

INNOVATIVE PATHS TO CLEANER SKIES

2025 HONEYWELL APAC SAF CONFERENCE

TECHNOLOGY
NEW PATHWAYS TO SAF

SIMMI SOOD
SENIOR BUSINESS LEADER – HP & FATH

May 29, 2025

Honeywell



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AGENDA

NEW PATHWAYS TO SAF

- I. Honeywell UOP pathways to (e)SAF**

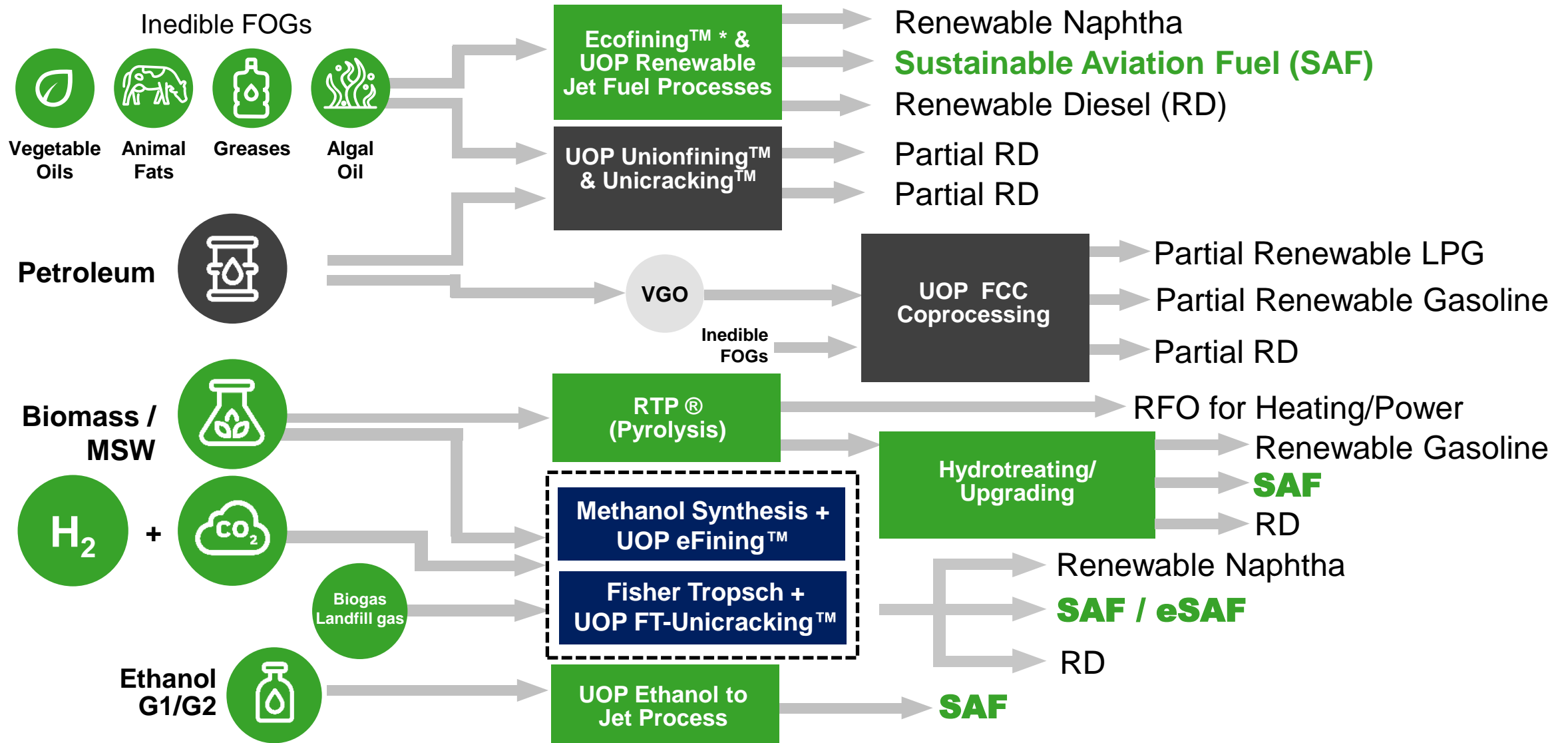
- II. Fischer Tropsch pathway with FT-Unicracking™**

