD

Ranido

ifeu
INSTITUTE FOR ENERGY AND ENVIRONMENTAL RESEARCH HEIDELBERG

EBA
European Biogas Association

equinor

JM

Funded by
the European Union

ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.

Renewable carbon needed for green transition

- Energy can be *decarbonised*. Chemicals and materials must be *defossilized*.
  - Make chemicals and materials from renewable carbon sources rather than fossil carbon sources
  - CO_2, biomass, recycled carbon materials (i.e., plastics)
- Biogas is an attractive source of renewable carbon
  - Ca. 50:50 mixture of CH_4 and CO_2
  - Agricultural
  - Urban (organic fraction of municipal solid waste)
  - 35 Mtonne produced in 2018
  - Estimated growth 4.4 % p.a.
- Biogas currently used *only* for energy production
  - CH_4 separated, CO_2 emitted

Utilization of biogas for chemicals production – specifically methanol (CH_3OH or MeOH) via dry reforming – will defossilize some MeOH production and promote development of local MeOH economies.

Funded by the European Union

ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.

MeOH production today

- MeOH is an important base chemical
  - Global market size ca. 98 Mtonne
  - Used as fuel, starting point for many chemicals and polymers
  - World class plants produce up to 3 Mtonne/a

- Production via steam reforming of natural gas to syngas (mixture of CO and H_2), then syngas to MeOH
  - Fossil carbon is both the carbon feedstock and the energy source
  - Reactor heating produces 350 kg CO_2 per 1000 Nm^3 syngas
  - Product related emissions are 307 kg CO_2 per 1000 Nm^3 syngas
  - Emissions account for 10 % of the CO_2 emissions from the chemical sector

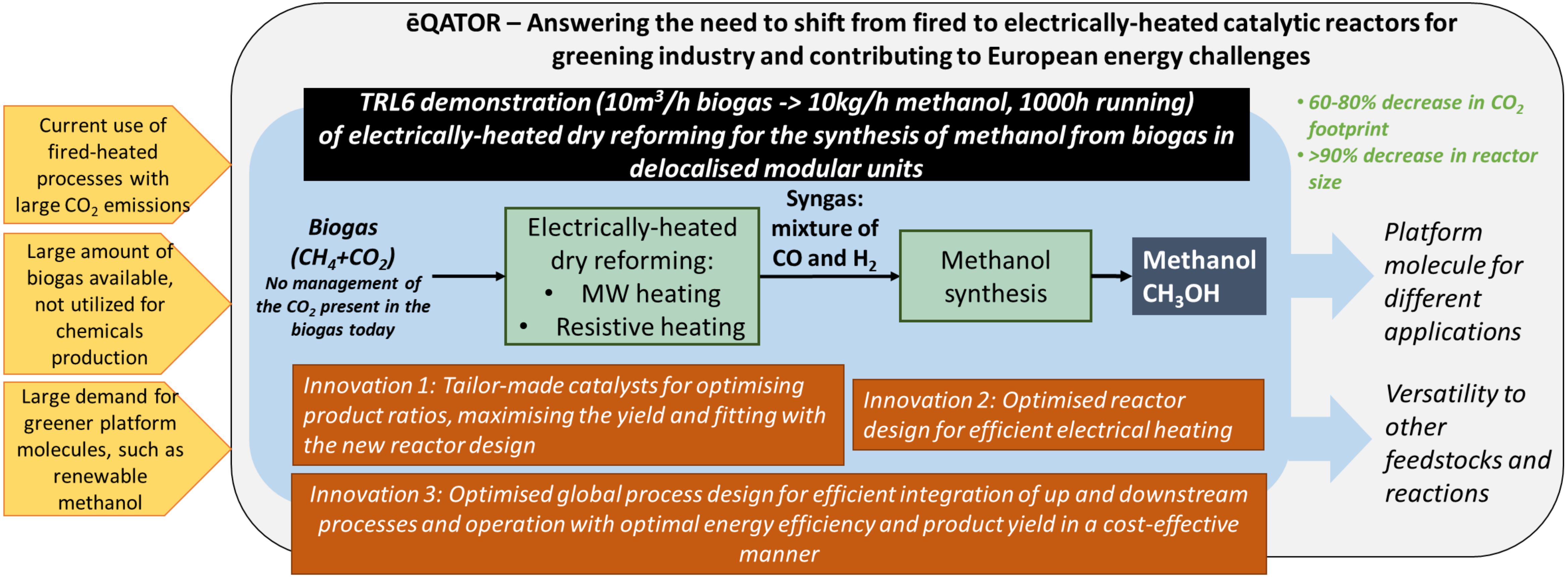
- About 0.2 Mtonne renewable MeOH produced/a
  - Primarily from CO_2 and H_2 (CCU approach)

