EUBCE
31st European Biomass Conference & Exhibition
IN PERSON, ONLINE 2023 | BOLOGNA. ITALY.

Biomass Low cost Advanced Zero Emission small-to-medium scale integrated gasifier-fuel cell combined heat and power plant (GA No. 815284)

# SOFC power production from BFB producer gas

J.P. Ouweltjes[*], A.M. Ferrario[§], D. Pumiglia[§], A.D. Wesoly[‡], S. Diethelm[*,‡]

[*]SolydEra S.A.- Yverdon-les-Bains - Switzerland
[§]ENEA Casaccia Research Centre – Roma - Italy
[‡]EPFL – Sion - Switzerland

6th June 2023 – European Biomass Conference and Exhibition (EUBCE) - Bologna (IT)

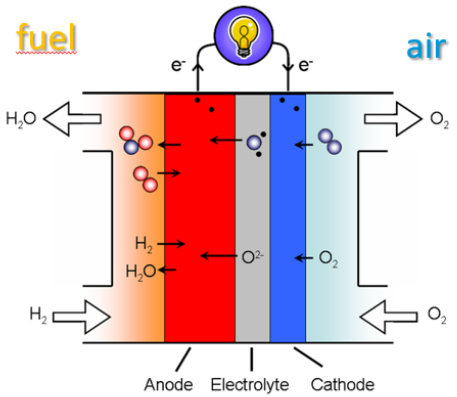
Parallel Event: High efficiency and low emissions CHP technologies from biogenic residues

# SOFC basics

Horizon 2020
European Union Funding
for Research & Innovation

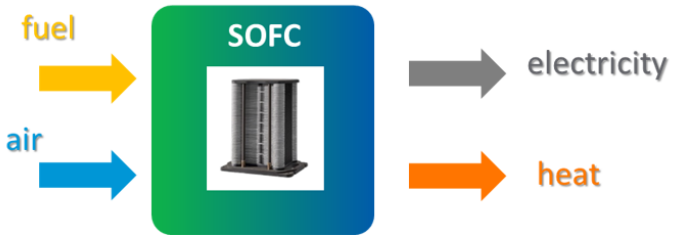
## Fuel Cell Technology

- Like a battery, a **fuel cell** generates electricity through an **electrochemical reaction**
- Electricity can be produced continuously 24/7, as long as a fuel is provided
- The device is **clean, highly efficient, reliable** and **silent** (no combustion, no moving part)
- Similar to a rechargeable battery, electric power can be also put into the fuel cell in reverse mode to **generate Hydrogen**




## SolydEra's SOFC technology

- SolydEra's fuel cells are **Solid Oxide Fuel Cells** ("SOFC")
- SOFC can operate using a **wide range of fuels**, including natural gas, hydrogen, propane/butane mixtures (LPG), ammonia, biogas and syngas
- SOFC offers high temperature **heat for cogeneration**






*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

# SolydEra at a glance

Horizon 2020
European Union Funding
for Research & Innovation

## Products

vertically integrated end-to-end fuel cell technology provider ready to enter green hydrogen production

Stack → Stack Module → Fuel Cell module → System

## Partners & Affiliations

BOSCH · Hydrogen Europe · Microsoft · EQUINIX · COGEN EUROPE

## Group structure

| HEINSBERG **GERMANY** | MEZZOLOMBARDO **ITALY** | PERGINE VALSUGANA **ITALY** | YVERDON **SWITZERLAND** | MELBOURNE **AUSTRALIA** |
|---|---|---|---|---|
| Assembling | R&D, Pilot Production | Stack Manufacturing, Head Quarters | R&D Center | R&D Center |

## Facts & figures

- **2,700+** units installed
- Products sales in **17** countries
- **250+** customers
- **60M** hours of operation
- **80 GWh** energy produced

6th June 2023 – European Biomass Conference and Exhibition (EUBCE) - Bologna (IT)

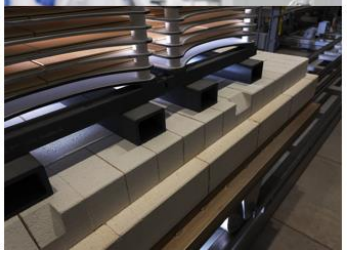
SolydEra

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

# SolydEra at a glance

Horizon 2020
European Union Funding
for Research & Innovation

## AUTOMATED STACK MANUFACTURING PLANT

**25 MW**
on 2 shifts

**1mn**
cells/year

**60**
stacks/day

6th June 2023 – European Biomass Conference and Exhibition (EUBCE) - Bologna (IT)

