October 9, 2024

Zero-Electricity Electrolytic Reactor

DeLome Fair, Vice President, Engineering

UTILITY

Company Overview

Overview

Sector	**Off-Gas-to-Value**
Size	**~45 employees**
Locations	Houston, Denver Korea, Japan: Sales offices
Incorporated	2019

Investors

- **>$80MM invested**
- Key stakeholder
  - Ara Partners
- Other investors
  - SAMSUNG ENGINEERING
  - SAINT-GOBAIN
  - aramco

Key markets

- Steel
- Biogas
- Mobility
- Chemicals
- Liquid Fuels

Commercialization progress

- **Field demo producing H_2 from blast furnace in single reactor**
  Successful pilot plant program with >4,000 hr runtime
- Multiple LOIs paving path towards commercial agreements
- **Extensive global opportunity pipeline across sectors**
- Strong IP position with 25 patents (+20 pending); significant body of trade secrets

Technology

eXERO™

Pronounced "e-zero"
E lectroless **X** Coupled **E** xchange **R** eduction **O** xidation

- Leading application flexibly processes dilute, variable waste-gases into **high-purity H_2**
- Combines advantages of chemical and electrolytic processing
- Proprietary to Utility Global

Zero Electricity
Electrolysis without electricity

~70% Reduction
in CO_2 emissions compared to traditional steelmaking

~40% Lower Cost
compared to alternative technologies like H_2 DRI-EAF

Key People


Claus Nussgruber
President and CEO


Greg Heinlein
CFO


Vladimir Novak
CCO


Stefan Reinartz
CTO


Nigel McMullen
COO


Kelly Goranson
VP of People

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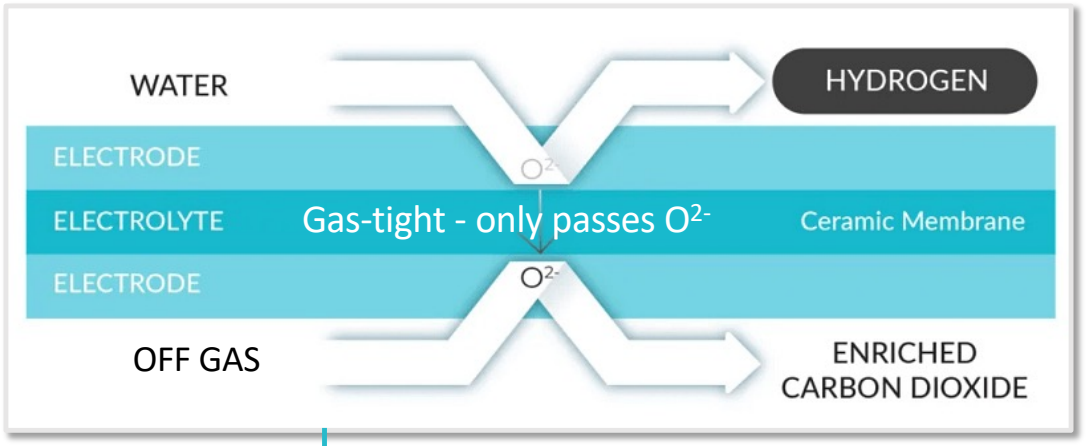
eXERO technology – **electrolysis without electricity**

Elegant single reactor design with “built-in” product separation

Standard solid oxide materials in proprietary combination

Inerts do not need to be removed upfront



Pure water results in pure steady state hydrogen

CO2 more cheaply captured from single source

Extensive electrical infrastructure & intermittency eliminated

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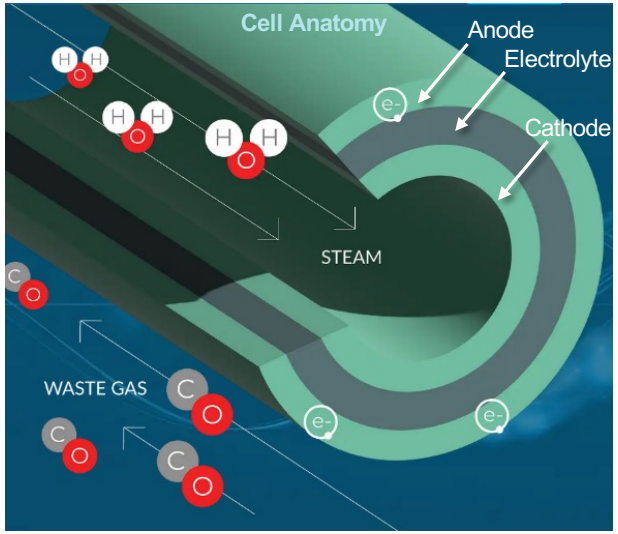
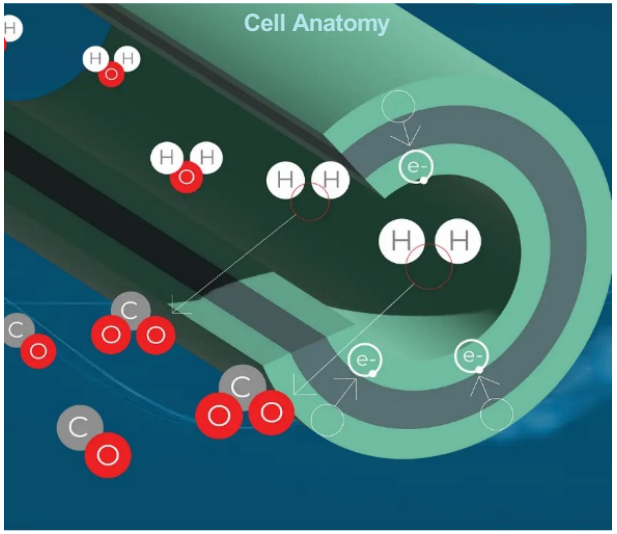
H_2 From Waste Gases Without Electricity eXERO™

