


UOP Olefins Seminar;
Efficient Monetization of
Natural Gas and LPG

UOP Limited – Richard Smith

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UOP ADVANCED MTO™ PROCESS

Natural Gas Monetization to Polyolefins

Agenda

- Natural Gas to Polyolefins Value Chain
- What is UOP Advanced MTO Technology?
- Commercially Proven Technology
- Why is UOP Advanced MTO the best choice?
- Summary

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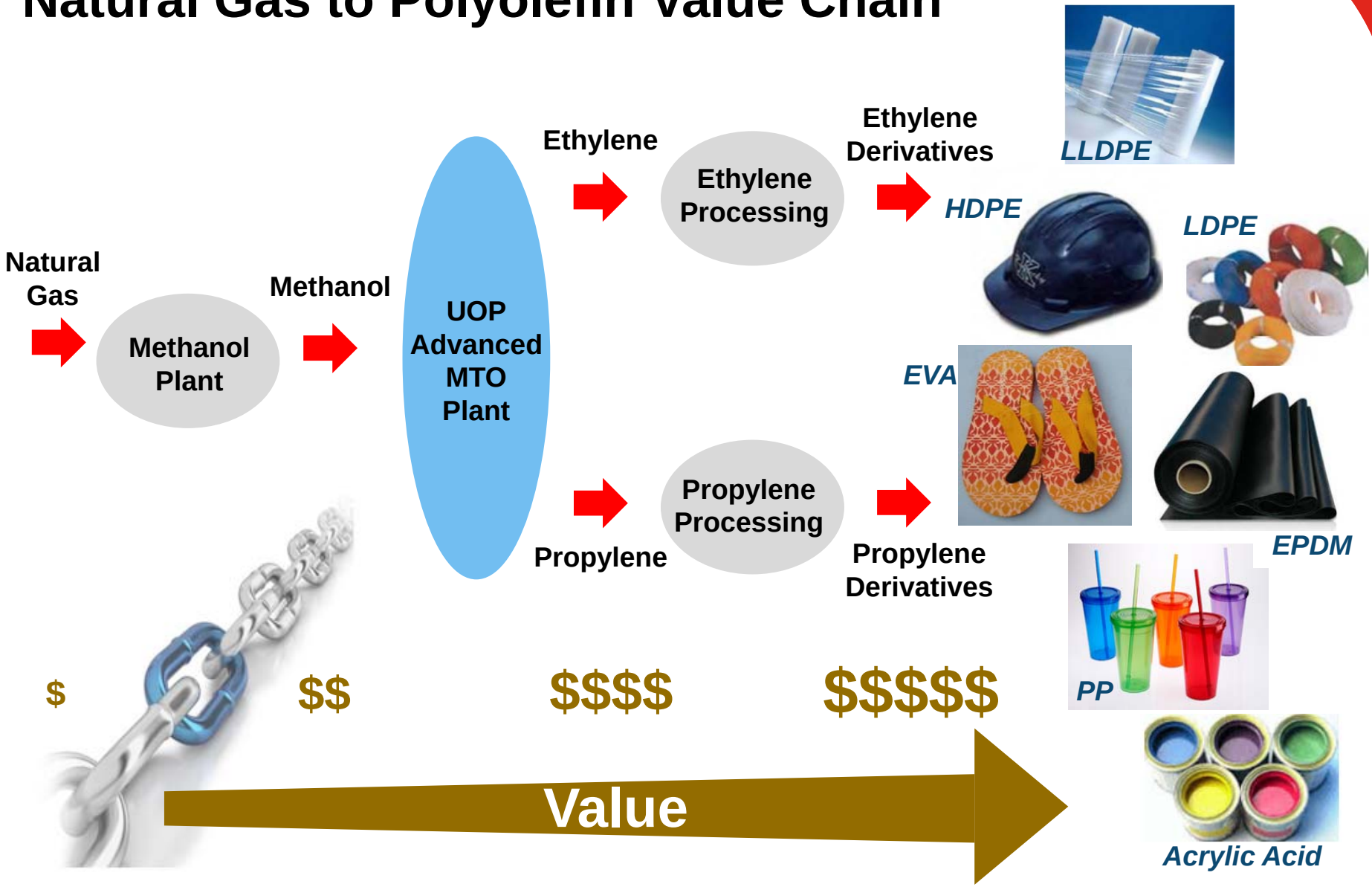
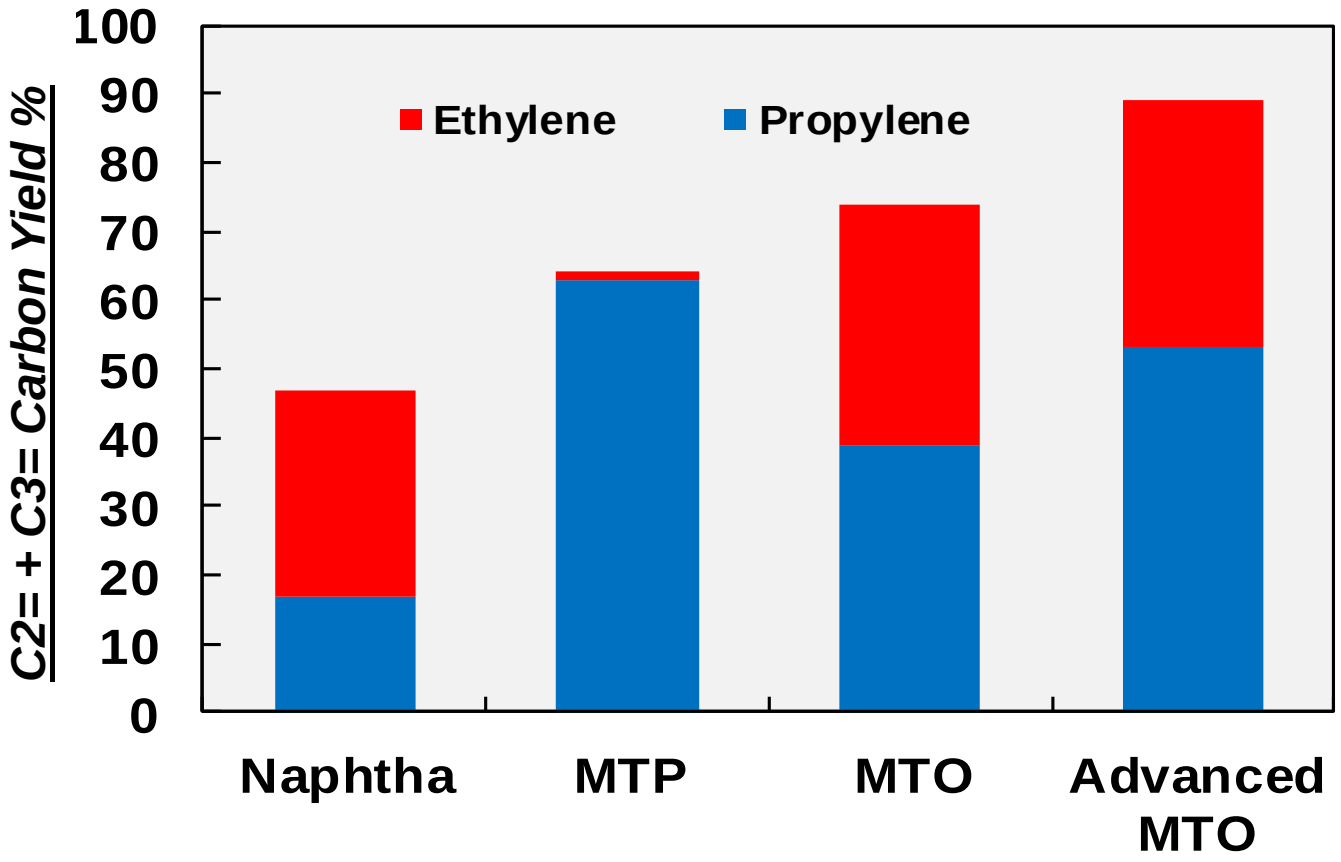
Natural Gas to Polyolefin Value Chain



