



UOP Olefins Seminar;
Efficient Monetization of
Natural Gas and LPG

UOP Limited – Kevin Whitehead
December 2016

OLEFLEX™ PROCESS

The Key to Achieving High Returns for Propane Upgrading

Contents

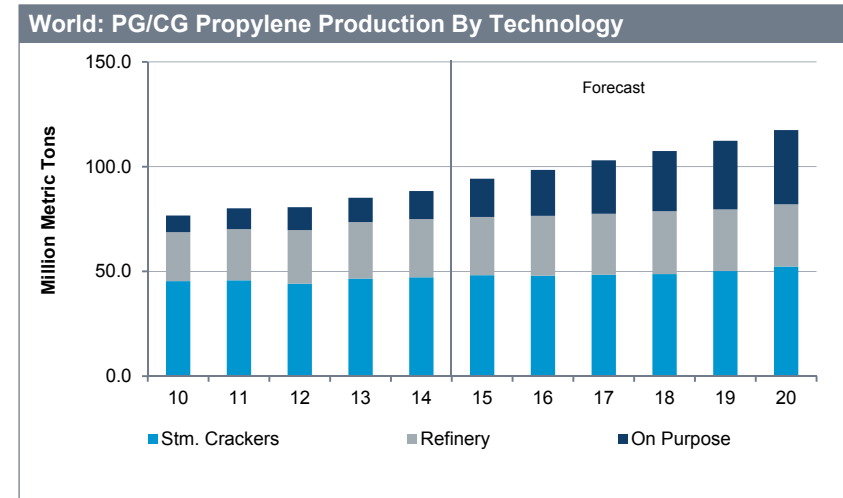
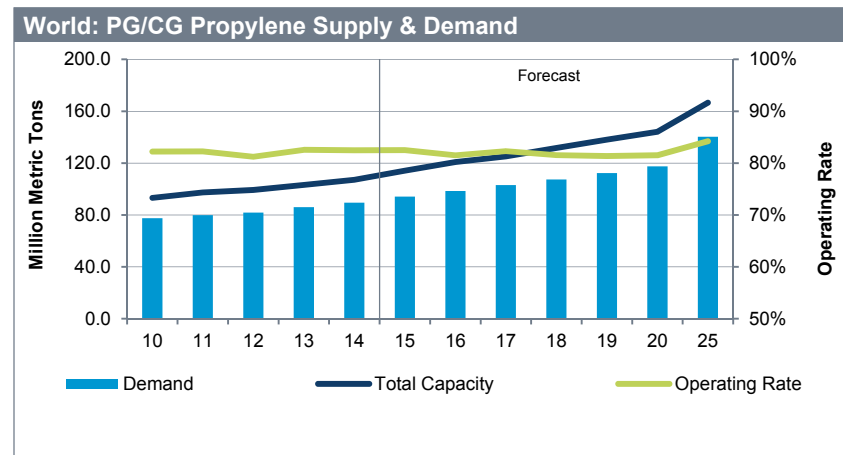
- Market fundamentals provide an attractive opportunity to upgrade propane to propylene
- Oleflex Process – the optimum route to produce high value olefins
- Why do customers choose the Oleflex Process?



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Propylene Market Remains Very Attractive