- III. Methanol pathway with eFinning™**

- IV. Fischer Tropsch & Methanol to Jet pathway**

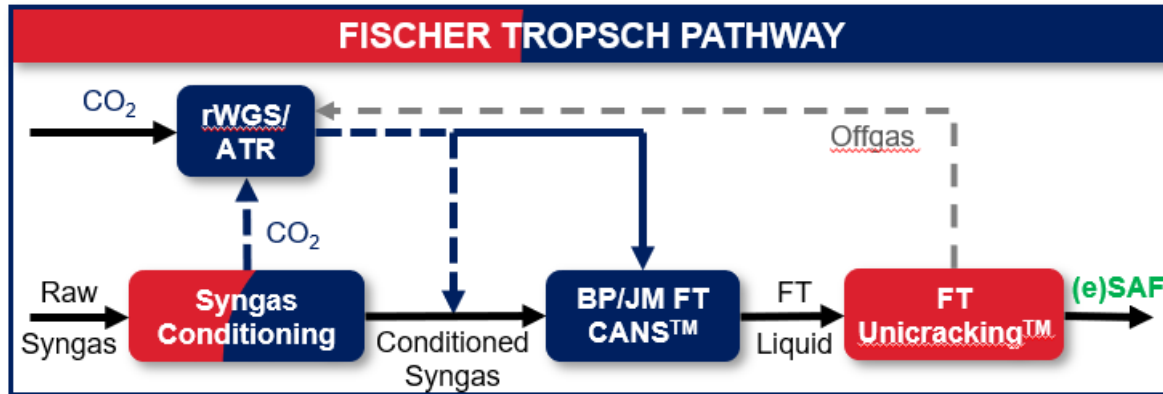
- V. Conclusion**

HONEYWELL UOP PATHWAYS TO RENEWABLE FUELS

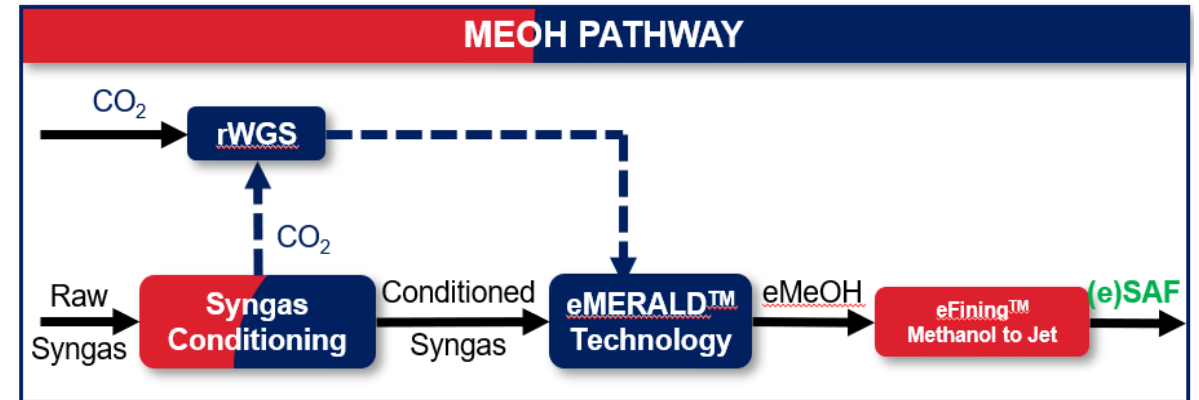


* Ecofining technology produces renewable diesel, SAF, and other renewable products from biogenic feed sources.

BUILDING OFF OF A STRONG FOUNDATION FROM HONEYWELL UOP AND JOHNSON MATTHEY



- Two best licensors, Johnson Matthey for FT CANSTM technology & Honeywell UOP for FT Unicracking™ technology join hands to work as partner for (e)SAF production through FT pathway
- Tailormade technology integration to achieve lowest CCOP for (e)SAF production with high H₂ efficiency
- Single point of technical responsibility to provide seamless execution experience



- Two leading licensors, Johnson Matthey for eEMRALDTM technology & Honeywell UOP for eFining™ technology join hands to work as partner for (e)SAF production through methanol pathway
- Strong & proven technology portfolio to offer highest (e)SAF production with higher H₂ efficiency
- Single point of technical responsibility to provide seamless execution experience