Funded by the European Union

ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.

Project objectives

- Syngas from the dry reforming of methane (CH_4 + CO_2), rather from steam reforming of methane
  - More difficult reaction, more prone to coking

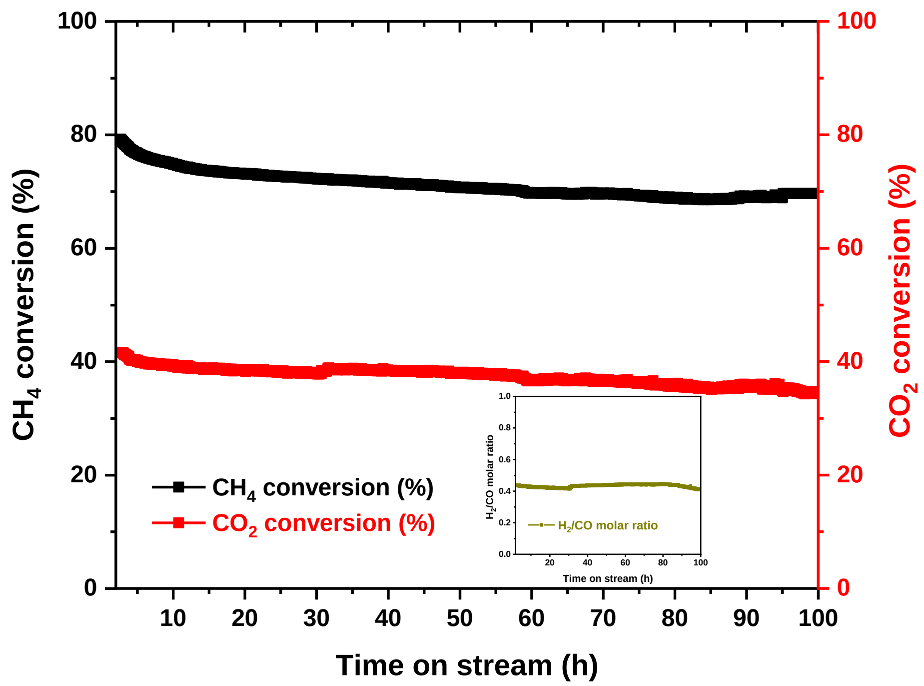


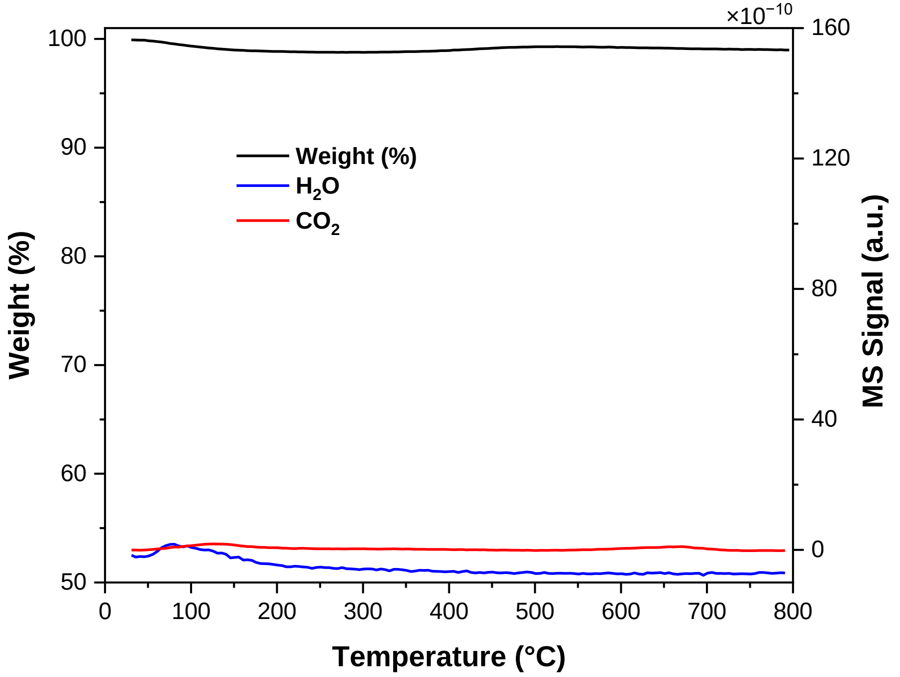
Funded by the European Union

ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.

Catalyst and process development

- Catalyst coking needs to be minimized/avoided
- Processes developed that provide gas mixtures with minimal coking potential
  - Dry Reforming (CH_4 + CO_2) for a biogas composition produced from the organic fraction of municipal solid waste
  - Mixed Reforming (CH_4, CO_2, H_2O) for a biogas composition produced from agricultural residues (manure)
- Catalyst composition found that shows minimal coking with the Dry Reforming gas mixture over 100 h