SolydEra

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

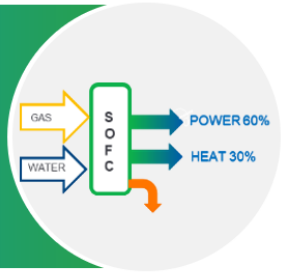
# SolydEra at a glance

Horizon 2020
European Union Funding
for Research & Innovation

## One stack – multiple applications

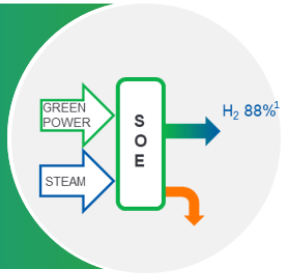
### GAS-TO-POWER

High efficiency Power and Heat production by using multiple fuels, including natural gas, H2 and H2/gas blends




### POWER-TO-GAS

Conversion of steam into H2 by using electricity for hard-to-abate industrial sectors and transportation




### POWER-TO-POWER

Reversible SOFC systems integrated with $H_2$ storage in order to decouple electricity production and use


## Applications

**Industrial solutions**
Integration of stacks for electrolysis and industrial sectors (*e.g.* green steel, synthetic fuel, marine sector, chemical industry)

**Professional solutions**
Integration of fuel cell modules into technical solutions of professional integrators (*e.g.* data centres)

**Commercial solutions**
Sales of power generators and co-generators to commercial customers (residential, retail, hospitality, offices, transport)

6th June 2023 – European Biomass Conference and Exhibition (EUBCE) - Bologna (IT)

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

# SOFC activities in Blaze


Supply of SOFC unit for demonstrator:

- Power output 25 kWe, integrating 4 stacks of 6.5 kWe
- Fuel: hydrogen or steam-reformed methane, with a maximum convertible $H_2$ flow of 280 slm, or a maximum convertible $CH_4$ flow of 70Nl/min, at 80% fuel utilization
- Oxidant: Air, with a maximum tolerated flow 5600 slm
- Operating temperature » 750 °C (inlet 690, exhaust 790 °C)
- Maximum stack electrical efficiency: 50%
- Dimensions: 1699 x 792 x 1385 mm
- Weight: 1505 kg



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

# SOFC activities in Blaze

Supporting activities:

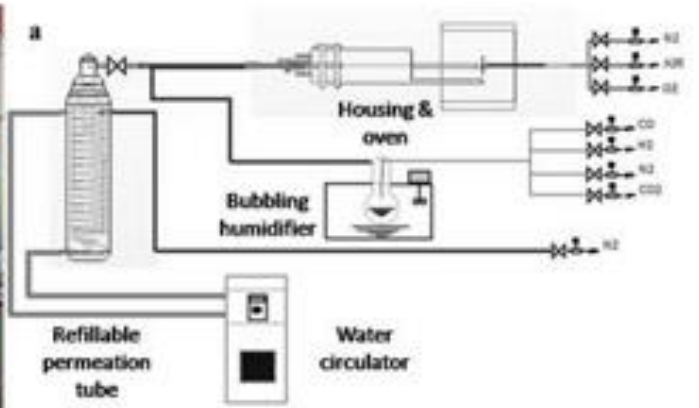
- Literature study about feeding SOFC with producer gas (SolydEra)

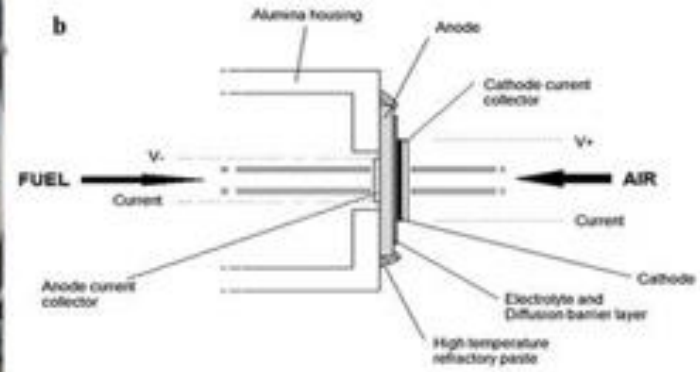
- Extensive experimental research
  - Mechanistic study  on single cells (ENEA)
  - Long term tests on small stacks (EPFL)



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

# SOFC activities in Blaze




6th June 2023 – European Biomass Conference and Exhibition (EUBCE) - Bologna (IT)

