# SOLID OXIDE ELECTROLYSIS EXPLAINED

# TOPSOE

**Hydrogen & P2X** June 15-16th 2022, Copenhagen, Denmark Christian Wix Product Owner, PtX

## **TOPSOE AT A GLANCE**



# SECTORS RESPONSIBLE FOR A LARGE PART OF GREENHOUSE GAS EMISSIONS

# CREATING NEW SOLUTIONS FOR HARD-TO-ABATE SECTORS



Source: Climate Watch, the World Resources Institute (2020)

# **OUR AREAS OF EXPERTISE**



# **TOPSOE HAS THE NECESSARY BUILDING BLOCKS**







**Renewable fuels** 



Methanol

Ammonia

NH<sub>3</sub>







**Carbon monoxide** 



# **TOPSOE'S POWER-TO-X SOLUTIONS ACCELERATE THE ENERGY TRANSITION**



# SOEC'S ADVANTAGES BECOMES SIGNIFICANT AT PLANT LEVEL



## DYNAMIC AMMONIA PRODUCTION FOR FLUCTUATING POWER SUPPLY

![](_page_7_Figure_1.jpeg)

## **Advantages** Power-to-ammonia

- Fully flexible operation 10-100% plant load
- No hydrogen storage
- Store energy as ammonia
- Grid balancing

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### TOPSØE AMMONIA CRACKING TECHNOLOGY FROM OLD TO NEW

![](_page_8_Picture_1.jpeg)

## 10 - 500 MTPD hydrogen:

- Operation pressure 30-50 barg
- PSAs for hydrogen separation – 99.9% purity
- 0 ppm ammonia in H<sub>2</sub>
- Approximately 10% energy loss on LHV basis

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# TOPSOE HIGH EFFICIENCY AMMONIA CRACKER ENSURES NEAR TO FULL CONVERSION OF THE AMMONIA FEED TO HIGH PURITY HYDROGEN

![](_page_9_Figure_1.jpeg)

# THE DEVELOPMENT PATH OF TOPSOE'S SOEC TECHNOLOGY

#### Solid Oxide Fuel Cell (SOFC) developed in the '80s

- SOFC cell and stack can also be used as SOEC
- Electrolysis of both water and CO<sub>2</sub>

#### Focus on SOEC since 2015

- Demonstration and industrial SOEC units since 2015
- SOEC cell and stack further improved

#### **Design of 500 MW SOEC stack manufacturing plant**

- Scheduled start-up in 2025
- Expansion to 1.1 GW/5 GW

![](_page_10_Picture_10.jpeg)

# HOW SOEC ELECTROLYSIS WORK

![](_page_11_Figure_1.jpeg)

#### CARBON MONOXIDE PRODUCTION FROM CARBON DIOXIDE AND RENEWABLE POWER

![](_page_12_Figure_1.jpeg)

# SOEC IS SIGNIFICANTLY MORE EFFICIENT THAN LOW TEMPERATURE ELECTROLYSIS

![](_page_13_Figure_1.jpeg)

![](_page_14_Picture_0.jpeg)

#### CARBON MONOXIDE PRODUCTION FROM CARBON DIOXIDE AND RENEWABLE POWER

![](_page_15_Figure_1.jpeg)

Demo site at National Lab, Denmark

- 50 kW Biogas upgrade
- 50 kW Ammonia Synthesis

Operating plant at customer site, USA
2 x750 kW ultrapure CO production

![](_page_16_Picture_4.jpeg)

![](_page_16_Picture_5.jpeg)

# A 20 MW SYSTEM WITH SOEC TECHNOLOGY

# SOEC ELECTROLYSIS OFFERS A WIDE RANGE OF ADVANTAGES

# Lower power consumption

![](_page_18_Picture_2.jpeg)

- SOEC has the highest efficiency of all electrolysers
- Without heat integration, SOEC is 20 % more efficient than alkaline and PEM
- With heat integration, SOEC is 30 % more efficient than alkaline and PEM

# Non noble materials

![](_page_18_Picture_7.jpeg)

- SOEC consists of materials that are abundant in nature and can therefore easily be scaled up without material availability constraints
- The use of non noble materials will benefit cost as the raw materials will not become more expensive due to scarcity

# Syngas creation

![](_page_18_Picture_11.jpeg)

- In addition to the electrolysis of steam, SOEC can electrolyse CO<sub>2</sub> and thereby generate CO
- CO<sub>2</sub> electrolysis enables carbon capture & utilization from a point source and provides advantages for making eFuels such as eJet, eDiesel and methanol

# THANK YOU. ANY QUESTIONS?

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