Low-Carbon Hydrogen Production with Integrated CO_2 Capture

Workshop on Hydrogen Production with CCS
November 5, 2019
EDF, Chatou, France

Markus Lesemann
Director, Business Development
GTI
mlesemann@gti.energy
+1 (919) 599 4096

Working With Industry and Governments to Increase Access to Abundant, Affordable, and Acceptable Energy

FOR A BETTER ENVIRONMENT AND A BETTER ECONOMY

RESEARCH & DEVELOPMENT

PROGRAM MANAGEMENT

TECHNICAL/ ANALYTICAL

CONSULTING

TRAINING

360+ EMPLOYEES

World-class piloting facilities headquartered in Chicago area

Hydrogen Production with CO_2 Capture: Process Schematic

Sorption Enhanced
Steam Methane Reforming

$CH_4 + 2H_2O + Heat(a) \rightarrow 4H_2 + CO_2$

$CaO + CO_2 \rightarrow CaCO_3 + Heat(b)$

$CH_4 + 2H_2O + CaO \rightarrow 4H_2 + CaCO_3$

Heat(b) ~ 95% Heat(a)

700°C, 20-35 psig

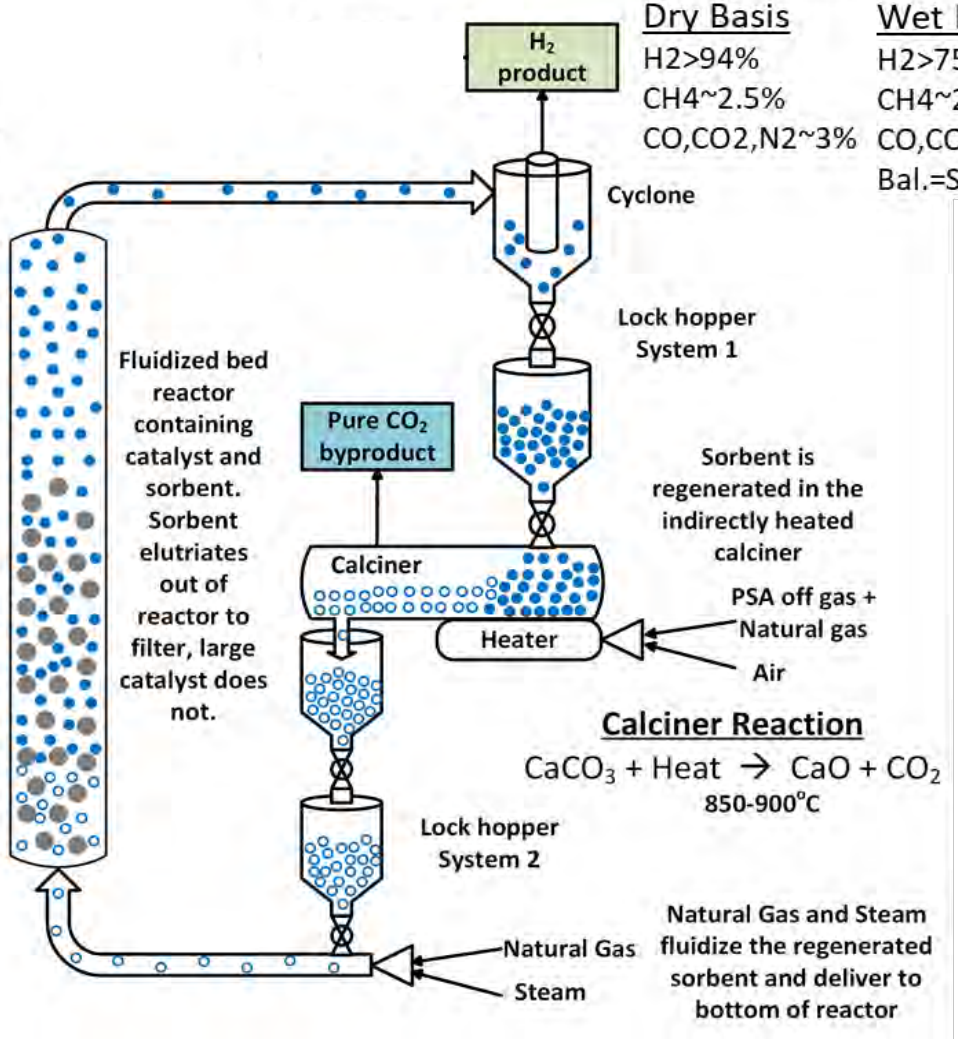
Catalyst:
Commercially Available
Ni on Alumina
2mm diameter