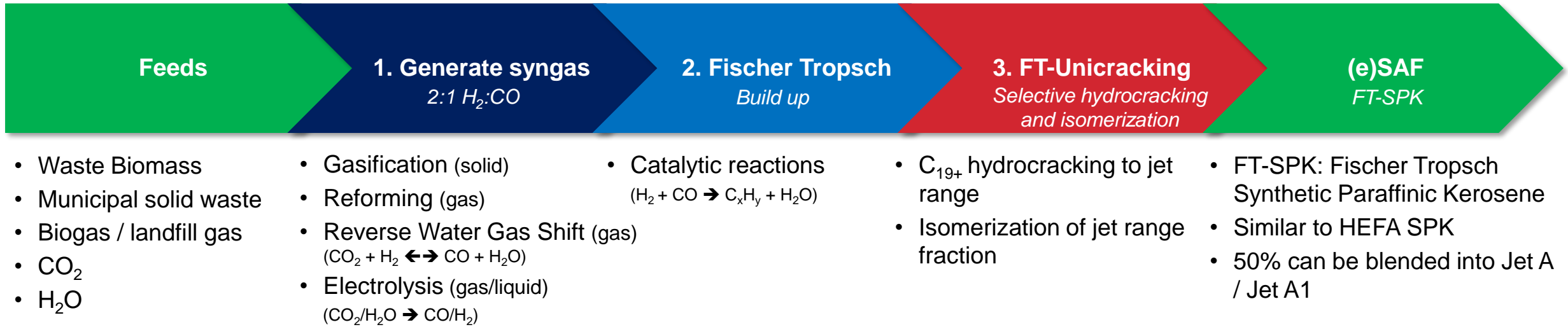
Partnering to Simplify & Expedite Project Execution with End-to-End Responsibility



FISCHER TROPSCH PATHWAY WITH FT-UNICRACKING

HONEYWELL UOP APPROACH: (e)SAF VIA FISCHER TROPSCH

A 3-STEP PROCESS



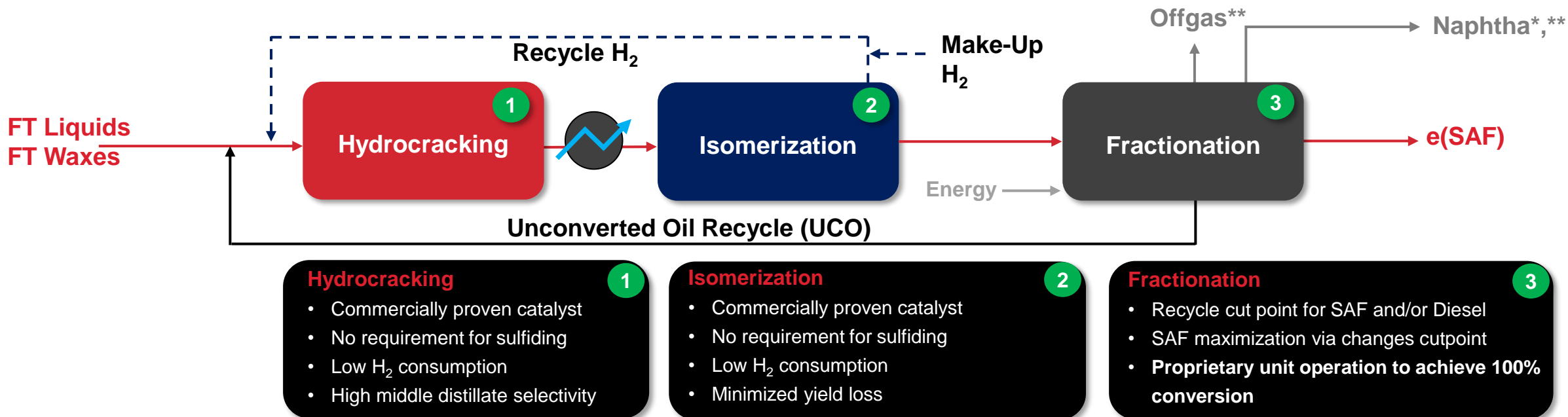
Features:

- ASTM D7566 approved pathway since June 2009
- 90% reduction in GHG emissions on a total lifecycle basis¹
- Further reduce GHG intensity with Carbon Capture, Electrification, Heat-, and Process integration
- High yields of (e)SAF
- Commercially demonstrated technologies & catalysts
- FT value chain End to End solution with strategic allies
- Build new or repurpose existing assets

1. Carbon intensity is based on ICAO CORSIA default lifecycle emissions values for CORSIA-eligible fuels, Table 1 - agricultural residues and forestry residues.
Corsia Eligible Fuels - Life Cycle Assessment Methodology - Version 3.2, June 2022 | International Inc. Neither this document nor the information contained herein may be reproduced, used, distributed or disclosed to others without the written consent of Honeywell