Methanol to Olefins Technology Key to Value Addition

UOP Advanced MTO Yield Performance

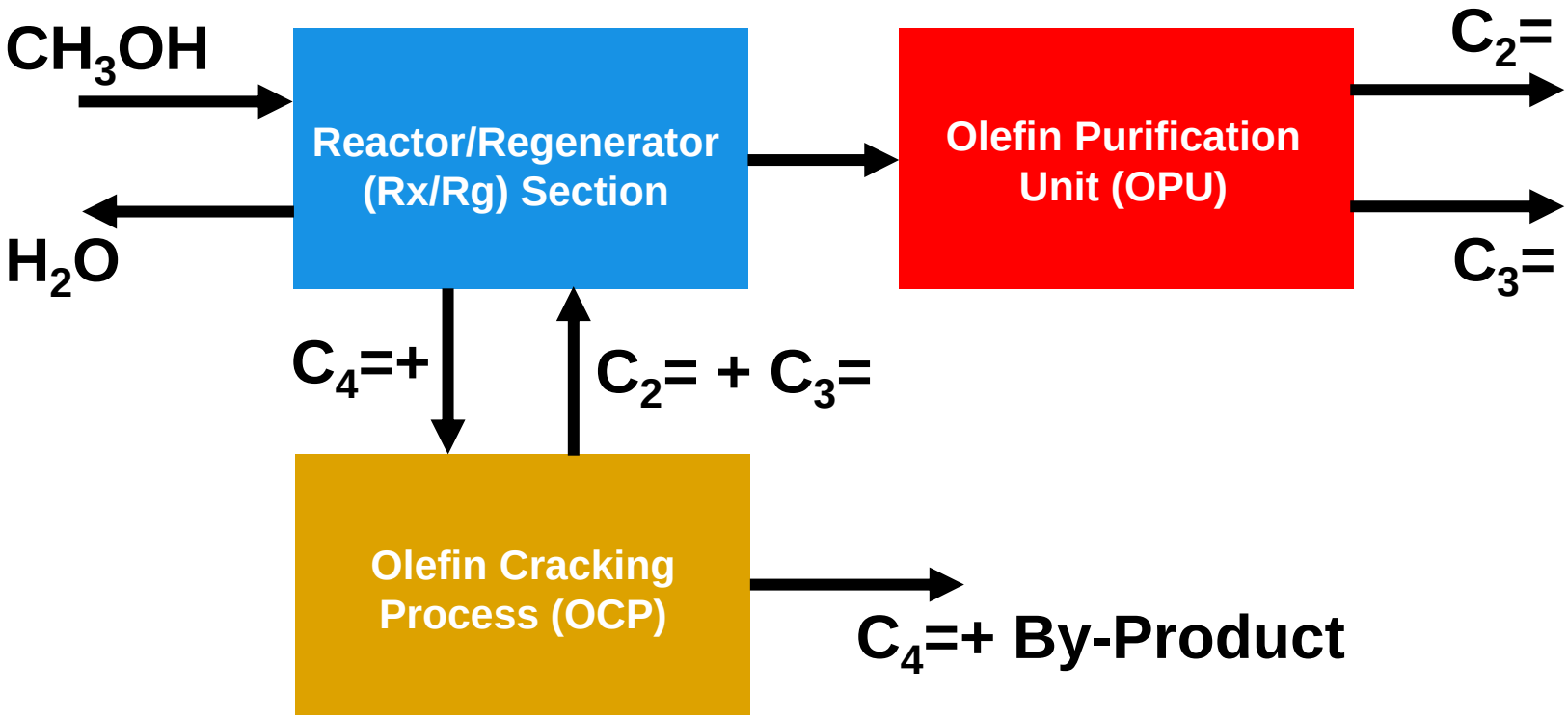
Technology Comparison



UOP Advanced MTO yields = highest added value

UOP Advanced MTO Technology