Sorbent:
Natural Solid Sorbent:
Limestone or Dolomite
<0.2mm diameter

- Catalyst
- Sorbent
- Sorbent with CO_2

H2 Product Composition

Dry Basis	Wet Basis
H2>94%	H2>75%
CH4~2.5%	CH4~2%
CO,CO2,N2~3%	CO,CO2,N2~2.8%
	Bal.=Steam for NOx Control



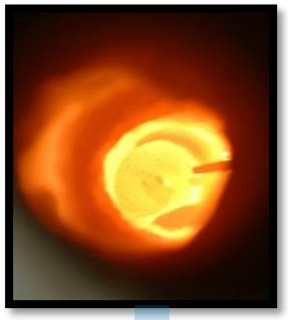
Process Development Status

> GTI has performed a systematic development of the CHG process, demonstrating each of the key system elements. Pilot plant which is operational and currently being tested under ~$6 million DOE contract.

Fixed Bed Tests
Demonstrated chemistry with commercial catalyst for wide range of operating conditions.

Cold Flow Tests
Defined component designs, demonstrated solids handling under wide range of operating conditions.

Flash Calciner Tests
Validated calcination rate models. Demonstrated operation of short-residence-time calciner.



Design Data and Operating Experience

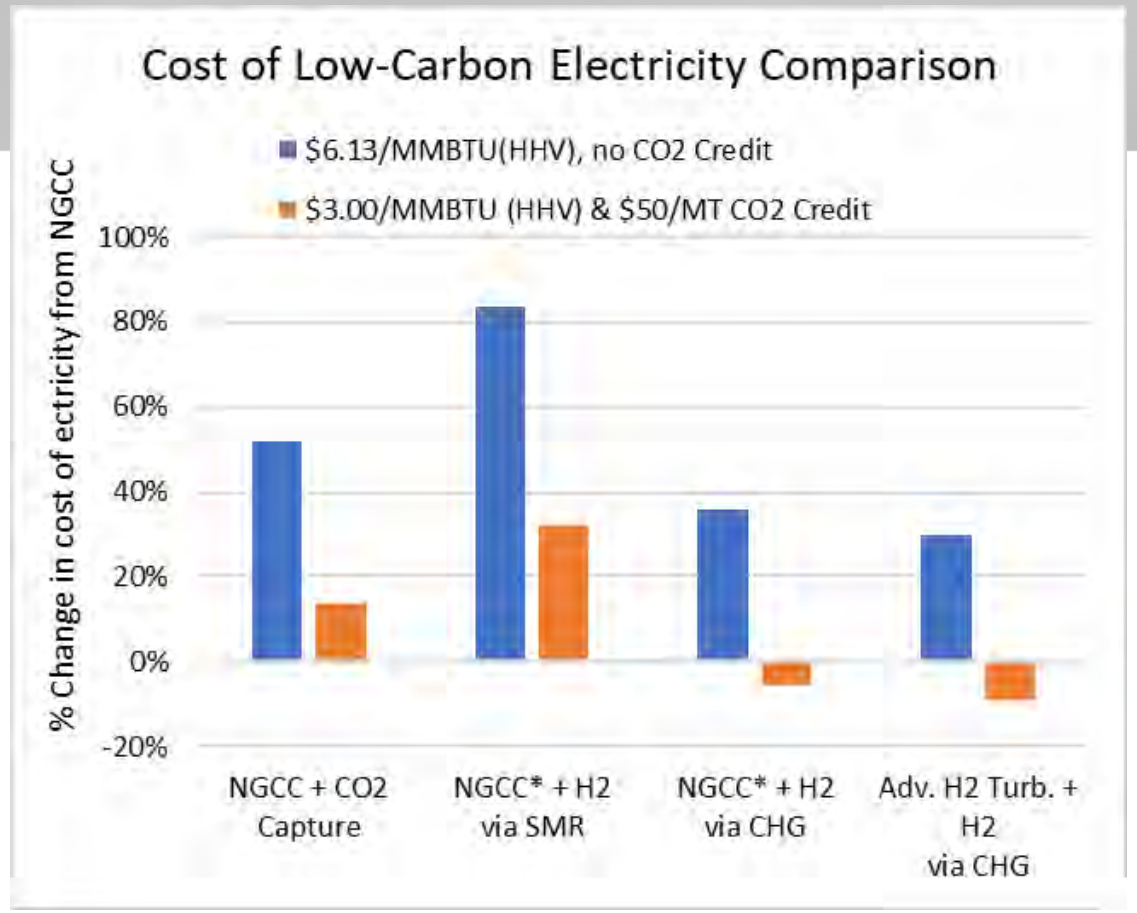
20 MSCFD Pilot
Accumulated ~100 hours of SER-mode and >200 hours of solids handling operation. Achieved up to 92% H2 purity