HONEYWELL UOP – FT UNICRACKING™

TYPICAL CONFIGURATION



Technology differentiators

1. 3-5% higher SAF yield¹
2. Up to 20% lower CAPEX^{2,3}
3. Lower OPEX⁴
4. Reduced generation of by-product process and waste streams^{1,2}

More (e)SAF at a lower cost and with less waste^{1,2}

* Offtake case - sales in i.e., California benefiting from LCFS, or in i.e., EU to naphtha crackers for green olefins production.

** Recycle and re-synthesize offgas / naphtha to syngas to increase carbon efficiency to (e)SAF.

1. By utilizing proprietary SAF selective Honeywell UOP hydrocracking and hydro-isomerization catalysts.

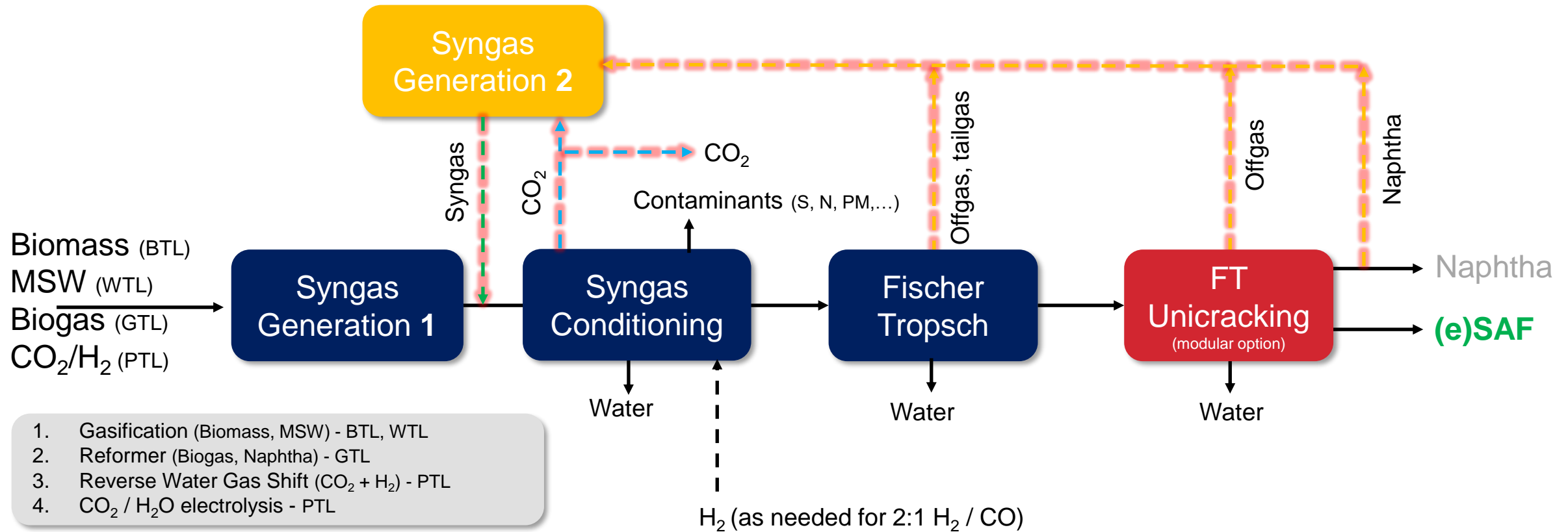
2. By utilizing a Honeywell patent pending process configuration.

3. Based on internal UOP cost (Estimated Erected Cost) analysis that compares a typical configuration with the patent pending configuration.

4. As a result of low operating pressure enabled by proprietary catalysts and a proprietary, energy efficient fractionation process.