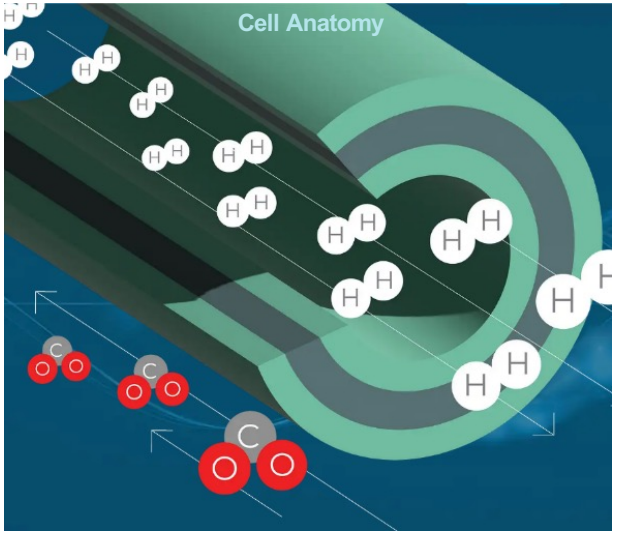
Off gas and steam enter the eXERO™ reactor

The waste gas and steam react electrochemically

High-purity H_2 is produced along with a concentrated stream of CO_2







Anodic reaction: $\mathrm{CO} + \mathrm{O}^{2-} \leftrightarrow \mathrm{CO_2} + 2\mathrm{e}^-$

Cathodic reaction: $\mathrm{H_2O} + 2\mathrm{e}^- \leftrightarrow \mathrm{H_2} + \mathrm{O}^{2-}$

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Electrolysis

eXERO™

Gas Processing

Combines the best

Elegant and competitive solution

- No need to remove inerts
- Minimal to no H2 purification
- Eliminates electrical infrastructure
- Scales from 1 tpd to “500” tpd
- Low pressure capability ideal for waste gas consumption
- No rare or precious metals

Superior, highly flexible operation

- Rapid load following ideal for variable off-gas feed
- Hot restarts from within minutes
- Long run-times between major relifes as more durable than traditional electrolysis cell-blocks

Attractive integration with existing processes

- Energy self-sufficient with no waste heat while offering energy integration opportunities
- Small footprint as high energy density and no electricals
- Highly modular factory manufactured transportable reactor encompasses majority of plant scope

>50 tpd H2 : $1 – 2/kg | 1 – 10 tpd H2 : $2 – 4/kg

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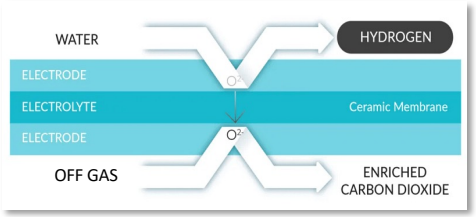
eXERO technology platform with multiple use cases

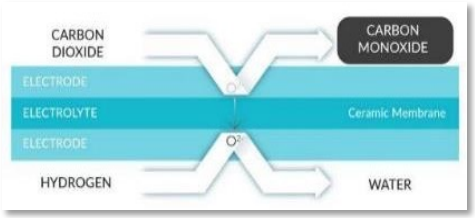
H2gen™



- Hydrocarbon-based waste gases and water react to form concentrated H_2 and enriched CO_2
- Validated in **pilot** and **field demo**
- **Next: Development & deployment of commercial reactor in 1 -3tpd H2 range**

- Off-gas to H2

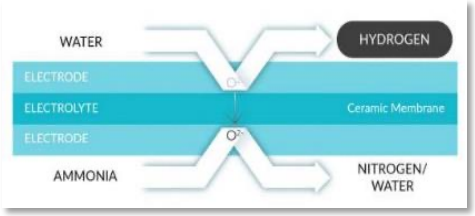
CO-Gen™



- Efficiently **converts vented CO_2 into syngas** to produce sustainable chemicals and fuels
- Extensively validated in **lab**,
- **Next: Piloted as part of commercial reactor development; small commercial demo oppt.**

- Circular carbon
- Renewable fuels
- Green chemicals

Ammonia (AM2H2™)