Overall Block Flow Diagram

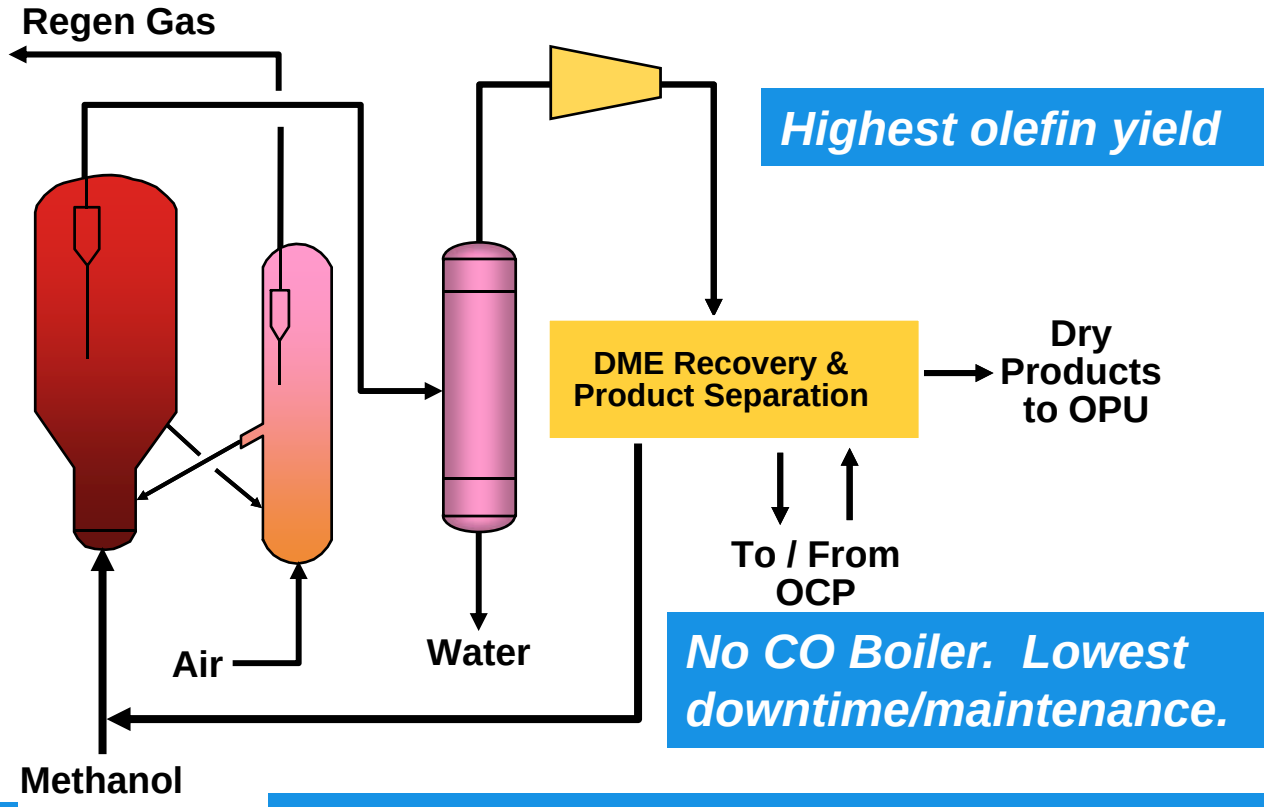


All Sections Commercially Proven

Reactor / Regenerator Section (Rx/Rg)

UOP has >200 fluidized bed units in operation

Smallest Rx/Rg and least compression = Lower CapEx.