FISCHER TROPSCH COMPLEX

RECYCLE STRATEGIES FOR FURTHER INCREASING CARBON EFFICIENCIES



Increased¹ Carbon Efficiency to FT-SPK and/or Diesel via naphtha / LPG / offgas / (CO₂) recycles

1. As compared to a base case where off-gas, LPG and naphtha are not recycled

HONEYWELL UOP – FTL/W UPGRADING EXPERIENCE

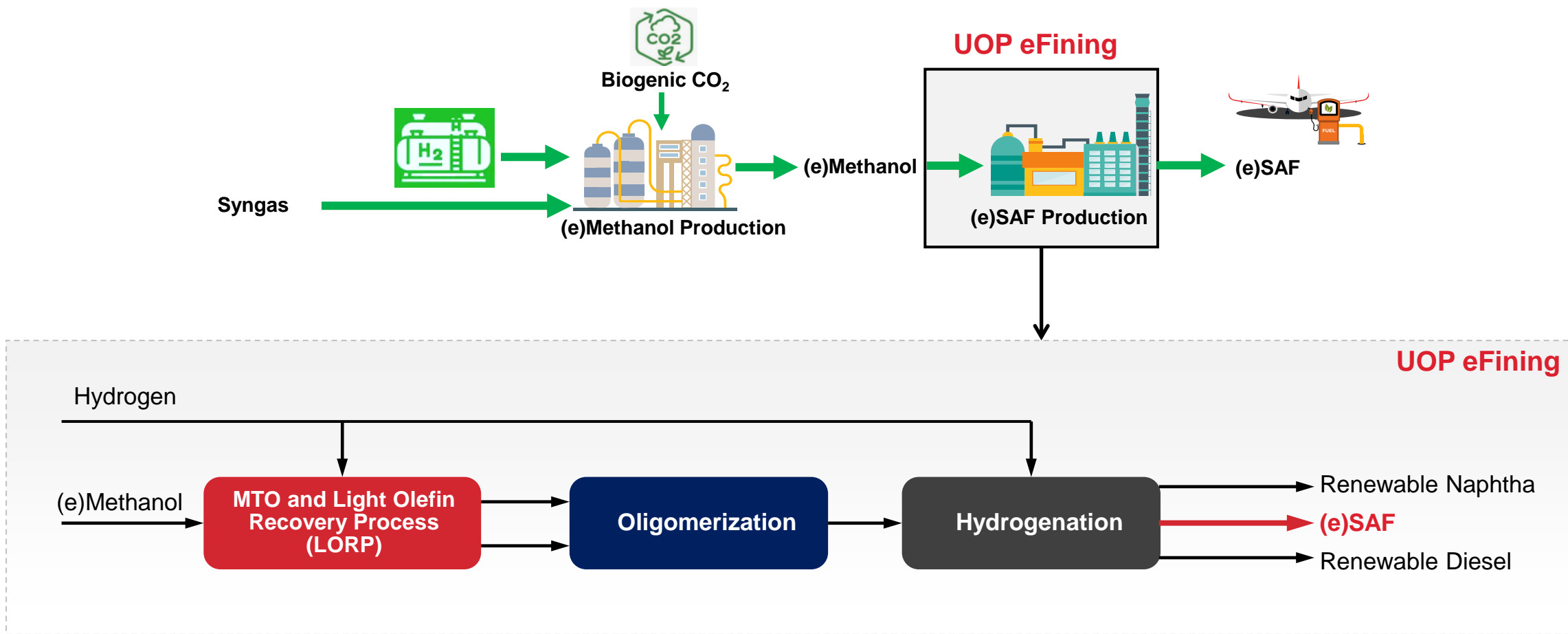
- **1986 US DOE study for characterization and upgrading of FT waxes via hydroprocessing**
- **Processed FTL/W from different FT licensors (Fe & Co based) in HON UOP pilot plants:**
 - > 10,000 hours of FT wax & liquids pilot plant testing
 - 9,200 hours in single stage testing with full on-line fractionation & recycle
- **Operating references demo scale units FT-Unicracking:**
 - Rentech, USA (Fe-based FT, 13 BPSD) - operated for approx. 5 years (2008 – 2013)
 - Japanese customer (Co-based FT, 1 BPSD) – produced SAF used in commercial flight Japan Airlines in 2021
- **Developed and commercialized:**
 - 4 generations of FT Unicracking catalyst (base & noble metal)
 - 3 generations of hydro-isomerization catalysts (noble metal)
- **Represented FT-Unicracking from 1 bpsd up to 20,000 bpsd FT crude**
- **Executing Schedule A's (i.e., DG Fuels) and multiple feasibility (FEL 2) studies**
- **High fidelity process models based on FT syncrude upgrading work/experience since 1980's**

Long history of developing and commercializing process technology



MeOH PATHWAY WITH UOP eFINING™

(e)SAF PRODUCTION THROUGH UOP eFINING™



Conversion of biogenic and eCarbon to (e)SAF through a flexible intermediate

METHANOL CONVERSION

METHANOL TO OLEFINS (MTO)