- **Converts ammonia into pure H_2** in a single process step
- Concept shown in **lab**
- **Next: Lab validation with targeted material set, seek partner to pilot/demo/commercialize**

- Low carbon ammonia supply chain

Protected by 25 patents, many more pending & deep know-how trade secrets

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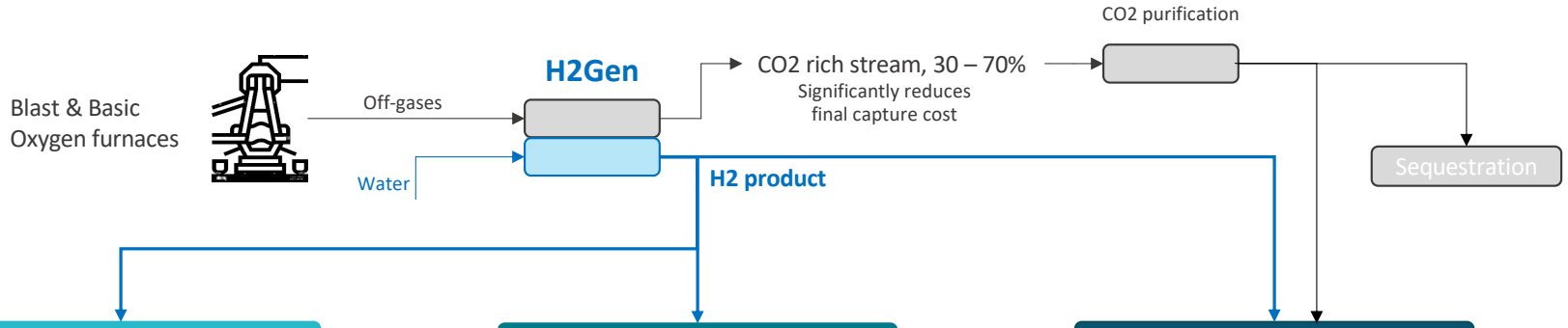
Multiple deployment opportunities in integrated steel making

Steel based H2 demand projected @ **16 million tpa -** electrolysis cannot serve this



Re-injection in BF

- Reduces coke consumption saving cost & carbon emissions
- Increases productivity of BF
- Permits importing of low C.I. energy for heat sources previously heated with BFG/BOFG

200 to 500tpd H2

Supply DRI

- Lowers cost of H2 injection into co-located DRI plants
- On-site generation of H2 reduces supply chain risk
- Enables ultra low C.I. iron-making from DRI plant

200 to 400tpd H2

E-Fuels

- H2 / CO2 feedstock source for low carbon chemicals, such as methanol, SAF, e-methane
- New revenue stream for steelmaker
- Permits importing low C.I. energy for heat sources previously heated with BFG/BOFG

50 to 100tpd H2

~70% C.I. reduction possible

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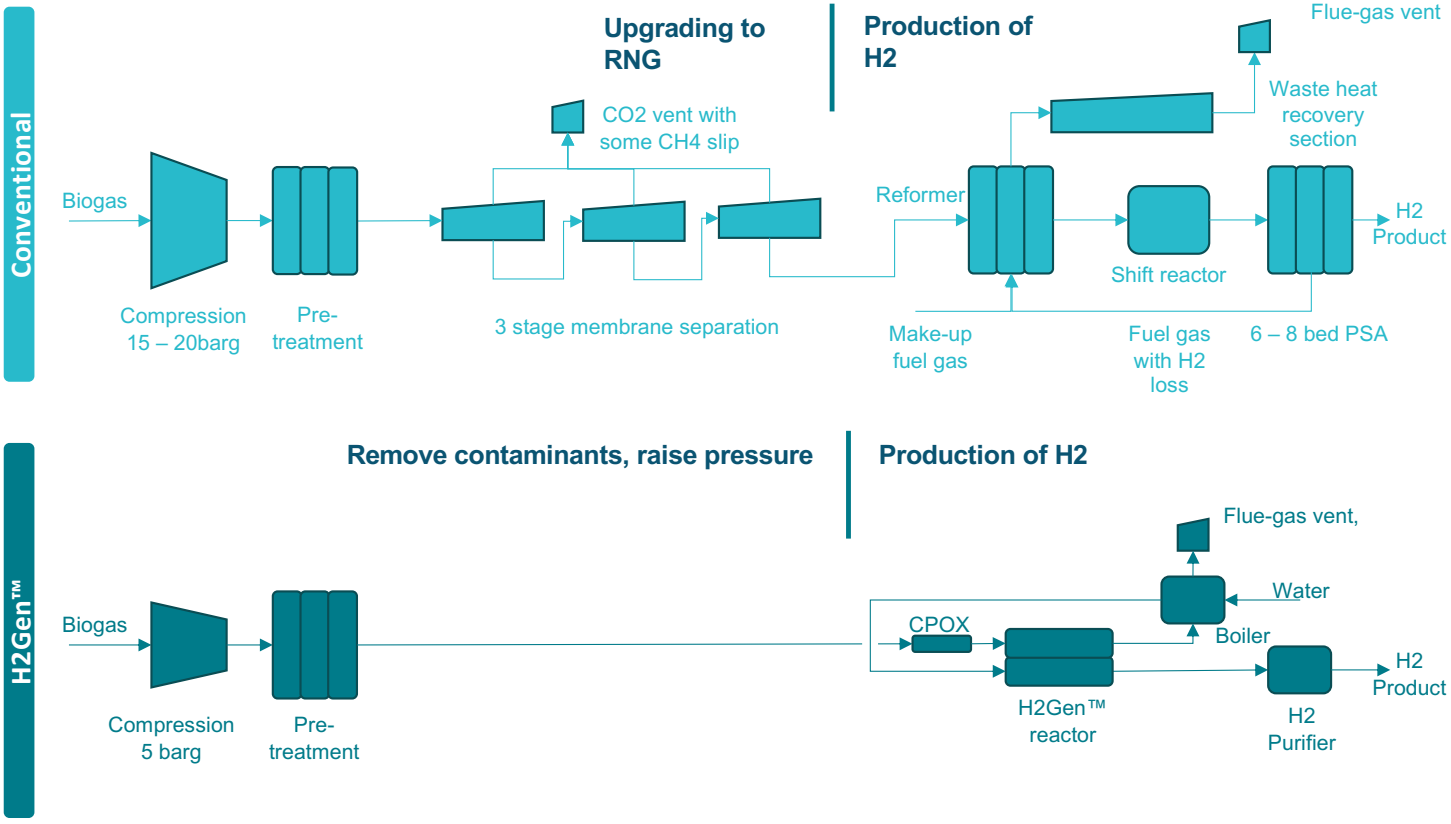
Biogas - Comparison of H2Gen™ and SMR