Test Article Skid

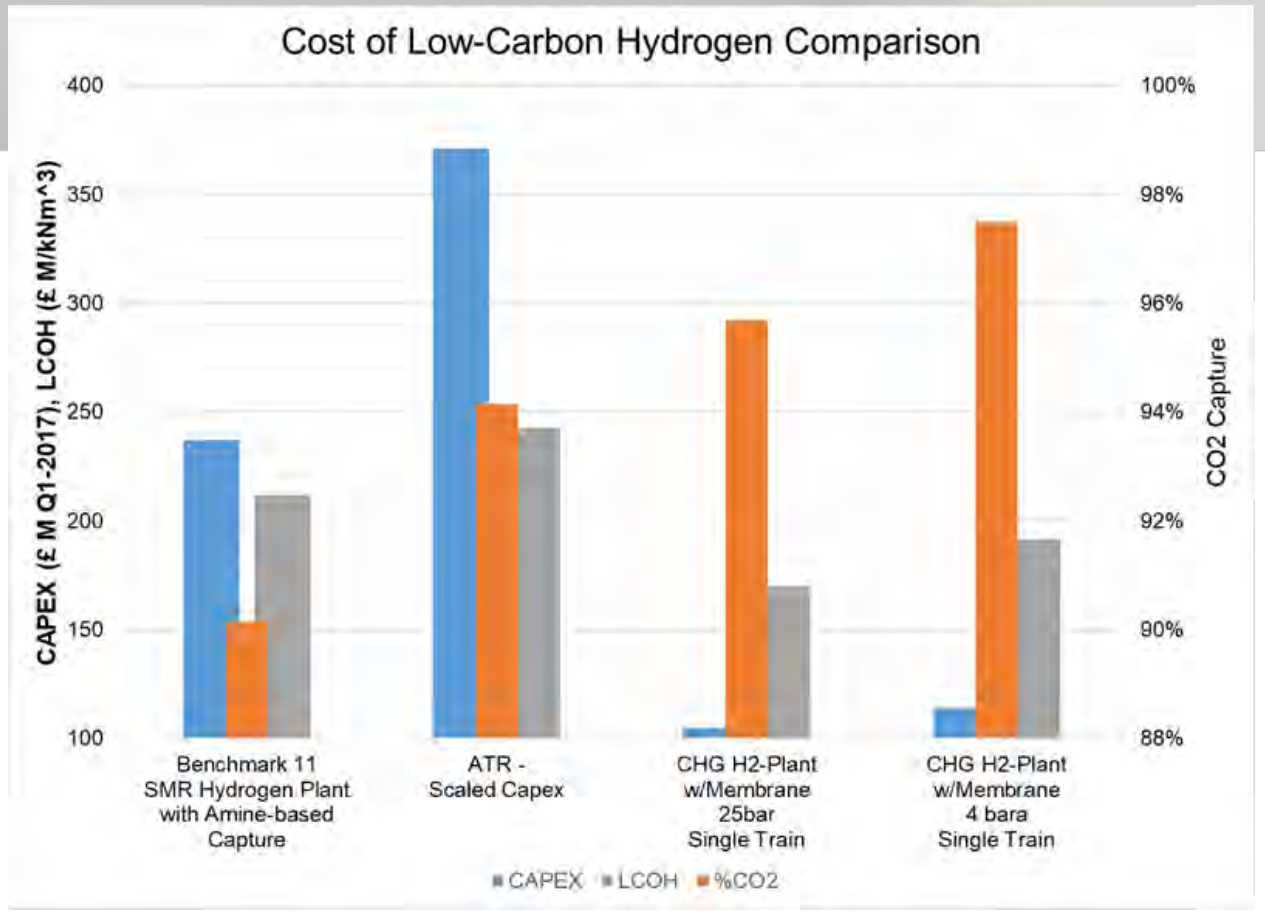
Complete Pilot Facility

Preliminary Large-Scale Economic Comparisons

Electrical Power Comparison



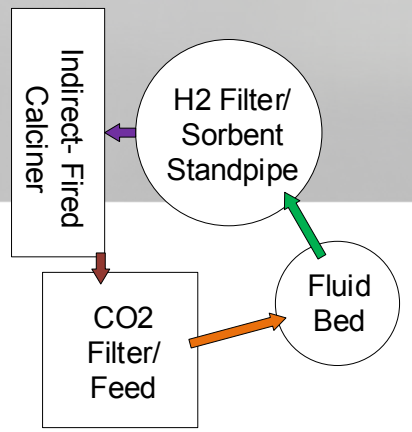
Hydrogen Production Comparison



System Scale-Up for H_2 production

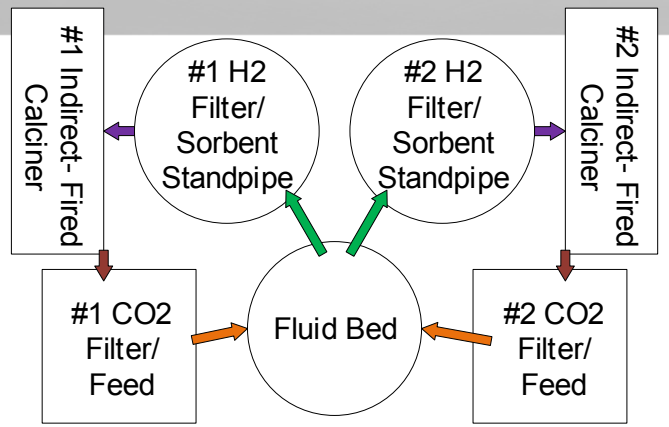
1.38 MWth Pilot System

- To be demonstrated under BEIS H1 Project



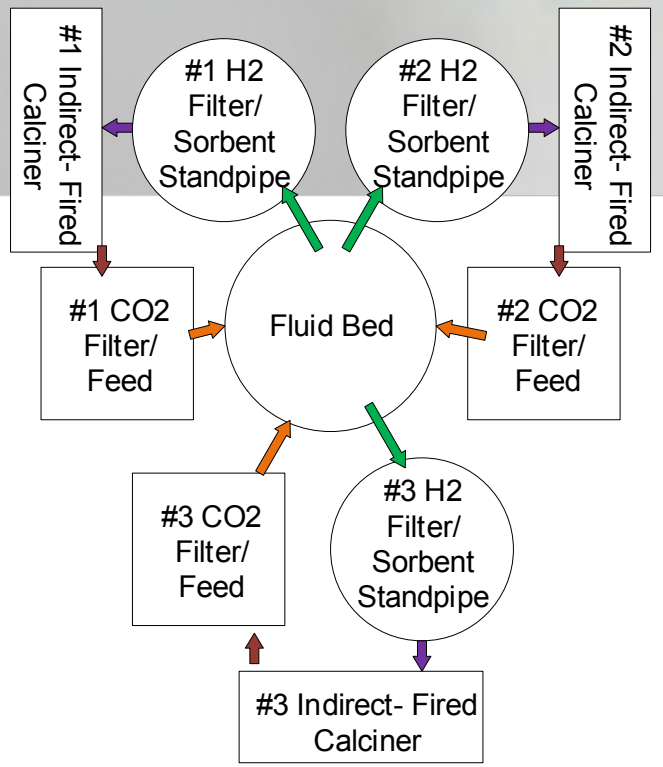
50 MWth System

- To be demonstrated on DOE H2-Power Project



100 MWth System

- Uses 2x 50MWth Solids Handling/Calcining Loops
- Reactor grows ~√2



150 MWth System

- Uses 3x 50MWth Solids Handling/Calcining Loops
- Reactor grows ~√3

300 MWth System will have 2x 150 MWth Units

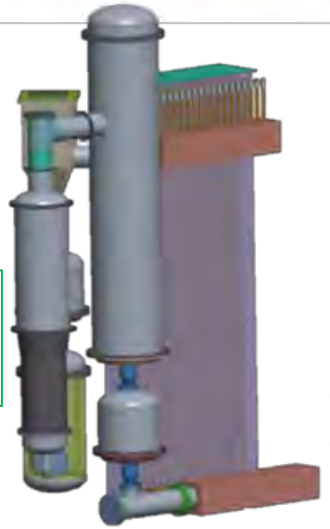
H2-Power Modular Heat Engine System

H2 Storage Subsystem

Titan 40XL H2 Storage

H2 Turbine Subsystem

CHG Subsystem



H2 Storage 40' x 8.5' x 13.5' H

H2 Storage 40' x 8.5' x 13.5' H

