HONEYWELL UOP REVAMP WEBINAR FOR POLYBED™ PSA

WILLIAM BLASKO
SR. OFFERING MANAGER, HYDROGEN

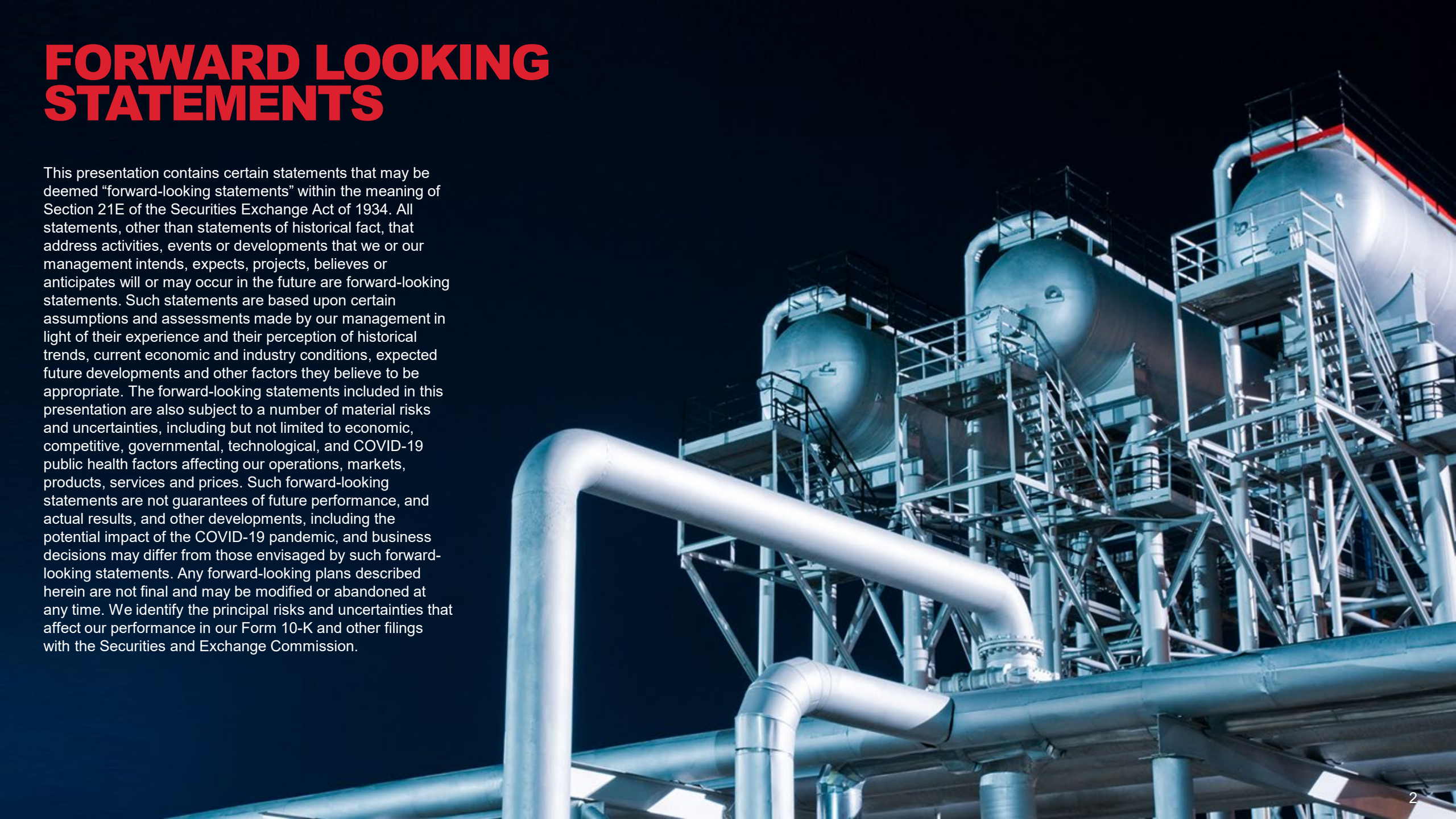
KILLOL THAKKAR
SR. OFFERING MANAGER, PROCESS INFORMATION AND CONTROL

Honeywell UOP

PSA AMB Webinar

FORWARD LOOKING STATEMENTS

This presentation contains certain statements that may be deemed “forward-looking statements” within the meaning of Section 21E of the Securities Exchange Act of 1934. All statements, other than statements of historical fact, that address activities, events or developments that we or our management intends, expects, projects, believes or anticipates will or may occur in the future are forward-looking statements. Such statements are based upon certain assumptions and assessments made by our management in light of their experience and their perception of historical trends, current economic and industry conditions, expected future developments and other factors they believe to be appropriate. The forward-looking statements included in this presentation are also subject to a number of material risks and uncertainties, including but not limited to economic, competitive, governmental, technological, and COVID-19 public health factors affecting our operations, markets, products, services and prices. Such forward-looking statements are not guarantees of future performance, and actual results, and other developments, including the potential impact of the COVID-19 pandemic, and business decisions may differ from those envisaged by such forward-looking statements. Any forward-looking plans described herein are not final and may be modified or abandoned at any time. We identify the principal risks and uncertainties that affect our performance in our Form 10-K and other filings with the Securities and Exchange Commission.



