Liquid Hydrogen: Enabling a Scalable Hydrogen Economy

CHART
Cooler By Design®

Niek Albers
Director Project Management & Engineering
Howden Thomassen Compressors, a Chart Industries Company

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Introduction: Chart Industries at a glance

50
Number of countries we operate in

64
Number of manufacturing sites globally

50
Number of repair and service sites globally

11,500
Global team members

1,500+
Engineers on our team

1,000+
Trademarks and patents held

169
Number of countries we have equipment installed

170
Years in business, Founded in 1854

USA
Headquarter in GA, USA

HUDSON Products Corporation – A Chart Industries Company
Howden – A Chart Industries Company
CHART | flow
CHART – Chart China
CHART | VCT
SMITHCO – A Chart Industries Company
CPI by Howden
SES INNOVATION – A Chart Industries Company
CHART FEROX
CHART | VRV
FEMA – A Chart Industries Company
FRONTI FABRICATIONS
Earthly Labs – A Chart Industries Company
CHART WATER
CHART | GOFA
Air-X-Changers – A Chart Industries Company
L.A. Turbine – A Chart Industries Company
Cryo Technologies – A Chart Industries Company
CHART | CSC

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Chart Industries in Hydrogen

Hydrogen Liquefaction

Hydrogen Compression

Hydrogen Storage

Hydrogen Refuelling

Hydrogen Marine

Cryogenic Transportation

Floating Liquefaction

Hydrogen Railcars

Hydrogen On-Board

Hydrogen ISO Containers

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Solid Track Record in Hydrogen

World's Largest Green Hydrogen Project

World's Largest Hydrogen Refuelling Station

Europe's Largest Bio Refinery

World's First Ship Operating on Carbon neutral Fuel

World's First Green Steel Plant

Multiple H2 Liquefaction plants in N Americas & Europe

World's Largest H2 Compression Solution

China's First Photovoltaic, Seawater Desalination H2 Integrated Project

Supported **220+ projects** in **25+ countries**, including some of the world's most **iconic clean-energy projects** covering across Hydrogen Applications

World's Largest Underground H2 Storage project

Shell Holand H2 One 200 MW Project

World's First eFuel Plant

Australia's First Hydrogen Blending Pipeline Project

Europe's First Refinery Decarbonisation Project

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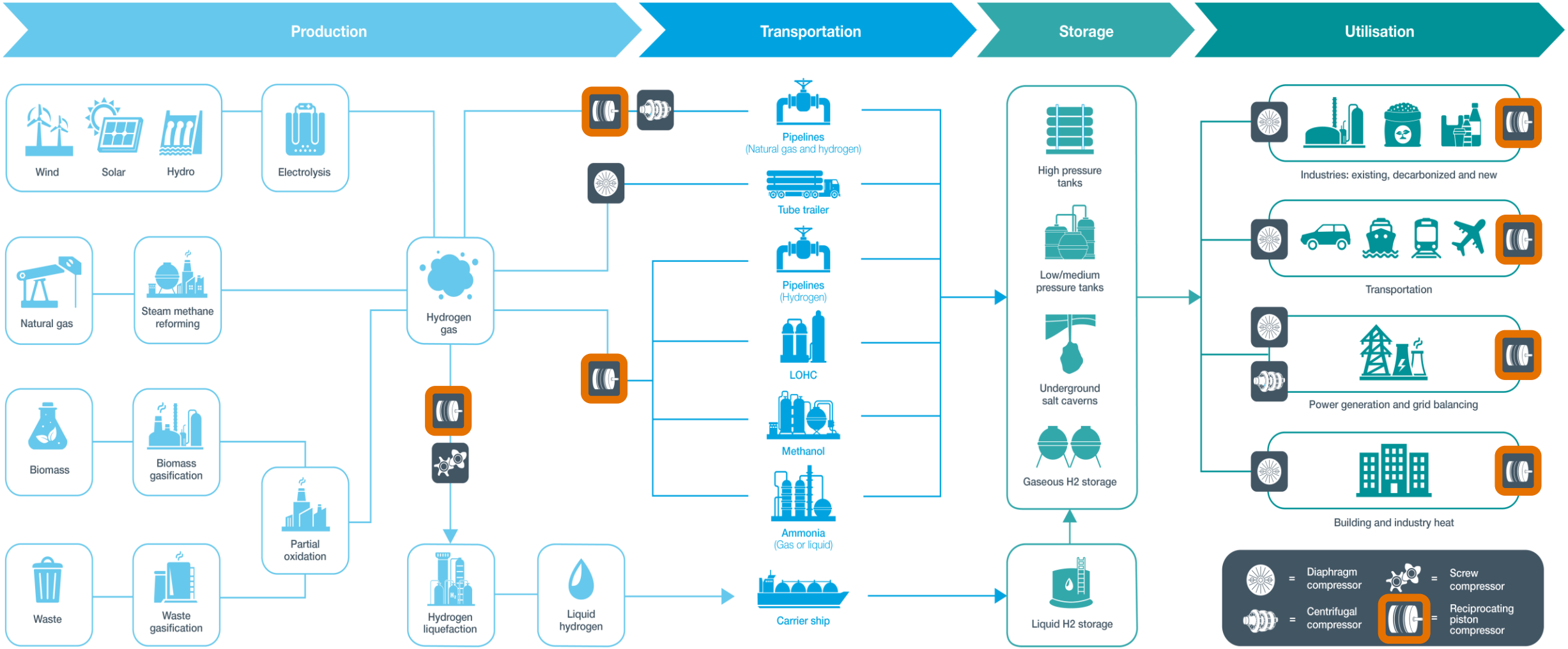
Hydrogen