Highest olefin yield

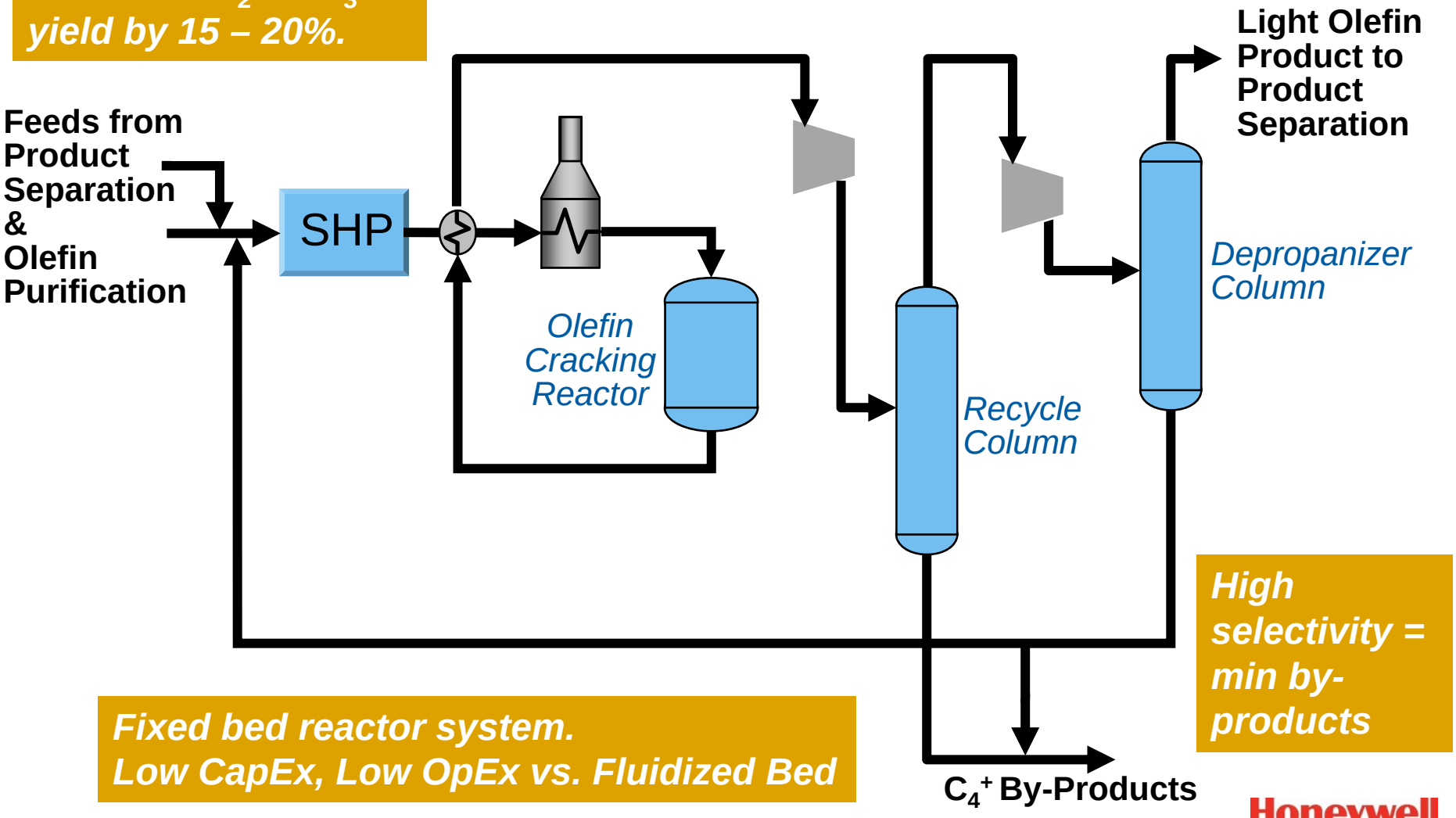
No CO Boiler. Lowest downtime/maintenance.

Fast fluidized bed reactor design utilizing UOP's extensive FCC experience

Lowest catalyst inventory and makeup rate = Lower OpEx.

Olefin Cracking Process (OCP)

Increases C_2= + C_3= yield by 15 – 20%.