GLOBAL HYDROGEN OUTLOOK THROUGH 2050

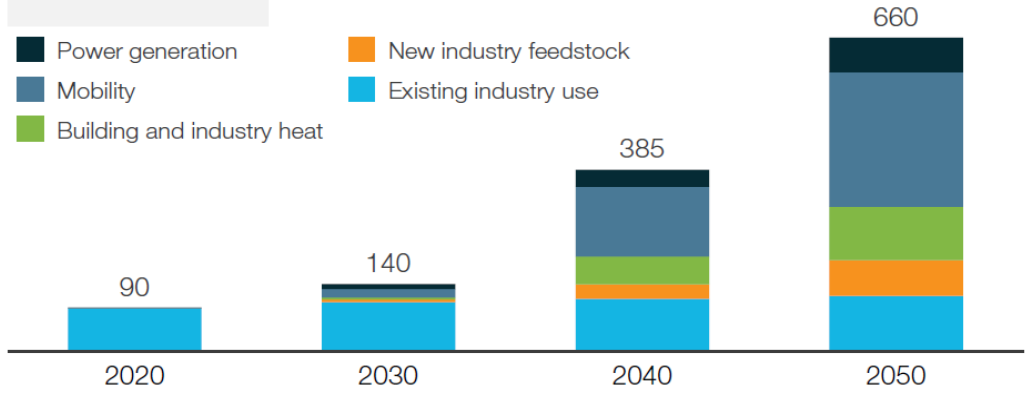
Demand

Global hydrogen demand by segment until 2050

660 MT
hydrogen required p.a. in 2050 for net-zero

22%
of global final energy demand[1]

Hydrogen end-use demand by segment, MT hydrogen p.a.



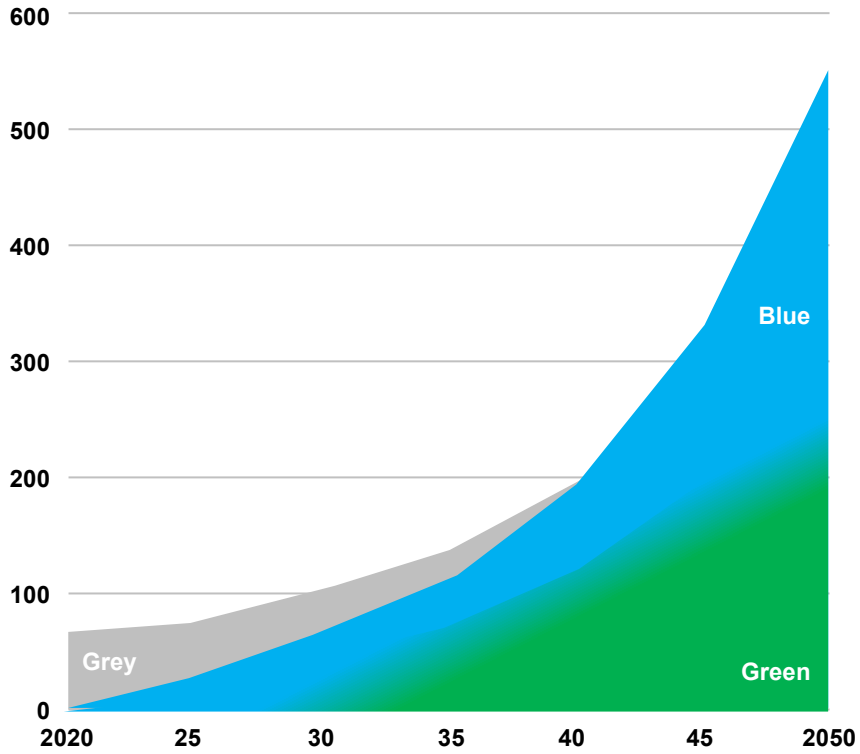
1. IEA net-zero scenario with 340 EJ final energy demand in 2050. HHV assumed. Excluding power.

7 Clean hydrogen is in this publication defined as either renewable or low-carbon hydrogen; Renewable hydrogen refers to hydrogen produced from water electrolysis with renewable electricity, while low-carbon hydrogen refers to hydrogen produced from fossil fuel reforming with carbon sequestration.
8 Assumes 35 GT anthropogenic emissions in 2050 in current trajectory.
9 Considers the share 80 GT CO_2 abated from hydrogen in terms of cumulative emissions from 2021 to 2050, subtracting the remaining carbon budget of 420 GT.

Source: Hydrogen Council: Scaling Up, McKinsey

Supply

H_2 Production Growth (Mt/yr)



SOURCE: Hydrogen Council, Decarbonization Pathways, 2021

22% of final energy demand

6Gt annual CO_2 abatement

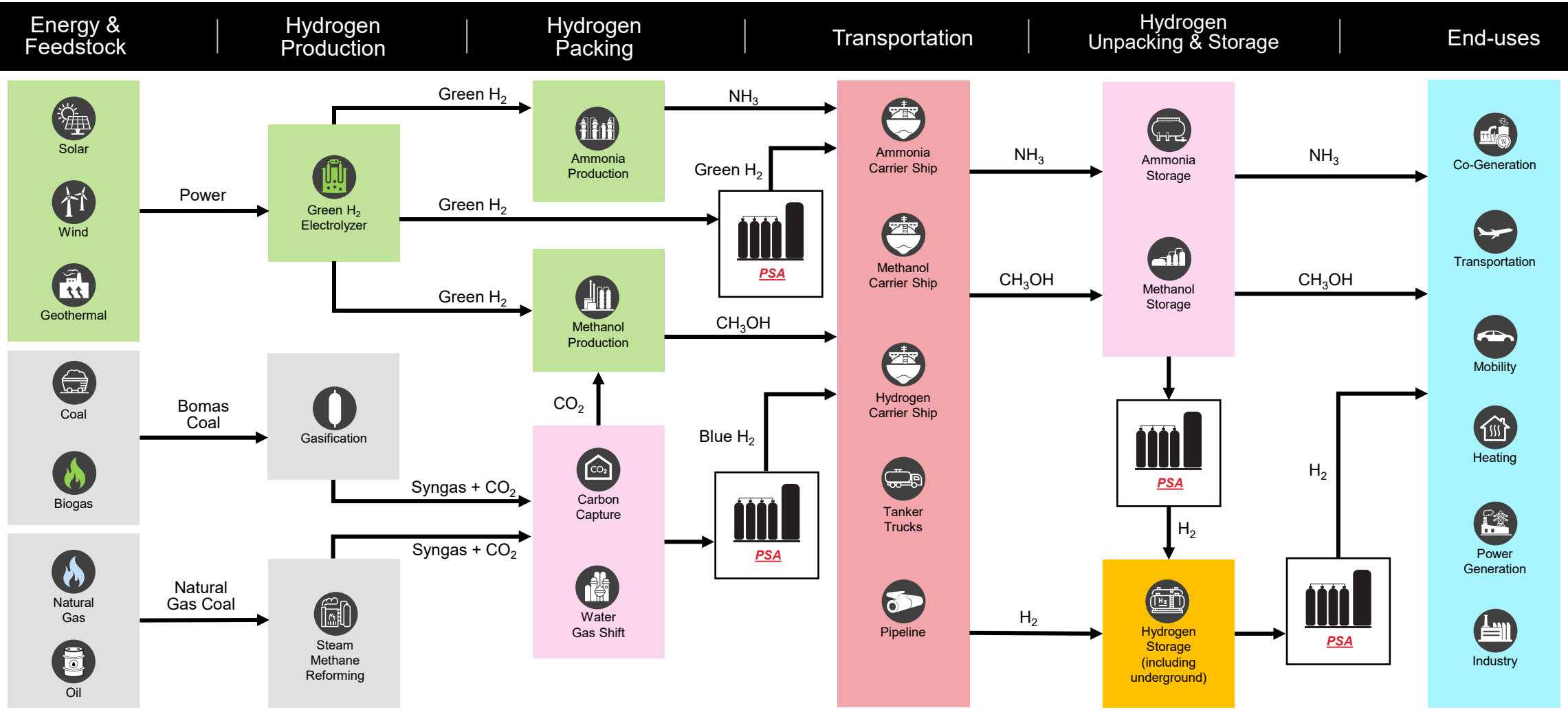
$2.5tn annual sales (hydrogen and equipment)