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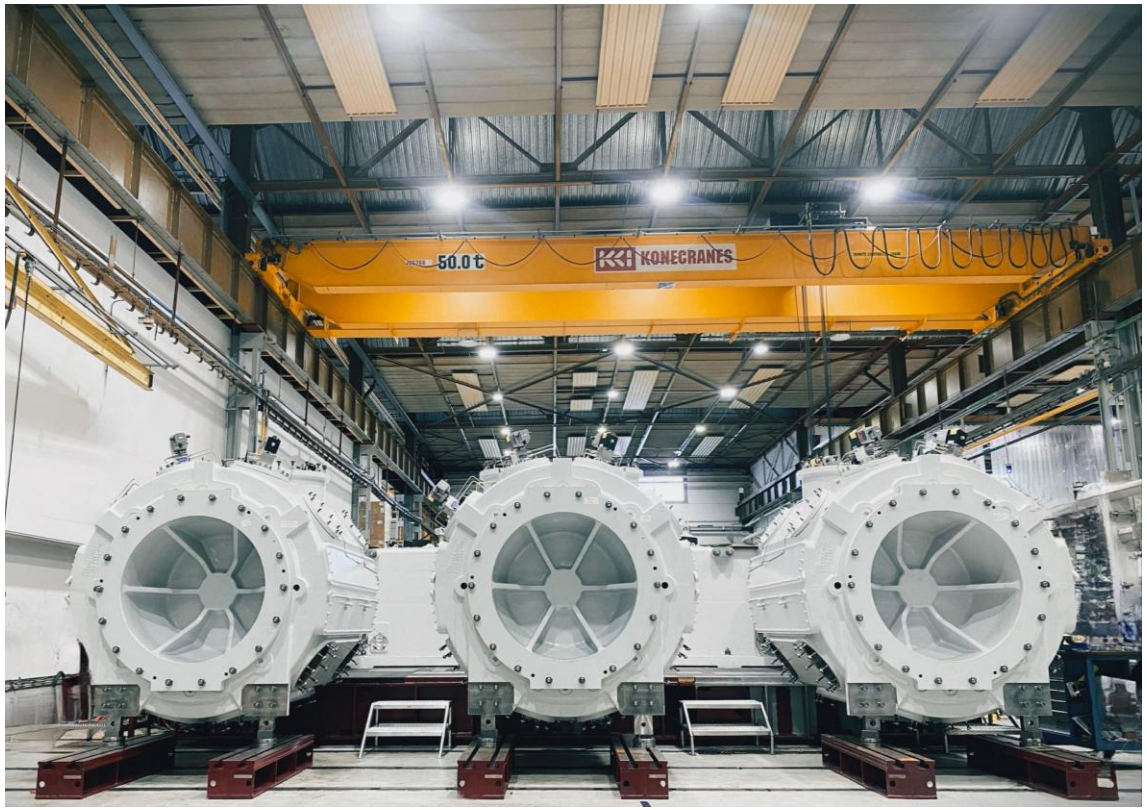
Hydrogen compression for liquefaction

Large scale hydrogen compression

- Suited for giga-scale electrolyzer systems with capacity of +500 MW
- Large API618 Reciprocating Compressors
- Oil-free design with FFP™ technology
- State of the art Control System and Monitoring System
- Compressor ancillaries (process + auxiliary) systems and piping

Application parameters	Performance envelope	
Application	Green Hydrogen	
Inlet flow	> 170.000 Nm3/hr	
Inlet Pressure	1.18 bar(a)	17.12 psi(a)
Mole weight [kg/kmol]	2.016 g/mol	
Outlet Pressure	13 bar(a)	188.55 psi(a)



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3 Hydrogen Liquefaction – Technology Overview & Key Challenges

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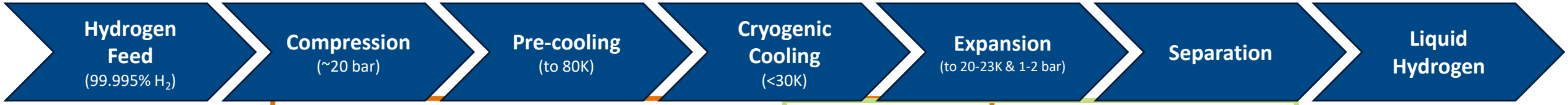
Technology Overview



1

1) **Pre-Cooling**
[to 80°K = - 193 °C]

2) **Cryogenic Cooling**
[to <30°K = - 243 °C]

3) **Expansion using JT effect**
[to <~20°K = -253 °C].