H2Gen™ offers significantly simpler option with less emissions



- Removal of CO2 upstream of SMR required – cost impact
- CH4 slip in membrane raises CI
- Supplemental CH4 to fire reformer raises C.I. or consumes valuable biogas
- Often has export steam requiring a home
- Steady state driven

- No CO2 separation required, i.e. no CH4 slip - savings
- O2 consumed in CPOX, N2 passes through
- Single reactor converts gas to >98% H2 - savings
- Expensive PSA reduced to polishing unit / purifier - savings
- No export steam, rapid load following – savings
- Small footprint

Simple, flexible process with small footprint as basis for competitive economics

Development Maturity

After successful demonstration, Utility Global is scaling the commercial reactor

H2Gen™ transitioning to commercial scale-up

Field demo moving into first commercial development

Pilot Plant

2022 | Proven Technology

- Successfully proven at pre-commercial scale
- 1,000 x scale up from lab
- ~4,000 hours of runtime
- Hot restarts in <45 min
- No material degradation

Complete

Field Demo

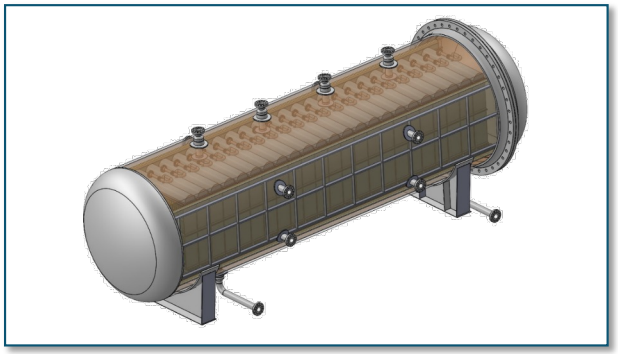
Q4 2023 | Steel Application

- Producing H_2 directly from blast furnace gas in single eXERO™ reactor step
- Performance above expectations
- Optimizing operational integration

Wrapping up

Commercial

2024 - 2027



- First deployment expected @ 1 – 3 tpd H_2
- Stepping-stone to larger facilities
- Standard modularized reactor for all applications
- Deep commercial pipeline across steel, biogas, chemicals, refining, ammonia, mobility
- Increasingly advanced commercial discussions globally

Designing

Expect 1st deployment in 1 – 3 tpd range

Overarching Objectives

- Demonstrate direct conversion of steel gases into H2 using the eXERO™ technology
- Develop a detailed data map to complement existing lab and pilot data
- Gain operational experience in directly coupling with a steel process