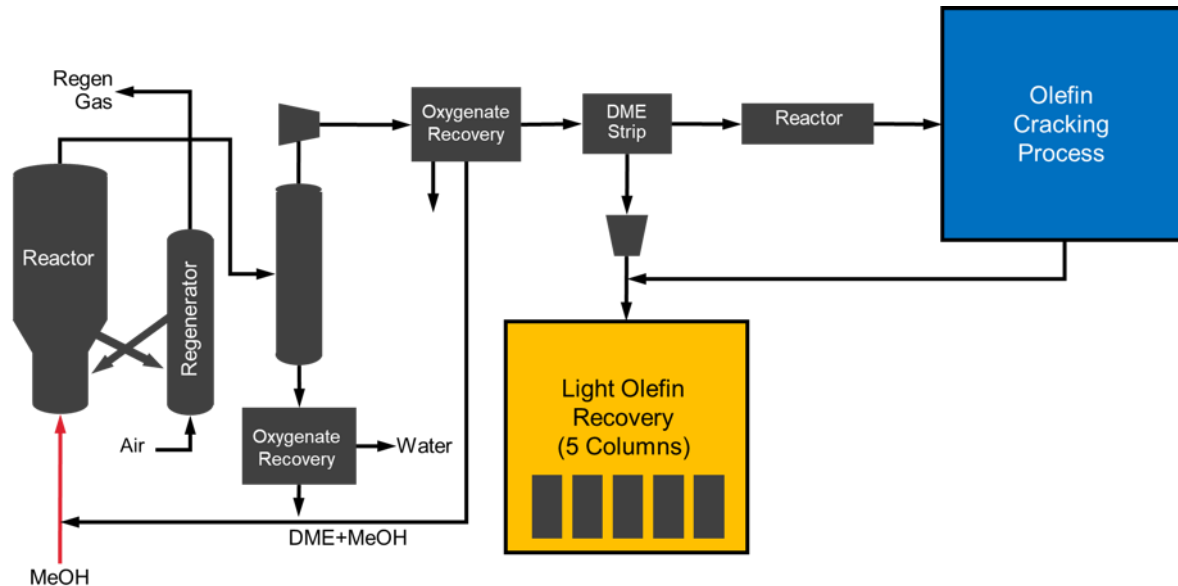
Proven at scale

- 7 operating units commercialized since 2013
- 37 years of combined operating experience, capacities up to 2.4 MMTA MeOH feed

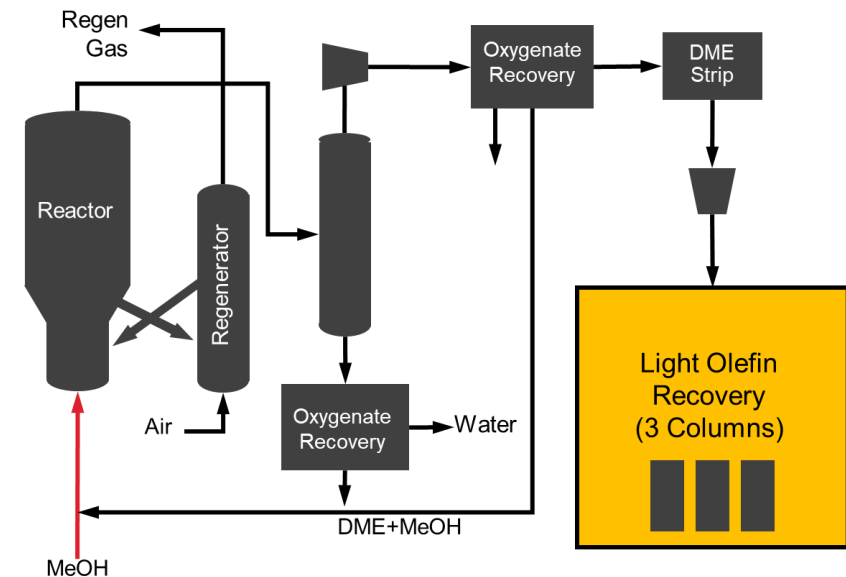
Simplified for SAF production

- Eliminated multiple pieces of major equipment for ~30% lower equipment cost
- Reduced utilities vs. traditional MTO process