Cooling down the Hydrogen to -253 °C

2

Stabilizing Hydrogen against vaporization

Using **Catalyst** embedded inside the finned heat exchangers to convert the hydrogen molecule **from ortho- (unstable) to para-hydrogen (stable).**

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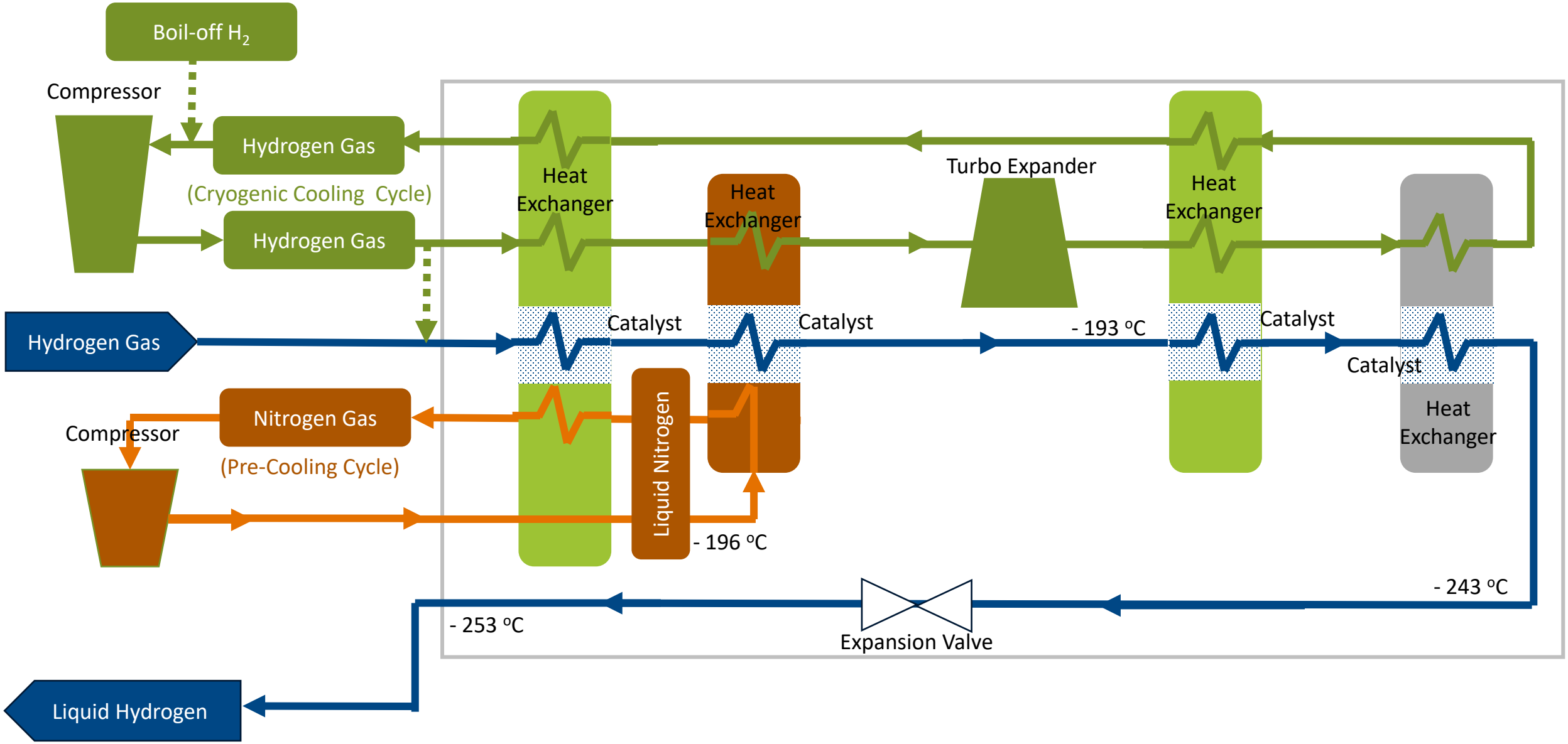
Process Schematic



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