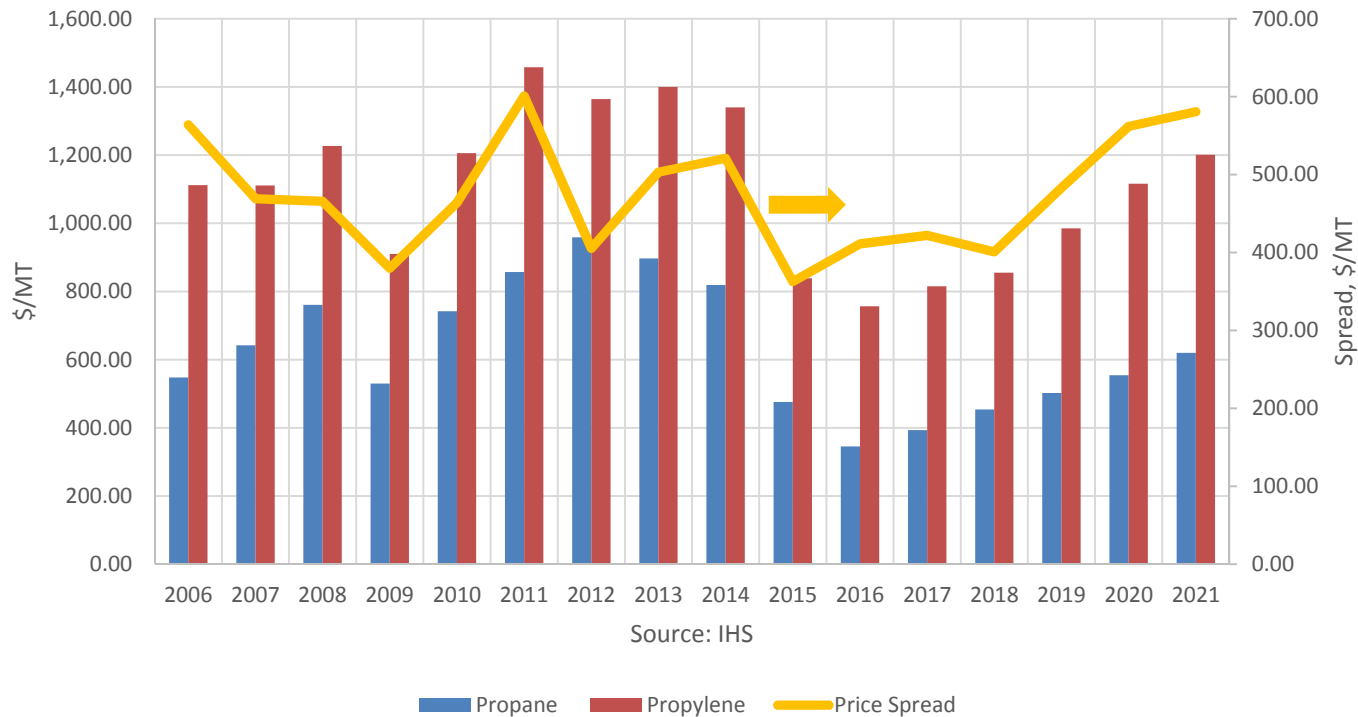
- On a global basis, propylene markets are healthy
 - Demand growth, 4.5%
 - Current utilization ~82%
 - Demand growth begins to exceed capacity gains by 2019
- Steam cracking and refining generate the majority of propylene supply
- Increase in light cracker feedstocks reduces C3= from steam crackers
- **On-purpose technology** has grown rapidly and now has a significant share of the market (~20%)
- Natural Gas Liquids offer profitable route to on-purpose propylene



Source: Independent Analysis

On purpose propylene technologies key to growth

C3=/C3 Pricing Differential Creates Value



- Propylene commands an attractive premium over propane
- Consistent financial incentive to upgrade propane
- Cost position of Iran is ideal