H2 Storage 40' x 8.5' x 13.5' H

H2 Storage 40' x 8.5' x 13.5' H

H2 Storage 40' x 8.5' x 13.5' H

H2 Storage 40' x 8.5' x 13.5' H

Siemens SGT-400
For high H_2 fuel

Gas Turbine Genset Module
~42' L x 8' W x 9.75' H

H_2 Compressor for H_2 Storage

Control Center

CO_2 Comp-ression

Atm. Calciner

HRSG

H_2 Gen.

CHG 6 modules
32'L x 13' W x 70' H

Dry Cooler (Optional)
40' L x 7.5' W x 9.25' H

GTI's CHG H_2 Generator (38.8 MWth)

Summary

- Compact Hydrogen Generator with Integrated CO_2 Capture (CHG) has been developed from proof of concept to current pilot, offering:
  - One-step conversion of natural gas to H_2 (for power or high purity H_2)
  - 15-30% lower H_2 product cost vs. current technology (SMR w/ CO_2 capture, ATR)
  - 40-50% lower CAPEX vs. current technology
  - >97% CO_2 capture rates economically viable
  - Significantly lower carbon footprint (<40%) vs. current technology
  - Lowest cost of electricity for power generation with CO_2 capture
- CHG is the enabling technology for multiple low-carbon markets
  - Power and H_2 infrastructure
  - Hydrogen for existing applications (refining, ammonia)

Outlook

- GTI, Southern Company, Siemens have evaluated the CHG-based Modular Heat Engine System
  - Vision for a Hydrogen Power Engineering Center (HyPEC) in U.S.
  - Team has submitted a 3-year proposal to U.S. DOE to perform Risk Mitigation Tests, HyPEC preliminary design and cost estimates
  - Cornerstone will be a 38 MW_{th} CHG system
- European applications
  - CHG with integrated CO_2 capture is highly relevant for European market
  - Proposed 1.4 MW_{th} pilot system in U.K.
  - Looking for partners for additional feasibility studies & project for applications around North Sea (e.g. Norway, U.K., Netherlands).

Thank You!

Turning Raw Technology into Practical Solutions

www.gastechnology.org | jmays@gti.energy