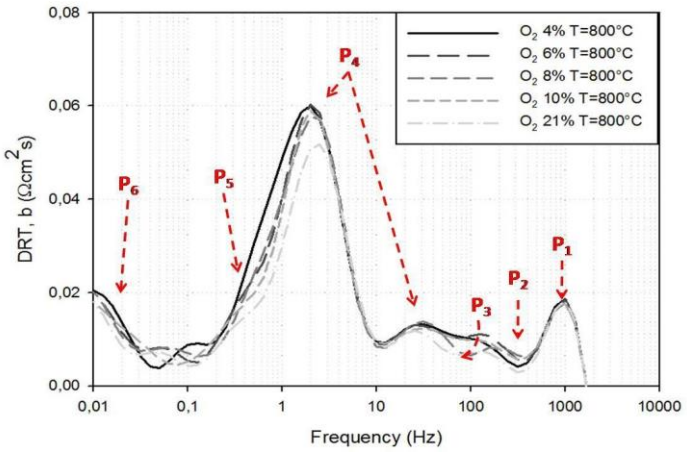
*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

# SOFC activities in Blaze

Horizon 2020
European Union Funding
for Research & Innovation

Approach mechanistic study:

- Impact of main compounds in producer gas
- Impact of fast tars (here: toluene)
- Impact of slow tars (here: naphthalene)
- Impact of sulphur
- Combined effects
- Durability up to 150 h




Extensive test matrix executed, including electrochemical impedance spectroscopy (EIS).



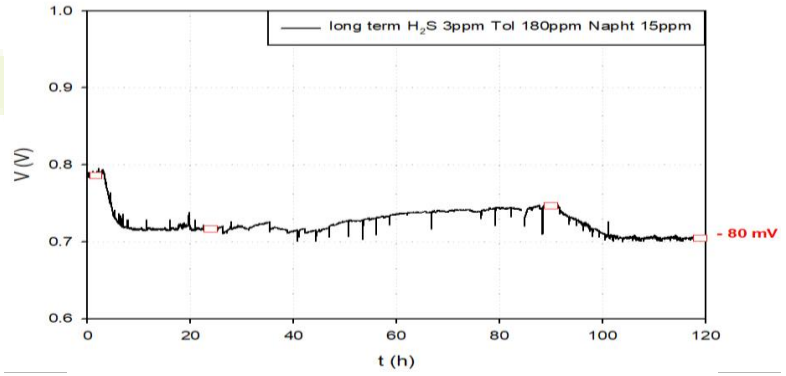
*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

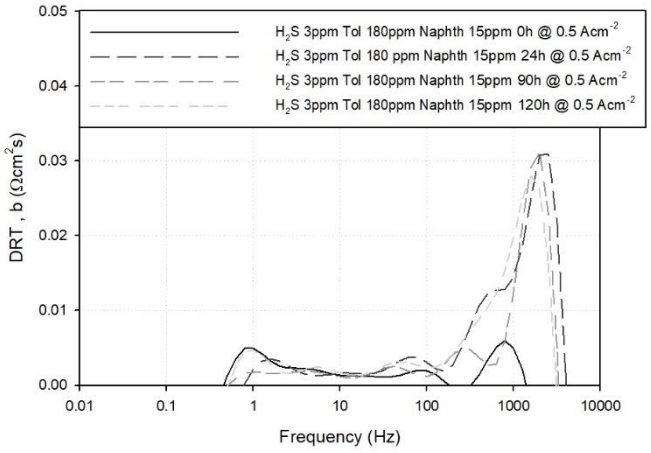
# SOFC activities in Blaze

Horizon 2020
European Union Funding
for Research & Innovation

Outcomes mechanistic study:

- Performance OK under clean producer gas
- Deactivation under naphthalene and S
- No deactivation under toluene, but test time was perhaps too short
- Sometimes alleviating effects observed when contaminants were simultaneously introduced
- Poisoning generally by deactivating charge transfer reaction in fuel electrode