C3=/C3 spread remains attractive over time

Create High Value Propylene direct from Propane with the Oleflex Process

Feedstock

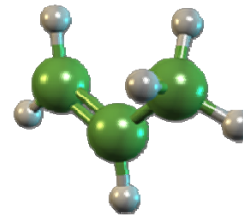
Propane →



Products

→ H₂

→ Propylene



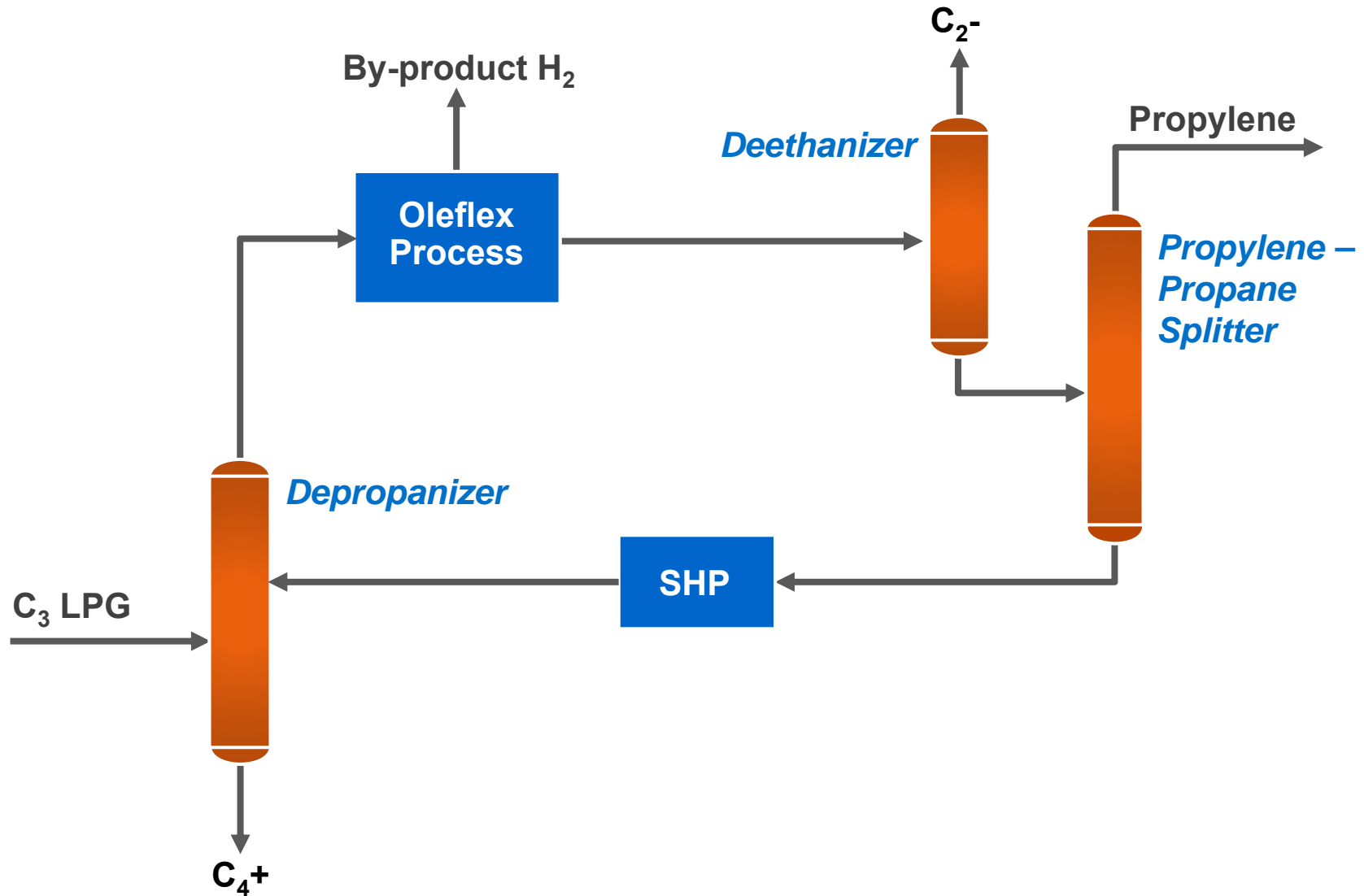
Uses



Oleflex Process
Propane Dehydrogenation (PDH)