30m jobs created

In a decarbonized world, H_2 demand could grow up to ~10-fold

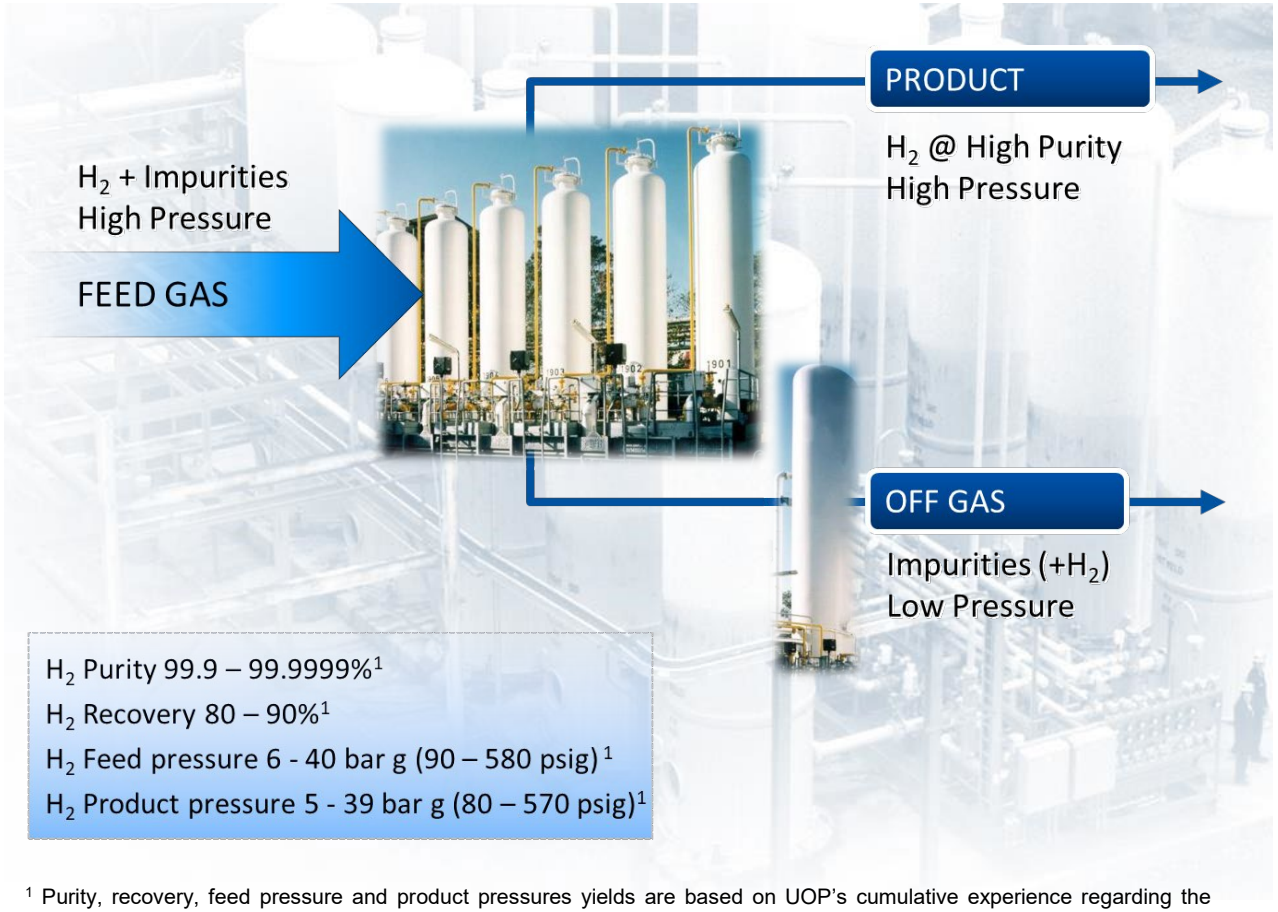
MARKET DYNAMICS

WHERE DOES A POLYBED™ PSA FIT?