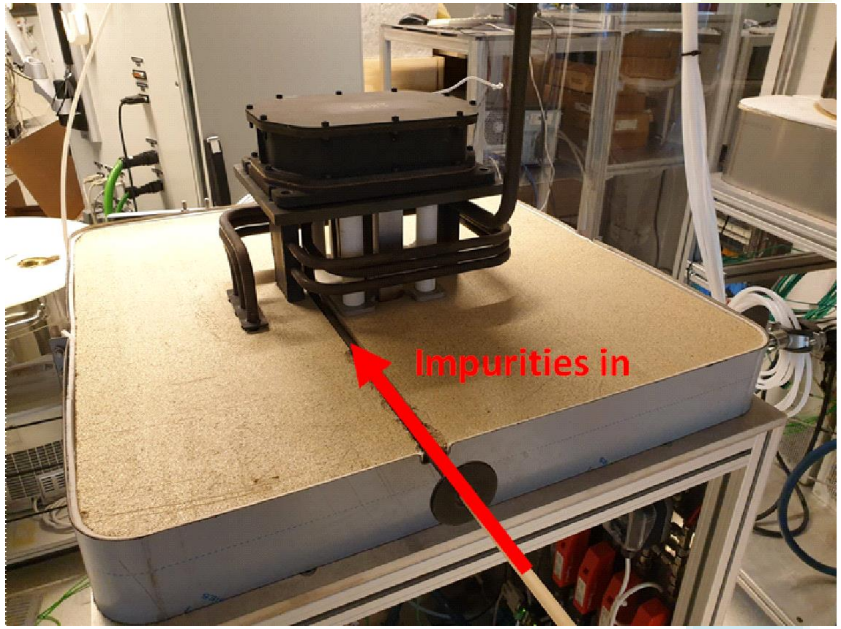

Post mortem analysis:

- No signs of poisoning, which indicates of adsorption/desorption poisoning mechanisms



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

# SOFC activities in Blaze




Three long term tests on short stacks:

- 9000 h test under clean producer gas
- 7000 h test including S + toluene
- 5500 h test including S + toluene + HCl (still running)

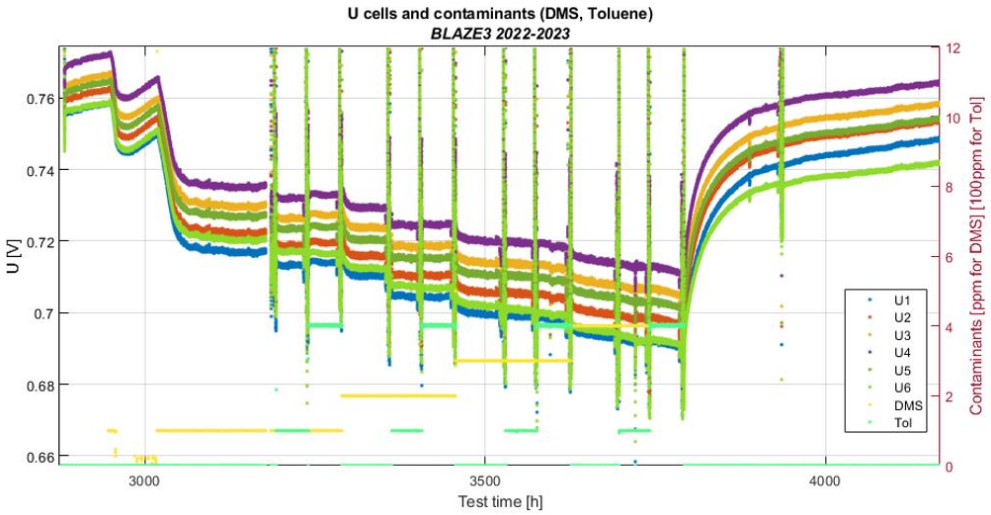
Extensive electrochemical characterization by recording I-V curves and performing EIS

Gas analysis on both feed and exhaust gases



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

# SOFC activities in Blaze




Outcomes:

- Performance OK under clean producer gas: degradation 0.5% $kh^{-1}$
- Stronger poisoning effect S than observed at ENEA (already at 0.2 ppm)
- No impact of toluene up to 400 ppm
- Poisoning S not alleviated by toluene
- Impact of HCl not yet determined



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

# Conclusions

To cut the long story short:

- 25 kWe SOFC unit from SolydEra will work well with clean producer gas
- Detrimental contaminants: S and naphthalene (representing slow tars)
- Likely not harmful: toluene (representing fast tars)
- To be confirmed: tolerance level of HCl (expectedly > 500 ppm)

Approach for final demonstrator:

- Conservative approach regarding contaminants → deep cleaning on all compounds

Long term outlook:

- Larger deployment of SOFC in CHP generation form producer gas
- Both small to medium sized systems (25 – 500 kWe)
- Further cost reduction and appropriate scaling of SOFC anticipated



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*

BLAZE

Horizon 2020
European Union Funding
for Research & Innovation

# *Thank you for your attention*

janpieter.ouweltjes@solydera.com

6th June 2023 – European Biomass Conference and Exhibition (EUBCE) - Bologna (IT)

SolydEra

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815284*