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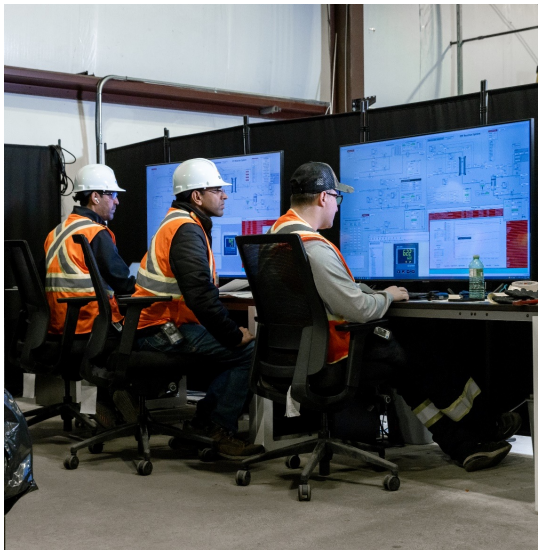
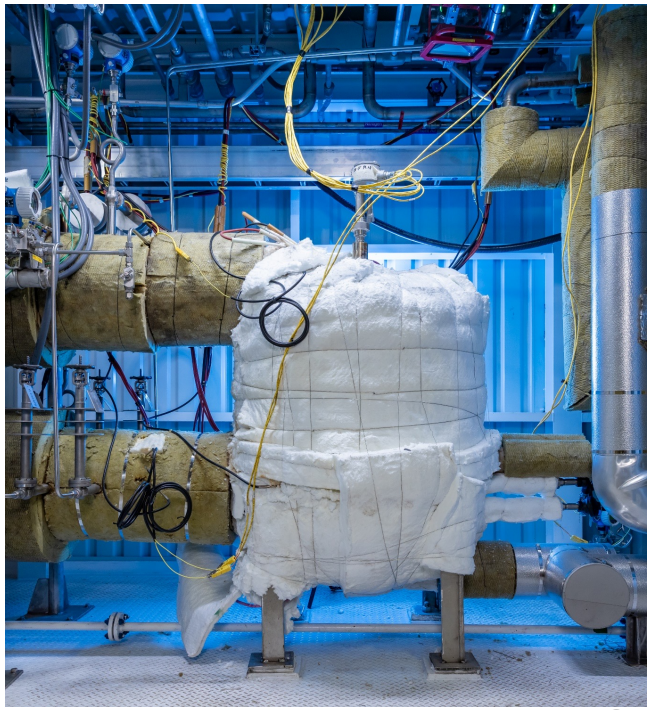
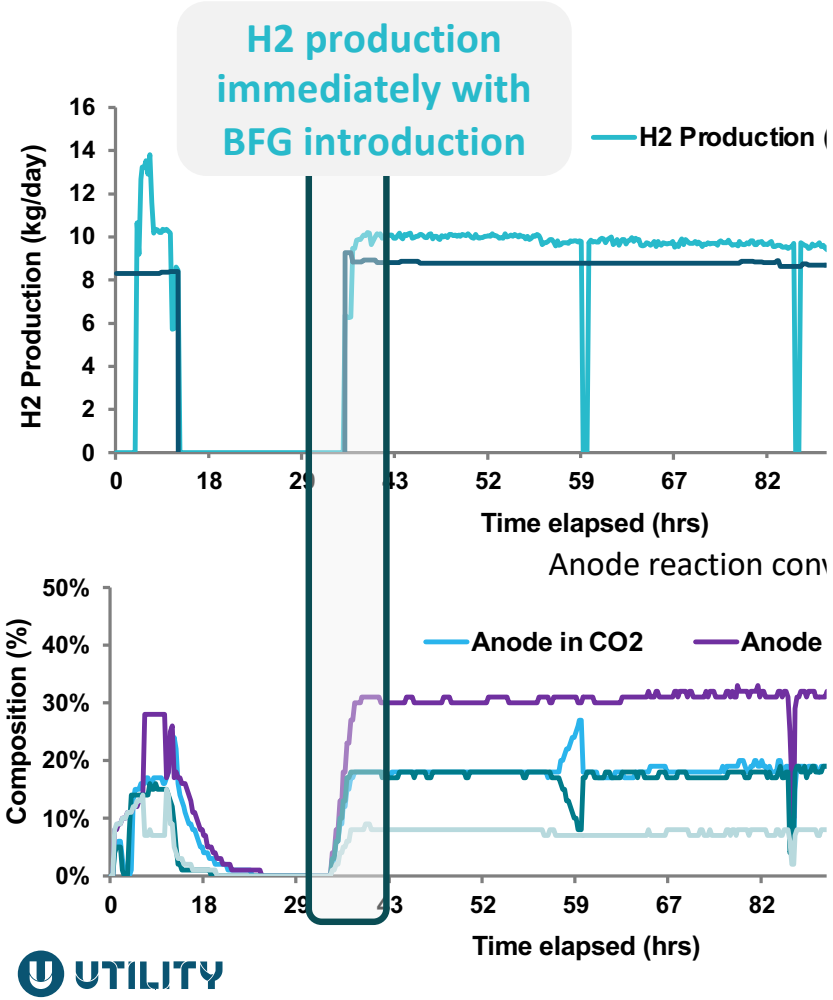
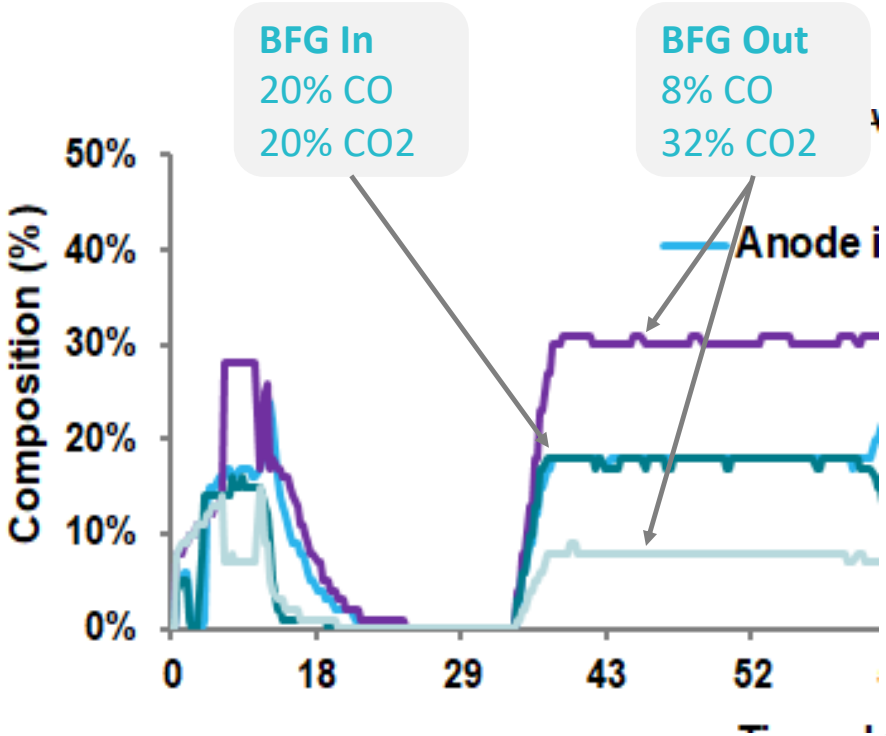
- >2,500hr operating time
- Many specialist tests successfully completed
- ~20 blast furnace gas interruptions, switching into standby and back online in minutes