Fixed bed reactor system.
Low CapEx, Low OpEx vs. Fluidized Bed

High selectivity = min by-products

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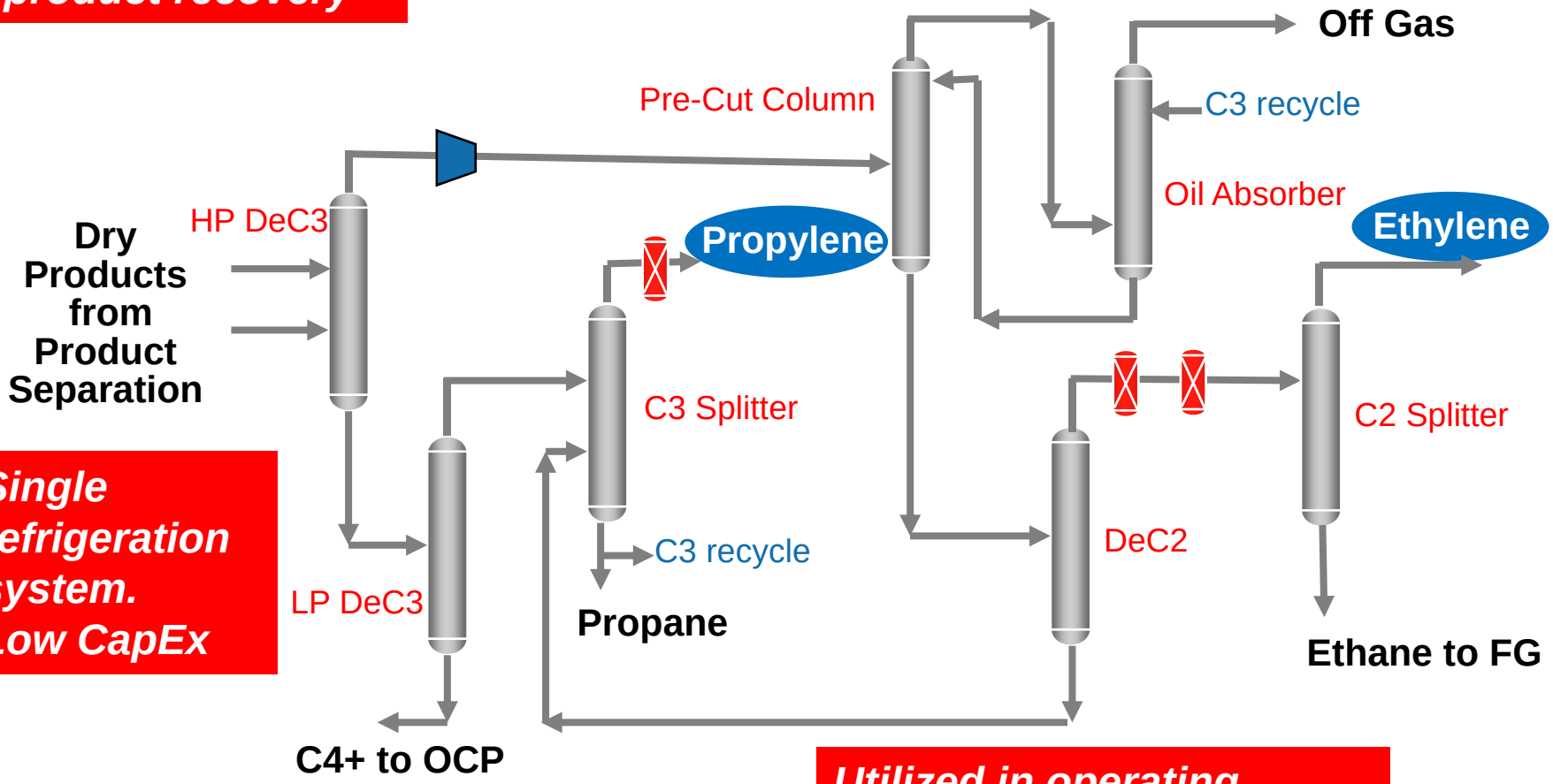
Olefin Purification Unit (OPU)*

Highest C2= & C3= product recovery

No De-Methanizer Required – Low OpEx



Single refrigeration system. Low CapEx

Utilized in operating UOP Advanced MTO Units

**UOP/Wison Partnership*

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Commercialization Status

#	Owner	Location	Status
1	Wison (Nanjing) Clean Energy Company, Ltd.	Nanjing, Jiangsu	Onstream 2013
2	Jiutai Energy (Zhungeer) Company, Ltd.	Ordos, Inner Mongolia	SU 2017
3	Shandong Yangmei Hengtong Chemicals Company, Ltd.	Linyi, Shandong	Onstream 2015
4	Jiangsu-Sailboat	Lianyungang, Jiangsu	SU Dec 2016
5	Shandong Better Energy	Dongying, Shandong	Awarded
6	Undisclosed	China	SU 2018
7	Undisclosed	China	Awarded
8	LUXI Chemical Group Co. Ltd.	Liaocheng, Shandong	Design
9	Connell Chemical Industrial Co. Ltd.	Jilin City, Jilin	SU 2017