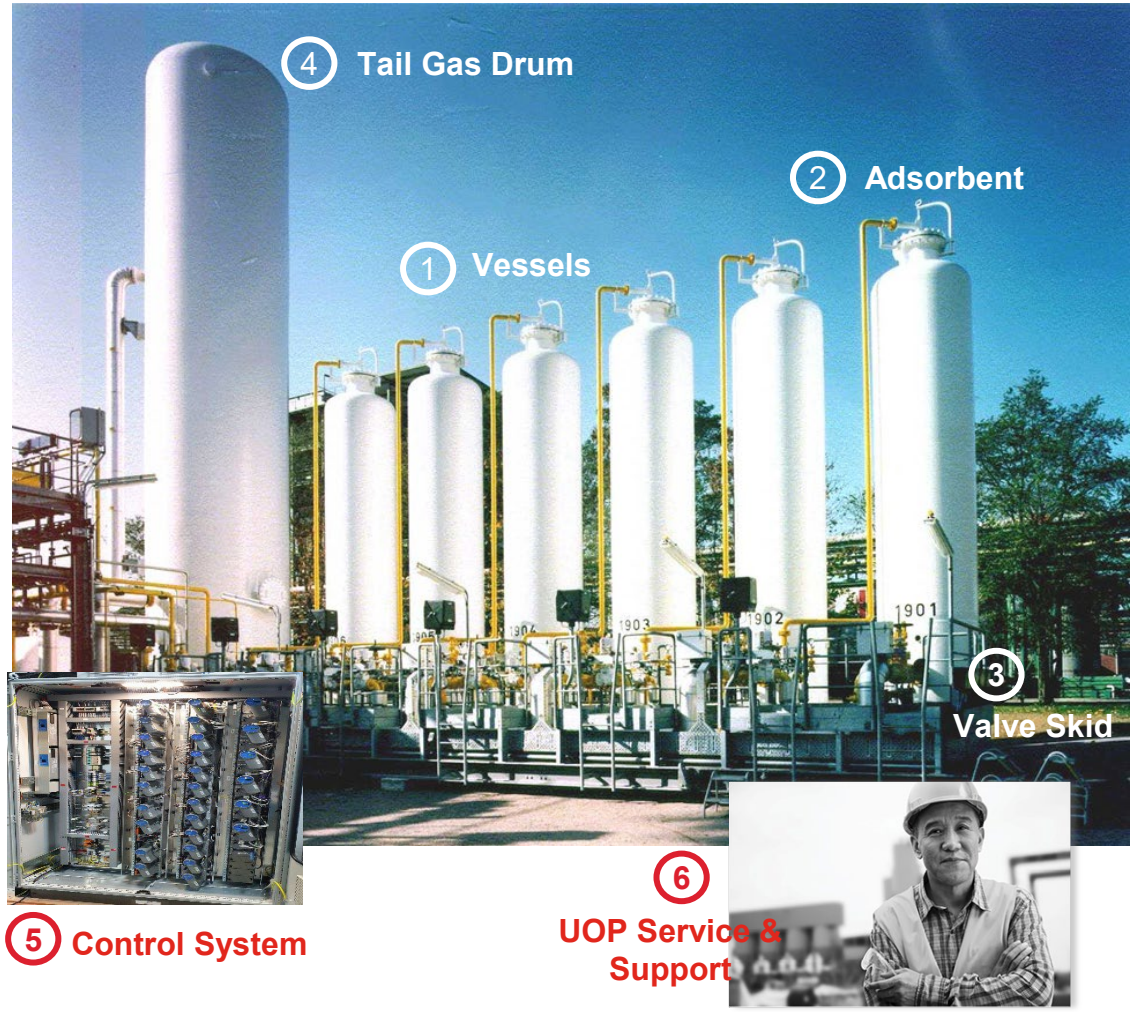
Many Opportunities for PSA Revamp in H2 Value Chain

PERFORMANCE & COMPONENTS OF A UOP POLYBED™ PSA NEW UNIT



- H_2 Purity 99.9 – 99.9999%[1]
- H_2 Recovery 80 – 90%[1]
- H_2 Feed pressure 6 - 40 bar g (90 – 580 psig)[1]
- H_2 Product pressure 5 - 39 bar g (80 – 570 psig)[1]

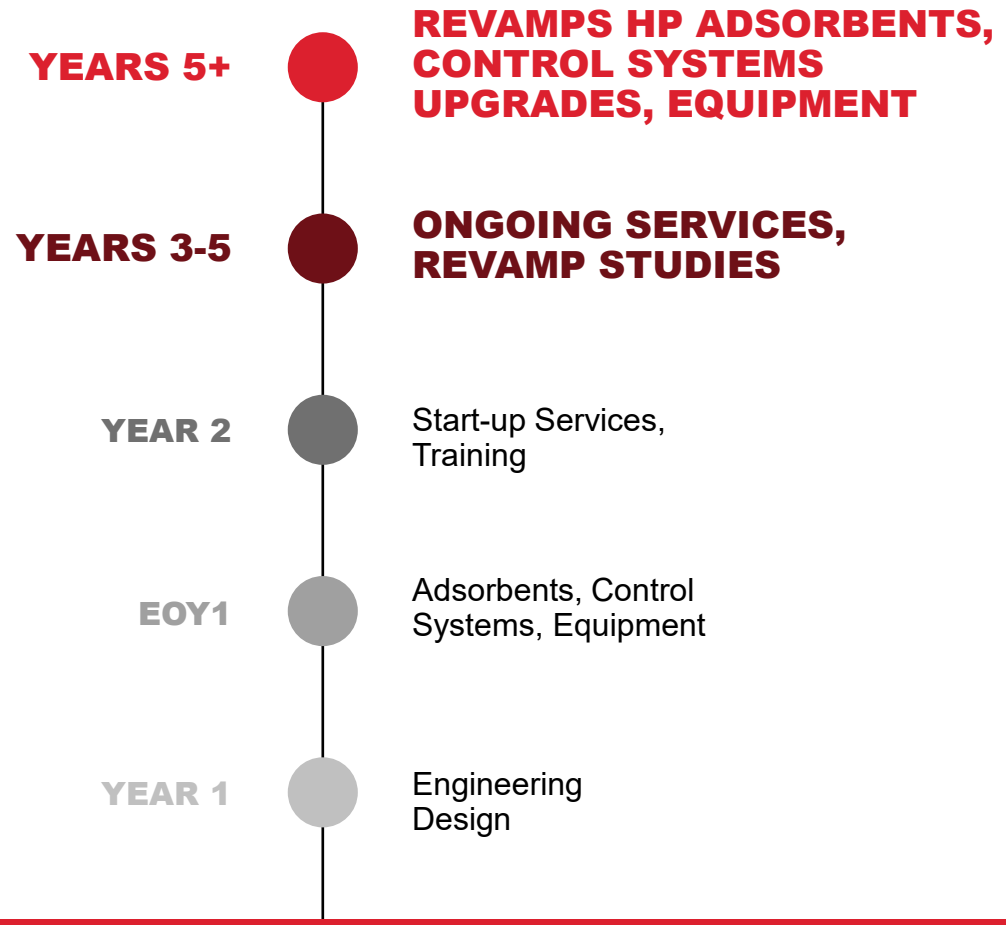
[1] Purity, recovery, feed pressure and product pressures yields are based on UOP's cumulative experience regarding the operational performance of more than 1,150 PSA units that UOP has supplied to customers worldwide starting from the 1960s, and these PSA units having consistently achieved the requisite targets for purity, recovery and operating in the pressure ranges.