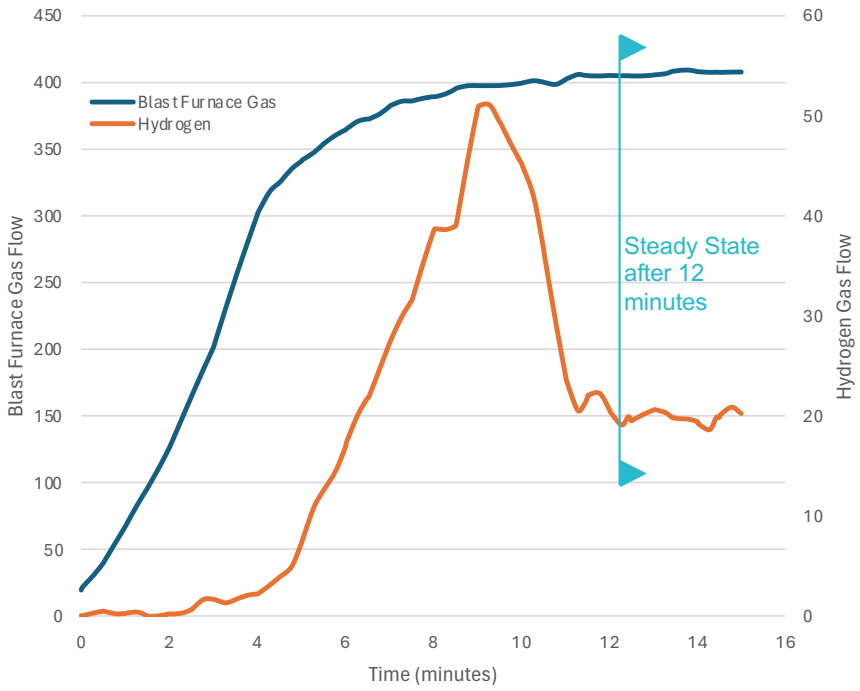
FTF operation demonstrates promise of technology





Dynamic response in H2 production with changes in feed-gas

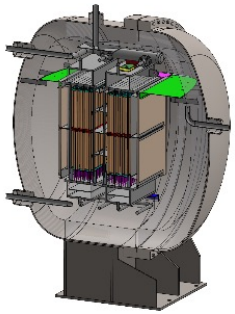
Unparalleled fast responsiveness within minutes to significant changes in feed-gas flow



- Compared to SMR, no steady state is required which makes start-ups from standby within minutes possible, while a SMR takes many hrs or even 1 – 2 days
- With its unparalleled fast process response to changes in feed-gas flow and/or composition, the eXERO™ technology is ideally suited:
  - to non steady state applications where flow, composition, & availability varies
  - where “as required” H2 production is supported with fast switching between standby and online