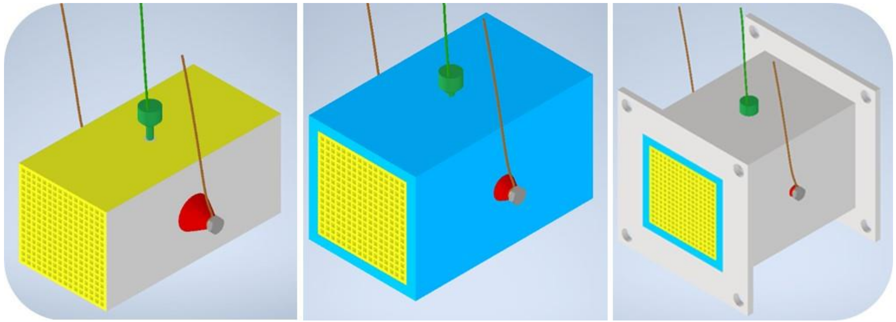




Funded by the European Union

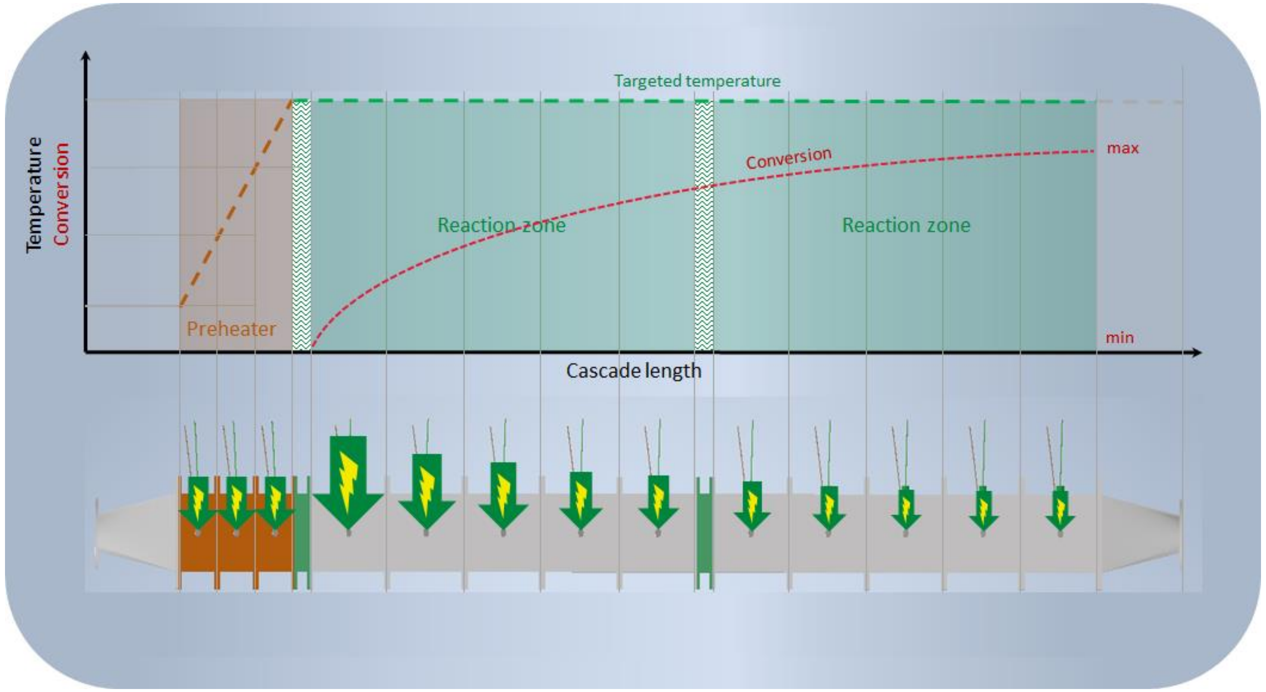
ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.

Reactor development – resistive heating reactor



Coated honeycombs with electrodes, fiber mats, and metal housing

T = 1100 °C



Schematic temperature profile and conversion over cascade length – differentiated power supply possible

Funded by the European Union

ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.

Electrically Heated Reactors

Key Impacts

ēQATOR provides an integrated development of catalysts and reactors, and two different, complementary electric heating technologies: **resistive heating** and **microwave heating**

Reduction of carbon dioxide emissions by 60-80 % compared to current syngas production processes. This reduction will **save from 7 Mt CO_2 per year in 2030, up to around 45 Mt CO_2 per year in 2045.**

Higher conversion per pass, improved heat management, **higher energy efficiency** and better carbon utilisation and atom economy, in **more compact reactors**, using renewable carbon feedstock.

Strong industrial commitment to reach widespread deployment of catalytic process electrification, through economically-viable, local, smaller-scale methanol production from biogas.

Novel, **optimised catalysts** and **reactor designs** for biogas valorisation to methanol.

Funded by the European Union

ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.

Pathway to TRL 9

- Project will reach TRL 6 by project end
  - Demonstration of resistive heating and microwave heating with two different gas mixtures
  - Dry Reforming (only CO_2 and CH_4) and Mixed Reforming (CO_2, CH_4, H_2O)
  - 10 Nm^3/h feed for 1000 h
  - Methanol production step studied on modelled gas from syngas compositions

- Full-scale commercial plant anticipated to have feed of 500 Nm^3/h

- TRL 6 reactor design and construction aims to be fully scalable
  - Material selection suitable for larger scale
  - Parallel reactor configuration

- Next step (given caveats of a successful project with positive economic and environmental outlook)
  - Combined reforming and MeOH production at ca. 100 Nm^3/h scale

Funded by the European Union

ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.

Acknowledgements

- European Commission – Grant Agreement No. 101058293
- ēQATOR consortium

www.eqator.eu

ēQATOR project EU

@eqator_eu

ēQATOR - Electrically heated catalytic reforming reactors (Grant Agreement No 101058293). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting agency can be held responsible for them.