Units ranging from 300kMTA – 830kMTA of total C_2= + C_3=

Nanjing MTO Plant Construction – July 2012

Nanjing MTO Plant Construction – July 2013

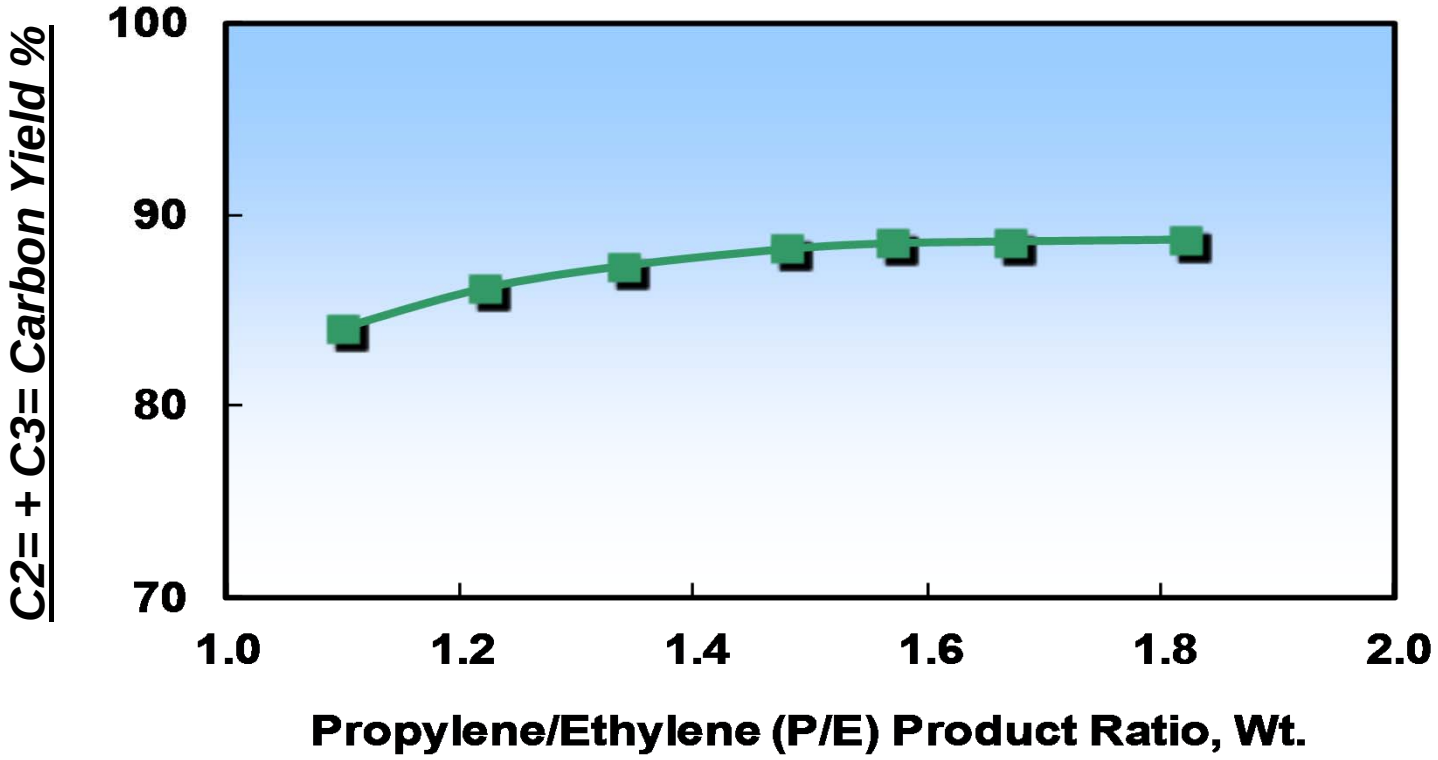
300kMTA of Ethylene + Propylene
Operating since 2013