High Purity H_2 Purification Equipment / Modular Supply

REASONS TO CONSIDER A REVAMP

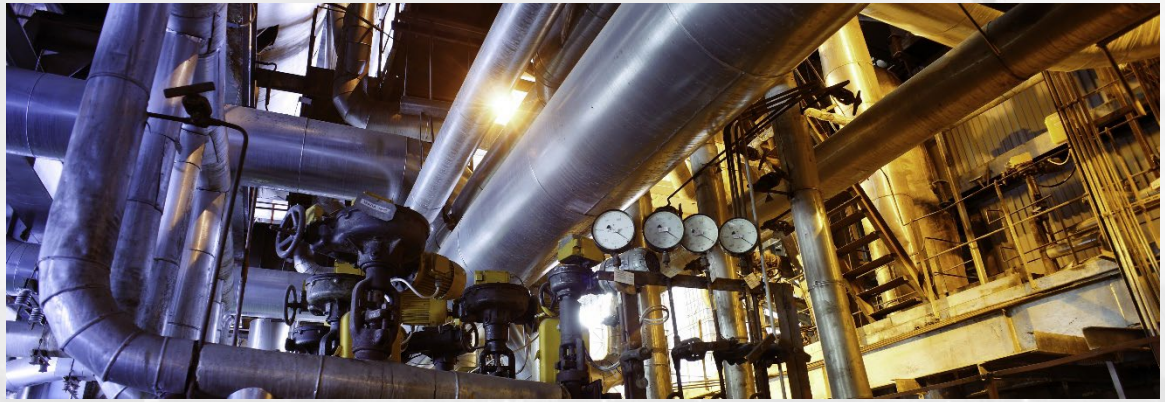
- New Product Specifications
- Change in Feed Composition
- Increase H_2 Recovery
- Increase Capacity
- Enhanced Operating Features (switchovers, …)
- Increased Reliability (older / smaller units)
- Upgrade Control System (obsolescence)
- PSA Health Check
- Vessel inspections



[1] UOP has executed over 3,500 PSA revamp projects Worldwide, which started in the 1980s, where the above benefits of the revamp project were provided or the revamp was due to the above reasons.

Revamps – The perfect way to upgrade your existing unit

REVAMP BENEFITS



REVAMP BENEFITS[1]

- Increased capacity possible with existing equipment
- Shorter schedules
- Lower capital investments

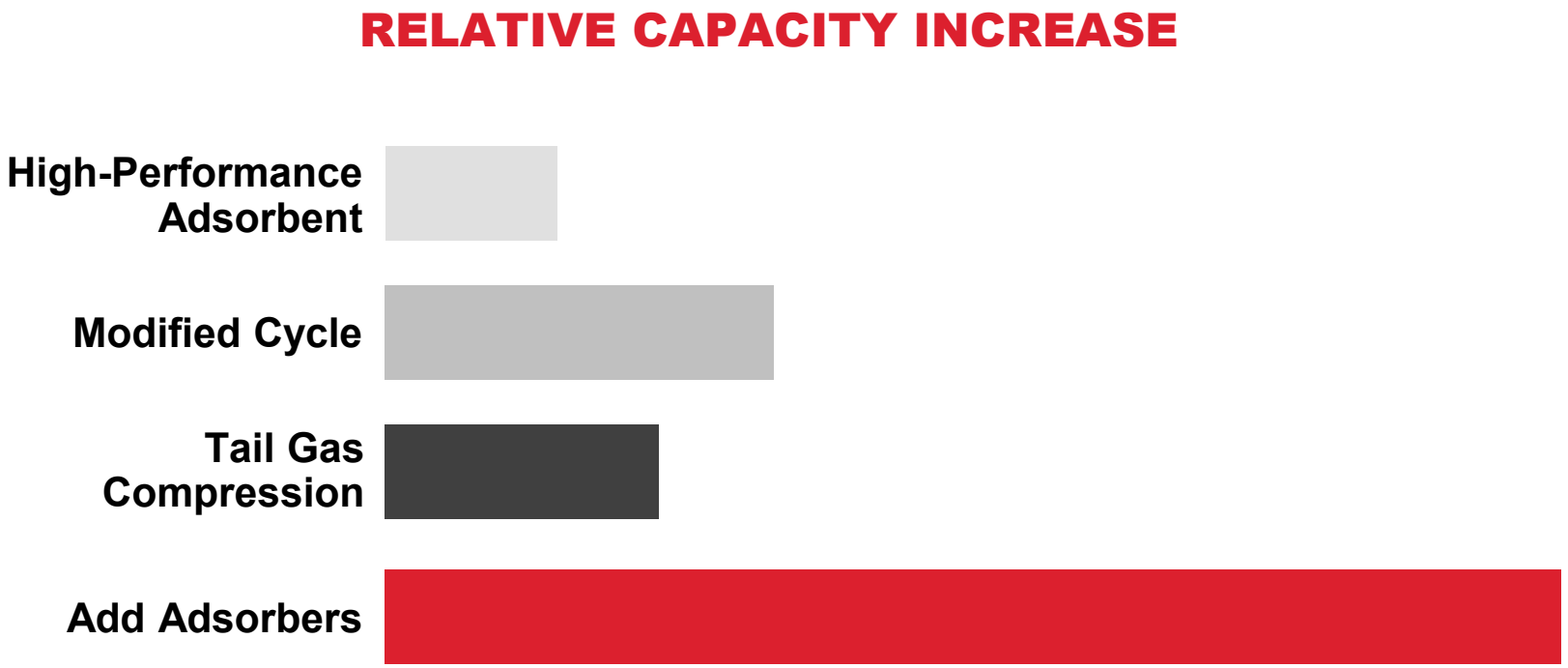
[1] These benefits have been demonstrated by UOP having executed over 3,500 PSA revamp projects worldwide starting from the 1980s, where UOP's revamp customers consistently experienced the above benefits as a result of UOP's revamp of their respective PSA units.