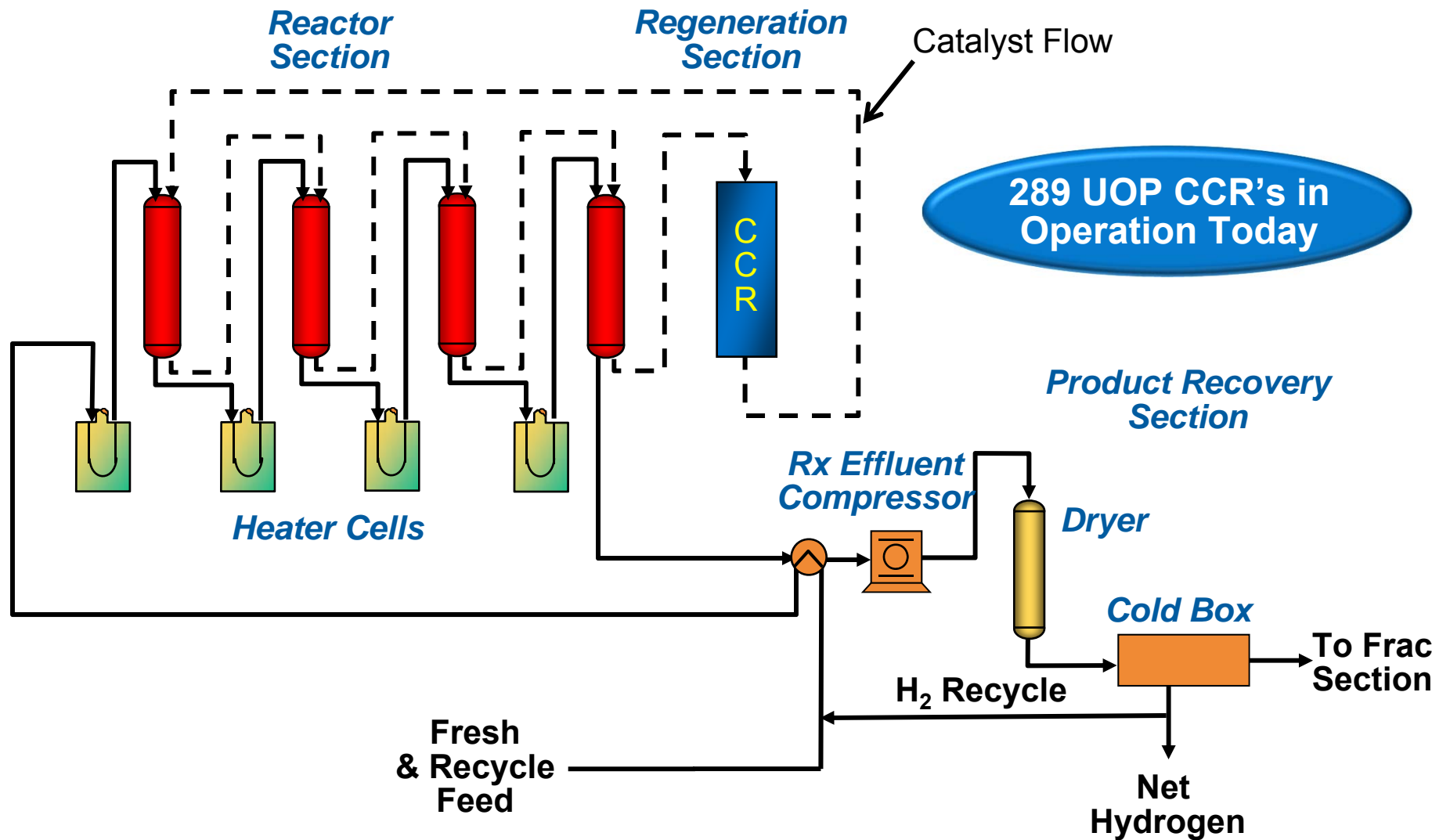
Honeywell
UOP

C₃ Oleflex Complex



C₃ Oleflex Process used for 67% of operating PDH units

Leverage UOP CCR Experience in PDH



Why Customers Choose UOP Oleflex

Lowest Overall Cost of Production

| | |
|---------------------------|---|
| Low feed consumption | Lowest MT C3 / MT C3= |
| Highest carbon efficiency | <10% of competitor coke make 2wt% higher hydrocarbon yield |
| Lowest energy usage | <80% of competitor energy use High efficiency product recovery, distillation & heat pump design Less compression |

Smaller Investment Required

| | |
|-----------------------------------|---|
| Lowest number of reactors | 4 reactors |
| Low cost design | No O ₂ plant required, no idle equipment No large, hot isolation valves |
| Smallest plot space | Minimizes bulks cost |
| Operates at low positive pressure | Lower cost design than vacuum |
| Efficient continuous regeneration | Smaller equipment required |
| Constant equipment count | Best economy of scale |

One design gives lowest Capex and Opex

Why Customers Choose UOP Oleflex (2)