Commercial reactor scaling

Operating 2025

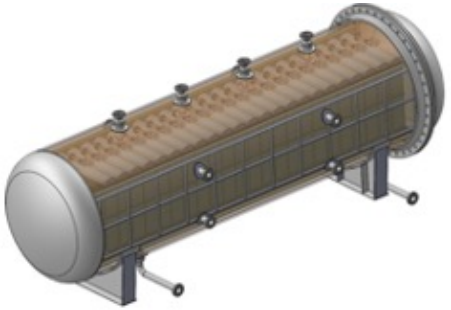


- Commercial reactor architecture with scalable, modular design
- 50 kg/d (NG);
- ~25 – 30kg/d (BFG/Biogas)
- 5 barg MAWP
- Advantages:
  - cold-walled pressure vessel
  - internal refractory
  - automated manufacturing of cell modules

x30 - 60

Scaling of same architecture

Operating 2027



- Scaled commercial reactor (40ft & 53ft iso-dimensions for shipability)
- 1 - 2tpd on BFG/biogas growing to 6tpd (>10tpd on NG)
- 5 barg MAWP or greater
- Add'l advantages:
  - Modular, factory manufactured, shippable reactors; integrated recuperator heat-exchangers
  - 50 - 70% of plant scope contained in reactor

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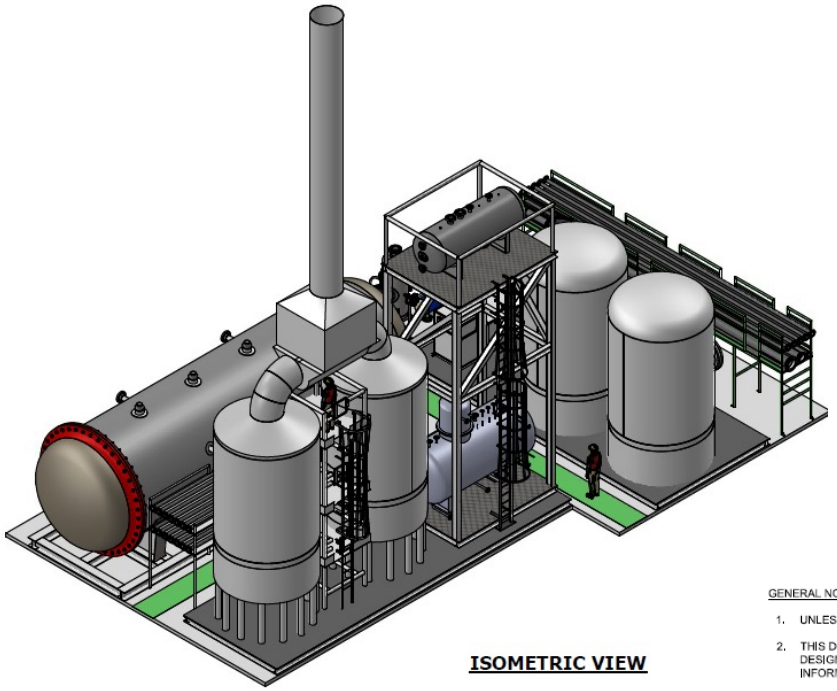
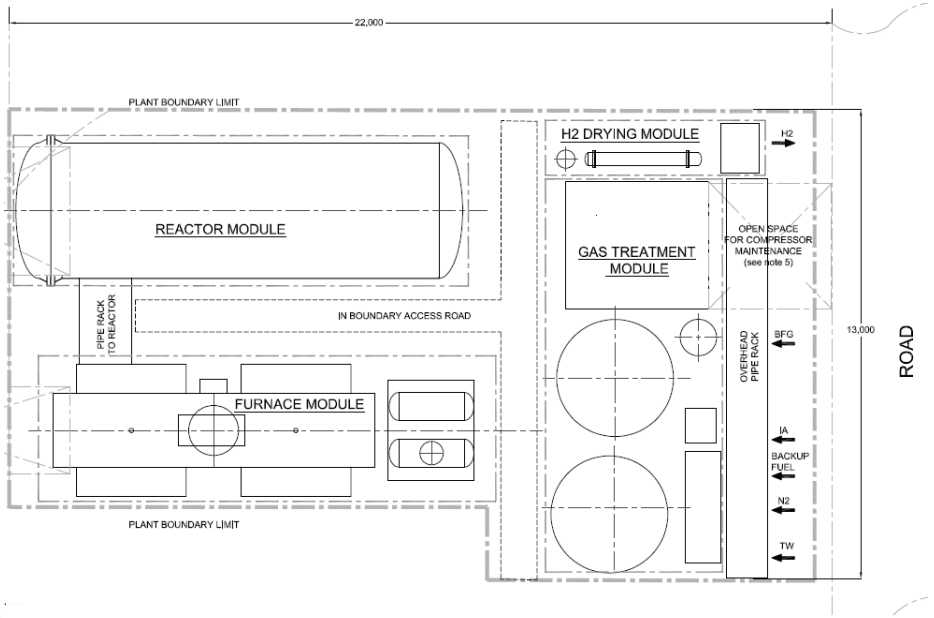
Plot plan for single reactor plant