REVAMP DELIVERED AS

- Process Evaluations / Studies
- Adsorbent Replacement: Optimized / Make-up / Partial / Complete
- Control Systems: Upgraded Hardware / Equipment / Software
- Capacity Expansions: Additional vessels / Valves / Piping
- Periodic Health Check:
  - Adsorbent / Control Panel / Auto Valve / Overall Unit Performance

UOP has been providing on-going revamp support for more than 25 years

SOLUTIONS TO INCREASE CAPACITY OF YOUR PSA



Any of the Above Options Can be Combined

NEW HIGH-PERFORMANCE ADSORBENT SMR &ROG/EOG PSA UNITS

General Observations[1]

+1% to +2% INCREASE

in H_2 recovery at same Product spec / CO slip

5 to 15 % INCREASE

in unit capacity in some cases

[1] For details on the recovery and capacity increase for the SMR (Steam Methane Reformer) applications see the following slide 11 of this presentation and for details on the recovery and capacity increase for ROG (Refinery Off-Gas) and EOG (Ethylene Off-Gas) applications see the 2nd slide from this slide - slide 12.

FIELD RESULTS – SMR PSA UNITS
NEW HIGH-PERFORMANCE ADSORBENT

UNIT A – SOUTHEAST ASIA

- 10-bed PSA system
- SMR feed
- 73 300 Nm3/h feed gas
- 24.5 bar g
- Original Design Recovery 89.0%
- 50 ppm v CO

ORIGINAL UNIT

RELOADED WITH NEW HIGH-PERFORMANCE ADSORBENTS IN MAY 2018

- Guaranteed Recovery 90.0%[1]
- 18% increase in K_F (capacity)[1]

Additional revenue of *$1.2M*[2] per year based on recovery improvement only

UNIT B – EASTERN EUROPE

- 10-bed PSA system
- SMR feed
- 65 000 Nm3/h feed gas
- 32 bar g
- Design Recovery 87.0%
- 20 ppm v CO
- Measured Recovery > 87.0%

ORIGINAL UNIT

RELOADED WITH NEW HIGH-PERFORMANCE ADSORBENTS IN SEPTEMBER 2017

- Measured Recovery 91.5%[3]
- Guaranteed Recovery 90.0%[3]
- 8.5% increase in KF (capacity) [3]

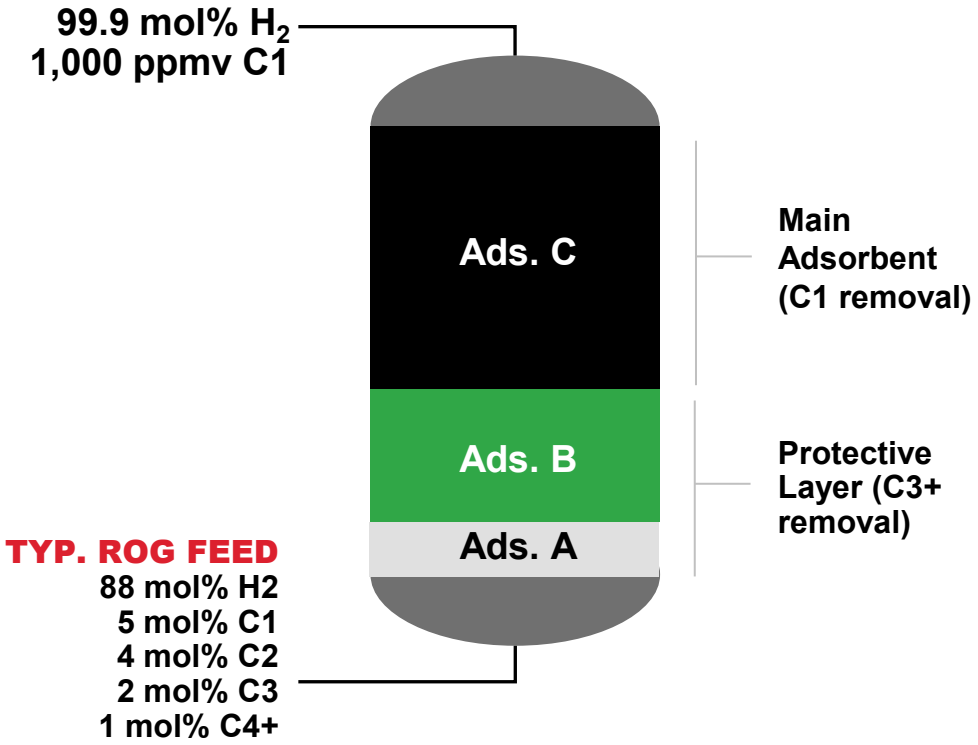
Additional revenue of *$2.0M*[2] per year based on recovery improvement only

[1] Based on the guaranteed recovery and capacity performance provided by UOP on the original designed PSA unit and the guaranteed recovery and capacity performance provided by UOP on the revamp design PSA unit.
[2] The additional revenue from the recovery increase only using a $1,200/MT price for hydrogen and 8400 operating hours per year.
[3] Based on actual operating data from the original designed PSA unit and operating data from the revamp designed PSA unit after the adsorbent reload with high performance adsorbents. Details on the actual data from the revamp designed PSA unit was provided in a Performance Test Report.