Traditional MTO



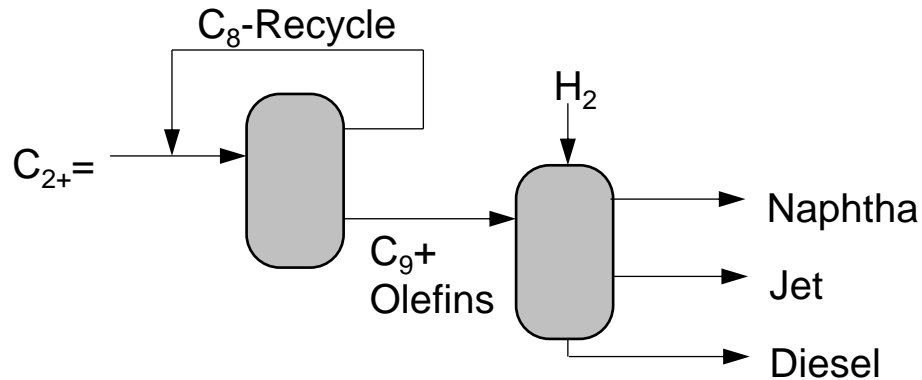
Methanol to Olefins for SAF



Light olefins produced via a simplified version of the proven MTO design

OLEFIN CONVERSION TO JET FUEL

OLIGOMERIZATION AND SELECTIVE HYDROGENATION



- Oligomerization of light olefins to jet-range, branched molecules
- Selective hydrogenation to saturate olefins
- Leveraging commercial experience to fine tune this process for jet fuel production
- Process demonstrated at laboratory scale, with a catalyst selective to jet range product

Relevant commercial experience:

Catalytic Condensation (“Cat Poly”) Process Technology:

- Oligomerization of C_3/C_4 olefins for gasoline blending and to nonene and tetramers for specialty chemicals
- Over 100 units licensed and designed since 1950

InAlk Technology:

- Oligomerization and hydrogenation of C_4 olefins to C_8 - C_{12} hydrocarbons for gasoline blending
- Commercialized in 2001, 25 units licensed and designed

Catolene Technology:

- Oligomerization of C_3 - C_5 olefins from FCC to diesel range hydrocarbons
- Commercialized in 2016

Selective Hydrogenation Process (SHP) and Complete Saturation Process (CSP):

- Selectively hydrogenate dienes or completely hydrogenate dienes/olefins to corresponding paraffins
- 42 units licensed and designed



FISCHER TROPSCH & METHANOL TO JET PATHWAY

CONSIDERATIONS FOR PICKING A (e)SAF PATHWAY

TODAY'S STATUS OF TECHNOLOGY

FISCHER TROPSCH

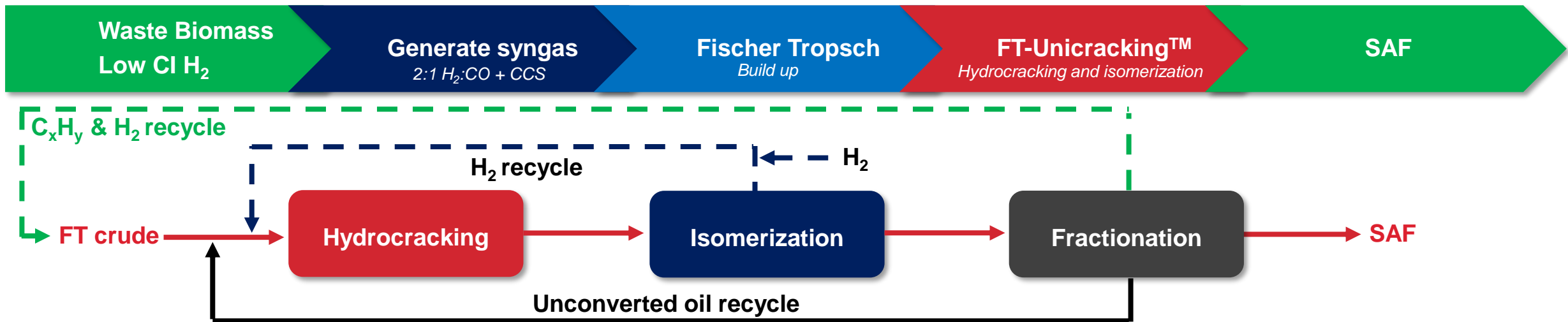
- **SAF** (lower CAPEX) / **eSAF** (requires rWGS)
- High H₂ efficiency to SAF and eSAF
- Product flexibility – designed to maximize either (e) SAF, (e) SAF + (e) Diesel, (e) Diesel
- Naphtha liquid byproduct (w/ option to recycle)
- ASTM D7566 approved in June 2009
- One stage investment typically required; Hub and Spoke model might be feasible as well
- Can leverage existing assets (hydroprocessing)