1.5 TPD plot plan for project currently developing



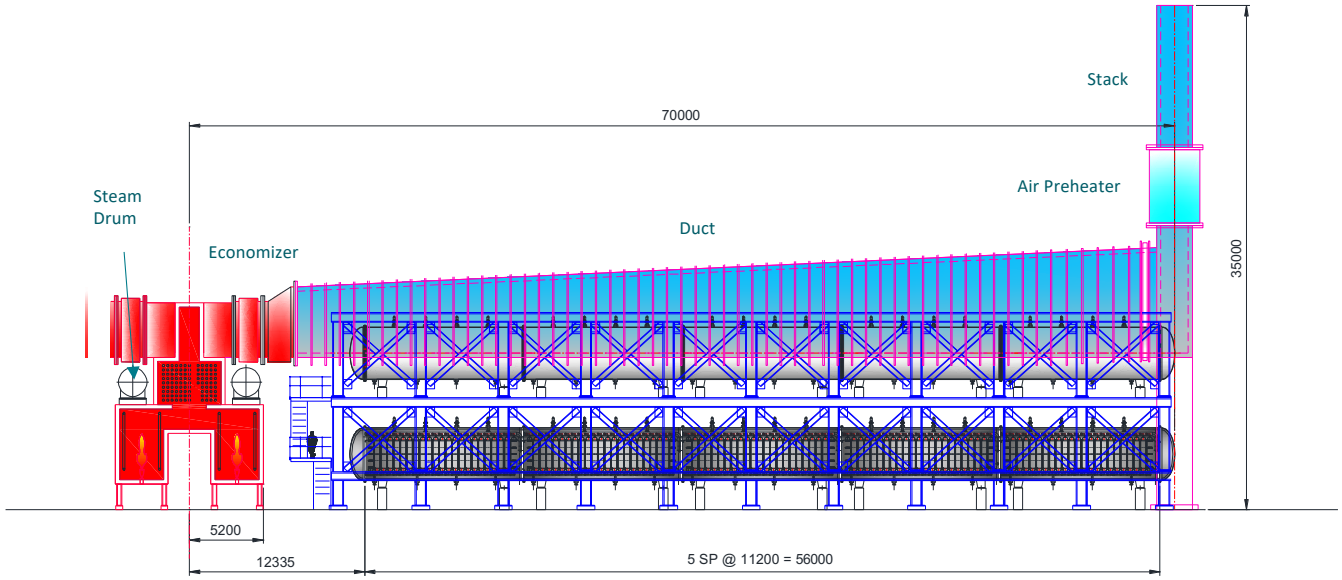
ISOMETRIC VIEW



GENERAL NOTE:

1. UNLESS OTHERWISE NOTED, ALL UNIT SHOWN ARE IN mm.
2. THIS DOCUMENT IS A PRELIMINARY AND SHOULD NOT BE USED FOR ENGINEERING DESIGN. DIMENSIONS AND ORIENTATION ARE SUBJECT TO CHANGE WITH NEW INFORMATION.
3. THIS PLOT PLAN ONLY INCLUDES MAIN PAD EQUIPMENT AND DOES NOT INCLUDE FUNCTIONS SUCH AS A CONTROL ROOM, WAREHOUSE, ENGINEERING OFFICES, ETC.
4. THIS PLOT PLAN ASSUMES THE CLIENT SITE WILL PROVIDE UTILITIES SUCH AS POWER, TREATED WATER, COOLING WATER, INSTRUMENT AIR, AND NITROGEN.
5. CERTAIN MARKED AREAS OUTSIDE THE DIMENSIONS OF THE PLOT PLAN WILL BE TEMPORARILY REQUIRED DURING COMMISSIONING AND MAINTENANCE OPERATIONS. THOSE AREAS WILL BE CLEARED ONCE MAINTENANCE ACTIVITIES HAVE BEEN COMPLETED.

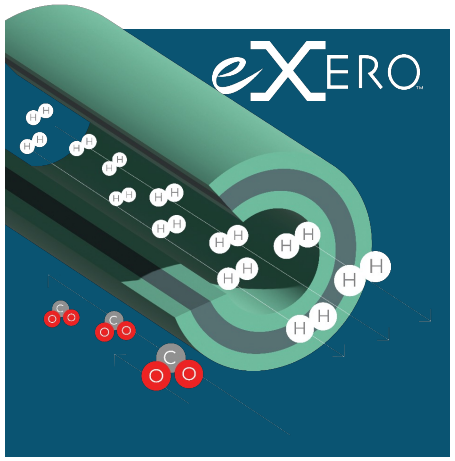
Modular design permits rapid deployment of world-scale capacity tailored to customer's specifics needs



- One train consists of 20 reactor units connected into four reactors in a stacked arrangement
- One common heat management section
- For larger plants, heat management can be doubled in the center with 20 reactors going in the opposite direction as well
- At 6 TPD per reactor, one train can produce ~120 TPD of H_2
- Larger configurations for 200 – 500 TPD of H_2 production possible with same design philosophy

Transformative solution to meet decarbonization goals

Developing first commercial deployment now



1. Competitively converts dilute off-gases into high value H_2 and syngas with low carbon intensity
2. Effectively decarbonizes existing infrastructure and processes
3. Highly modular and scales impressively while maintaining small footprint
4. Minimal site work and short downtime for tie-ins
5. If required, integrates elegantly with carbon capture, significantly reducing cost & complexity
6. No renewable electricity and related infrastructure required
7. Highly capable team with deep relevant industry experience
8. Strong investment partners with aligned strategy

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Thank You