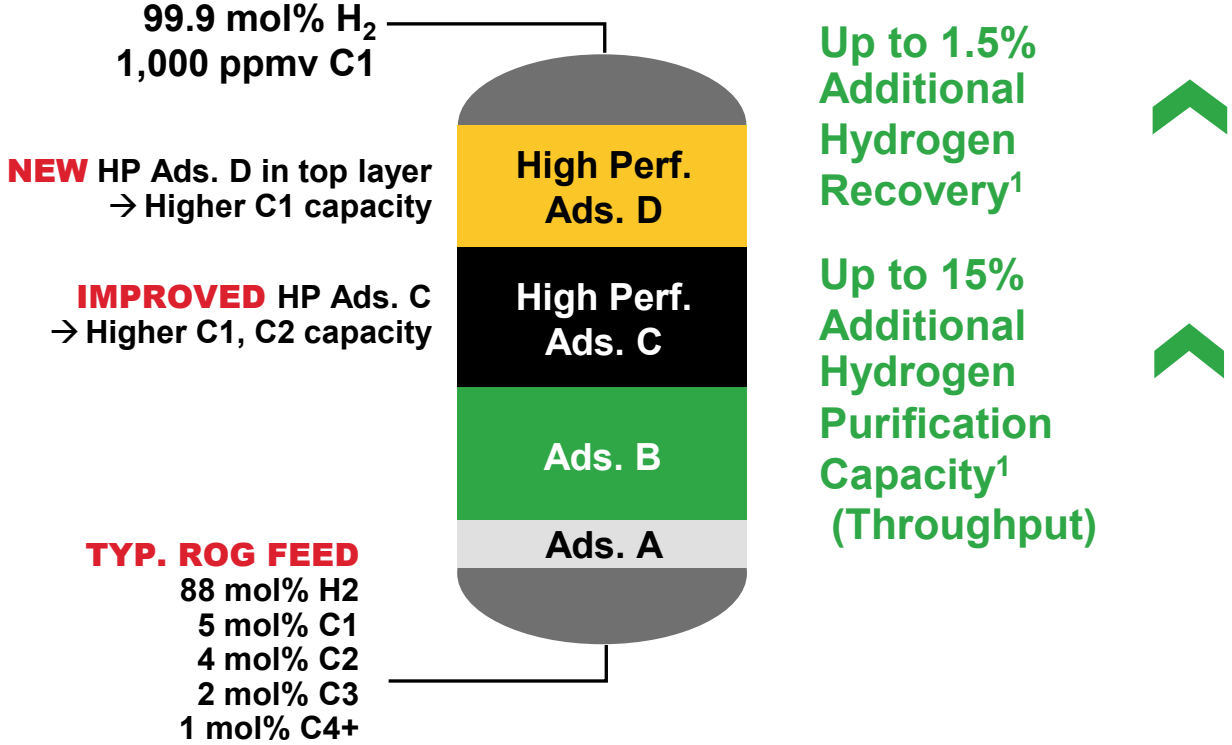
Better than original performance on Recovery by 1% & 3%

NEW HIGH-PERFORMANCE ADSORBENT ROG/EOG PSA UNITS

OPERATING UNIT



PROPOSED RELOAD



Estimated *$6.1M* of additional revenue per year (based on recovery and capacity improvement)[2]

[1] Based on a UOP pilot plant tests results conducted by UOP in 2019 & 2020 at its own facilities, confirming the improved performance in terms of recovery and capacity of the high-performance molecular sieve and carbon (C1) adsorbents.
[2] The additional revenue from the recovery and capacity increase using a $1,200/MT price for hydrogen and 8400 operating hours per year.

Improved Recovery & Productivity – New High-Performance Adsorbents

POLYBED™ PSA
CAPACITY EXPANSION REVAMP

UNIT A – INDIA

ORIGINAL UNIT

- 12-bed PSA system
- ROG feed
- 144,305 Nm^3/h feed gas
- 26.5 kg/cm^2 g
- Original Design Recovery 86.0%
- 99.9 mol% H_2 purity
- Supplied in 2010

NEW DESIGN

- 16-bed PSA system
- ROG feed (different concentrations)
- 191,927 Nm^3/h feed gas
- 25.8 kg/cm^2 g
- Original Design Recovery 90.0%
- 99.9 mol% H_2 purity
- Suppied in 2022

PSA CYCLE CHANGE 12-BED TO 16-BED EXPANSION

- Increased recovery 4% points to 90% recovery[1]
- Increased feed capacity 33%[1]
- No change to adsorbent split
- Provided 4-bed skid extenstion

1.Based on internal simulation model and project documentation.