UOP Advanced MTO Unit: Jiangsu Sailboat

830kMTA of Ethylene + Propylene
Currently in start-up phase

P/E Ratio vs Total Ethylene and Propylene Yield

P/E Ratio vs Yield



UOP Advanced MTO technology has P/E ratio operating flexibility

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UOP Advanced MTO Technology Performance Analysis Basis

- MTO Unit Capacity
  - 1650KMTA MeOH

- Price Sets:

$/MT	2020 Intl. Expected	2020 Iranian Netback	2017 Iranian Netback
Methanol Feed	330*	290	230
Ethylene	1160*	1160*	1130*
Propylene	1120*	1120*	815*

** Source - IHS*

- Economic Basis
  - Methanol to Olefins
  - 10% Discounting Rate
  - 3 years unit construction with 20%/30%/50% capital spend, 20 years cash inflow
  - UOP Advanced MTO total CapEx $455M (ISBL + 30% cost allowance).
  - MTO Unit terminal value of 20% of CapEx
  - 30% equity / 70% debt funding
  - Catalyst and Utility allowance included

Highest Total Ethylene +Propylene Yield

- ~25% higher C_2= + C_3= yield versus commercialized alternative
- ~5% higher C_2= + C_3= yield than best represented alternate MTO Technology

Section	Description
Rx/Rg	Highest olefin production
OCP	High selectivity process to convert C_4=+ to C_2= and C_3=.
OPU	Highest C_2= and C_3= recovery. At least 0.2% higher than alternate

~$25M* per year additional product revenue than best alternate represented

* Unit capacity =1650kMTA MeOH

Lowest Capital Cost

- ~12% Lower Capital Cost than alternate MTO technology

Section	Description
Rx/Rg	Small Rx/Rg and fewest stage of product compression
OCP	Fixed bed reactor system
OPU	Single refrigeration system and no demethanizer column

~$60M Lower CapEx

* Unit capacity =1650kMTA MeOH

Lowest Operating Cost

- ~60% lower catalyst makeup rate
- Lower utility consumption

Section	Description
Rx/Rg	Robust MTO catalyst, lowest catalyst makeup rate, lowest compression
OCP	Fixed vs fluidized reactor
OPU	No demethanizer column

~$6M/year lower OpEx

* Unit capacity =1650kMTA MeOH

Highest Reliability and Unit Availability

- All sections commercially proven

Section	Description
Rx/Rg	Full combustion regenerator. No CO Boiler. Highest reliability.
Rx/Rg	Utilization of UOP's extensive FCC experience with >200 FCC units in operation
OCP	Two fixed bed reactor system vs fluidized bed.

>$2M per year more LO product through higher unit availability

* Unit capacity =1650kMTA MeOH

UOP Advanced MTO vs Alternate MTO Technology

- Comparison of project financial performance:

Project IRR (100% Equity)	UOP Advanced MTO	Alternate MTO
2020 Intl. Expected	29.5%	21.4%
2020 Iranian Netback	38.8%	30.4%
2017 Iranian Netback	34.7%	29.4%

Project IRR (70/30 Debt/Equity)	UOP Advanced MTO	Alternate MTO
2020 Intl. Expected	24.0%	15.5%
2020 Iranian Netback	34.0%	24.9%
2017 Iranian Netback	29.5%	23.9%

UOP Advanced MTO technology provides the best project economics

Summary

- UOP Advanced MTO produces the highest total ethylene and propylene yield at the lowest cost.
- UOP Advanced MTO is commercially proven technology with 9 units licensed 2 of which are operating successfully with 1 currently in start-up.
- UOP Advanced MTO operating units have demonstrated stable operation that exceed guaranteed performance.
- UOP Advanced MTO technology operating units have demonstrated significant P/E ratio flexibility.
- UOP Advanced MTO provides the best project economics and the minimum project risk.