METHANOL

- **SAF** (higher CAPEX) / **eSAF** (when rWGS not required)
- Higher H₂ efficiency to eSAF
- Pathway specifically designed to maximize (e)SAF
- Naphtha and Diesel liquid byproduct – minimized and used as internal fuel to lower emissions and CI
- ASTM D7566 approval pending 2025
- Hub and Spoke enables utilization of low-cost feedstocks remotely, economies of scale, and staged investment
- Can leverage existing assets (MTO)

Your business model will define the right technical path

SAF PATHWAY CASE STUDY | FISCHER TROPSCH



FISCHER TROPSCH COMPLEX (GREENFIELD)

Geography:

- USA

Carbon source:

- Biomass syngas: gasification

Hydrogen source:

- Biomass syngas + low Cl H₂

Technology considerations:

- High SAF yield & carbon efficiency
- Heat & process integration: minimization CAPEX/OPEX/byproducts
- Carbon capture & storage (CCS)
- Modularization: simplified & shorter project

Key market:

- Sell SAF in US and qualify for LCFS / RIN / 45Q / 45Z credits

Product flexibility:

- Target to maximize overall carbon yield to carbon negative SAF

CUSTOMER VALUES

Feedstock flexibility

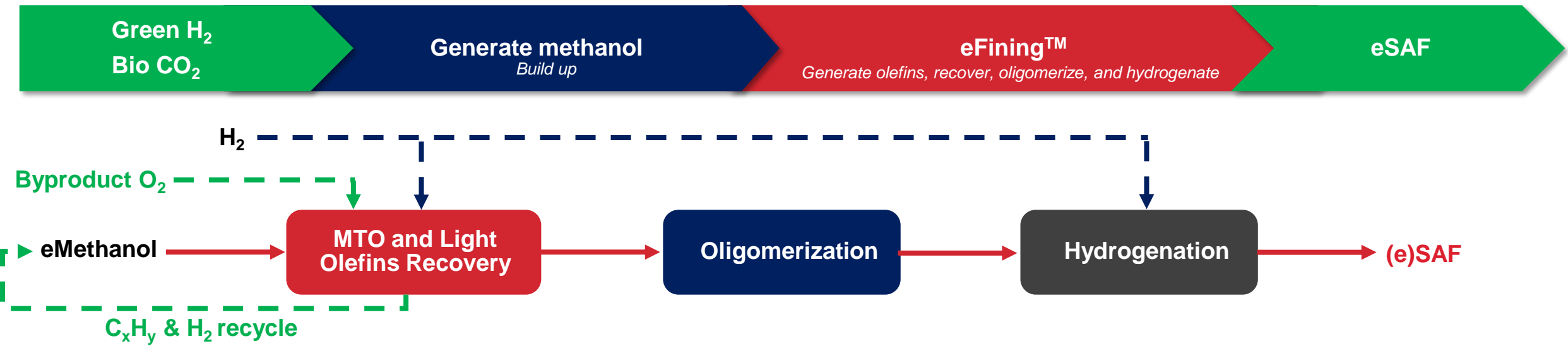
Abundant low-cost feedstock

High bankability score & TRL

ASTM D7566 approved

Max carbon negative SAF

eSAF PATHWAY CASE STUDY | METHANOL



METHANOL TO JET COMPLEX (GREENFIELD)

Geography:

- EU

Carbon source:

- Captured biogenic CO₂

Hydrogen source:

- Green H₂ from electrolyzer

Technology considerations:

- Integrated with electrolyzer & methanol plant
- Carbon & H₂ efficiency
- OPEX & byproduct minimization
- Byproduct recycle

Key market:

- Selling eSAF into the EU market to satisfy ReFuelEU mandates
- RFNBO submandate

Product flexibility:

- Target to maximize overall carbon yield to eSAF

CUSTOMER VALUES

Direct conversion of CO₂ to fungible intermediate

Efficient and integrated assets

Max eSAF

Talk to us to help you navigate the right pathway based on your business model and investment strategy.

With technologies that convert the broadest range of feedstocks to (e)SAF and the expertise to back it up, we are here to help.

Honeywell



THANK YOU

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