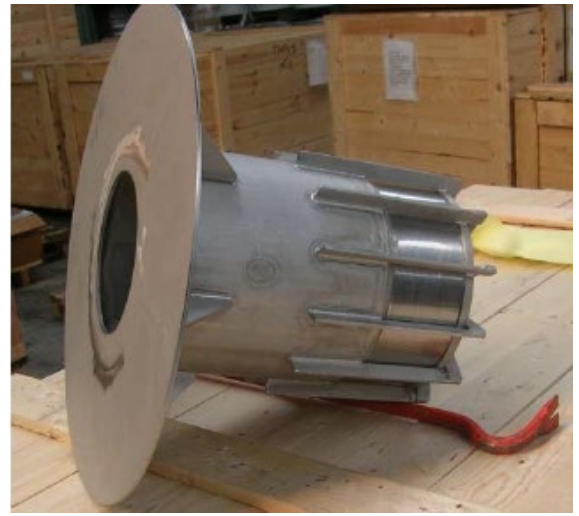
Improvement on recovery versus pre-revamp Unit by ~ 4%

POLYBED™ PSA
IMPROVED TOP FLOW DISTRIBUTOR

ADVANTAGES NEW VS. OLD DESIGN[1]

- Improved flow distribution
- Wedged wire screen instead of mesh
- Rugged design with reinforcements
- Even further reduced risk of a failure
- Easy one on one replacement
- No vessel modifications required

New Improved Design



HOW TO UPGRADE

- There is no direct need of immediate replacement of the existing distributors
- In order to ensure trouble free operation beyond the design life and to upgrade internals to UOP's latest offering to enhance mechanical reliability, we highly recommend replacement of the Top Flow Distributors during next scheduled vessel inspection or during an adsorbent reload

Old Design

[1] Advantages of new top flow distributor design for Polybed PSA have been confirmed by the results of CFD (Computational Fluid Dynamics) performed on the improved top flow distributor modeling in March of 2009. In addition, a metallurgical examination was completed by a 3rd party (Praxair) in 2012 to verify the new top flow distributor design improvements versus the old top distributor design. In addition, UOP has supplied this new top flow distributor model on over 150 PSA units since 2013 without any known issues reported to UOP to date by the customers related to the new model of the top flow distributor.

CONTROLS
RELIABILITY AND AVAILABILITY ENHANCEMENT

CUSTOM CONTROL SYSTEM SOLUTIONS

- Full replacement or upgrade of obsolete Control System
- Fully redundant control system hardware and communications
- Fast Trending HMI station with comprehensive fault detection diagnostics

HONEYWELL EXPERION C300 SOLUTION

- Integrate PSA with Honeywell Experion PKS using UOP's Honeywell C300 control system and Experion HMI Web PSA graphics
- Fully integrated DCS control replacing PLC-DCS interface

HMI STATION UPGRADES AND SPARES

- Replacement of obsolete HMI PC and Software upgrades
- Upgrade HMI station communication set up
- Control System spares to improve process unit on-stream performance and decrease process upsets

POLYBED™ PSA
CONTROL SYSTEM UPGRADE – FIELD RESULTS

UNIT A – NORTH AMERICA

- 10-bed PSA system
- SMR unit
- Rockwell AB L5x/6x hardware
- Windows 7 based operator and engineering station
- 4:3 resolution HMI graphics

ORIGINAL UNIT

REPLACED WITH HON C300 CONTROL SYSTEM SOLUTION IN FEBRUARY 2023

- Seamless integration and interface in Experion PKS ↑
- Costs for separate DCS screens and start-up time ↓
- Costs for maintenance and capital spares ↓
- Operational efficiency w/ advanced diagnostics ↑

UNIT B – ASIA

- 12-bed PSA system
- SMR unit
- Modicon Quantum hardware
- Windows XP based operator and engienerig station
- 4:3 resolution HMI graphics

ORIGINAL UNIT

REPLACED WITH NEW PLC BASED CONTROL SYSTEM SOLUTION IN DECEMBER 2019

- Increased reliability e.g. 2oo3 signals, permissives, valve limiting, modern & user-friendly graphics ↑
- Improved operations using enhanced features e.g. Dry cycle mode, improved valve failure logic ↑
- Risks of parts failure and downtime ↓

Upfront cost savings >= $250k[1], YoY savings ~ $30k[1]
Downtime & Operation savings > $1M per year[2]

[1] Based on UOP's subject matter expertise, internal evaluation model and estimates for Unit A or B
[2] Based on $1,200/MT price of hydrogen and 8400 operation hours per year, within minimum downtime of 7 days for Unit A and downtime for 3.2 days

Improved performance and reliability for maximum on-stream PSA operations & minimal downtime

PSA
HEALTH CHECKUP

WHY WE NEED A HEALTH CHECKUP?

- To Avoid Unexpected Shutdown
- Improve On-Time Availability
- Improve Performance
- Timely Procurement of Spare Parts
- Advance Maintenance Planning

Proactive Maintenance Has a Real Impact on Profitability

PSA HEALTH CHECKUP CONTINUED

WHAT UOP DOES DURING A HEALTH CHECKUP?

- Performance Audit
- Physical Verification of Control System
- Physical Verification of Valve Skid
- Operating & Maintenance Procedures Audit
- Troubleshooting
- Training

PERFORMANCE AUDIT

- Collect Operating Information and Review
- Verify Information with Design
- Collect Process Data / Trends
- Analyze Process Data / Trends
- Evaluate Optimization Schemes
- Collect & Analyze Laboratory Analysis around PSA Unit

PSA Health Checkup Improves Performance.

TYPICAL SCHEDULE
FOR PLANNING PURPOSES

- Adsorbents – up to 6 months of port of export
- Phase 1 (Engineering) Studies – 3 months
- Control Systems Retrofits – 12 months or more
- Control System and HMI upgrades – 4-10 months
- Phase 2 (Implementation) – 6 to 12 months

PSA REVAMP WEBINAR CONTINUED

- Ongoing customer support
- ANY PSA unit design may be upgraded for PSA Revamps for new operating conditions[1]
- In our experience, PSA Revamp of existing unit has typically been more cost-effective and had shorter execution timeline as compared to the supply of new PSA units.[1]

WHO TO CONTACT

- UOP's PSA After-Market Business supports the needs of all internationally installed UOP PSA units
- Reach out to…
  - Technical Services
  - Sales Account Manager
  - Questions/requests via the online Portal

[1] These benefits have been demonstrated by UOP having executed over 3,500 PSA revamp projects worldwide starting from the 1980s, where UOP's revamp customers consistently experienced the above benefits as a result of UOP's revamp of their respective PSA units.

https://www.accessuop.com/

Customer Portal

THANK YOU

Honeywell
UOP