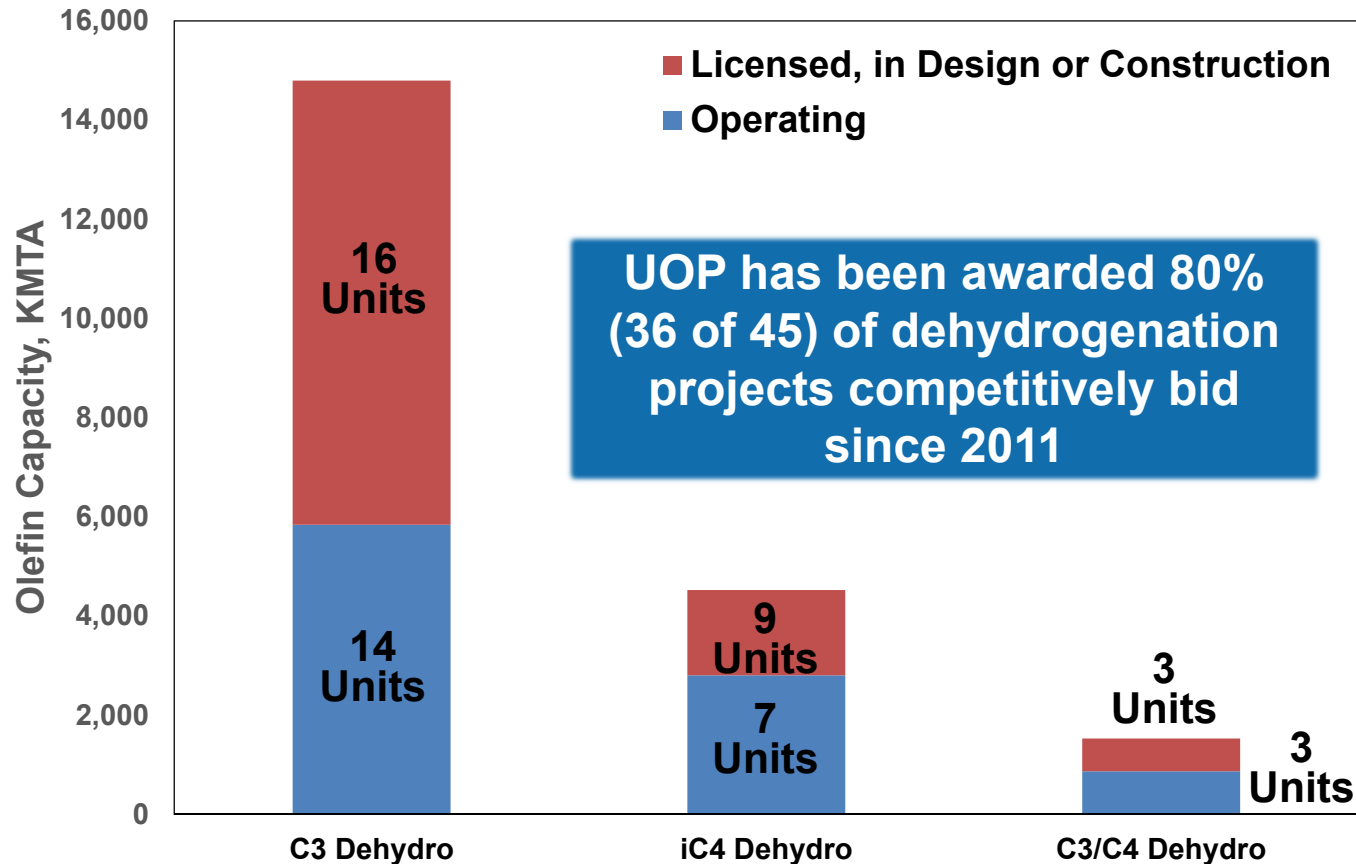
High Reliability / On-stream Availability

| | |
|---|--|
| Start of Run performance VCMStudy.ir whole operating cycle | Continuous on-line regeneration maintains yield over cycle |
| Proven regeneration technology | 289 CCRs operating >100 CCRs in design/construction |
| More days on stream | Catalyst can be changed without shutdown |

Smallest Environmental Footprint

| | |
|-------------------------------------|--|
| Lowest CO ₂ emissions | Lowest energy consumption |
| Low NO _x & VOC emissions | Low energy consumption and efficient low pressure design |
| Non-toxic catalyst system | Pt active metal |

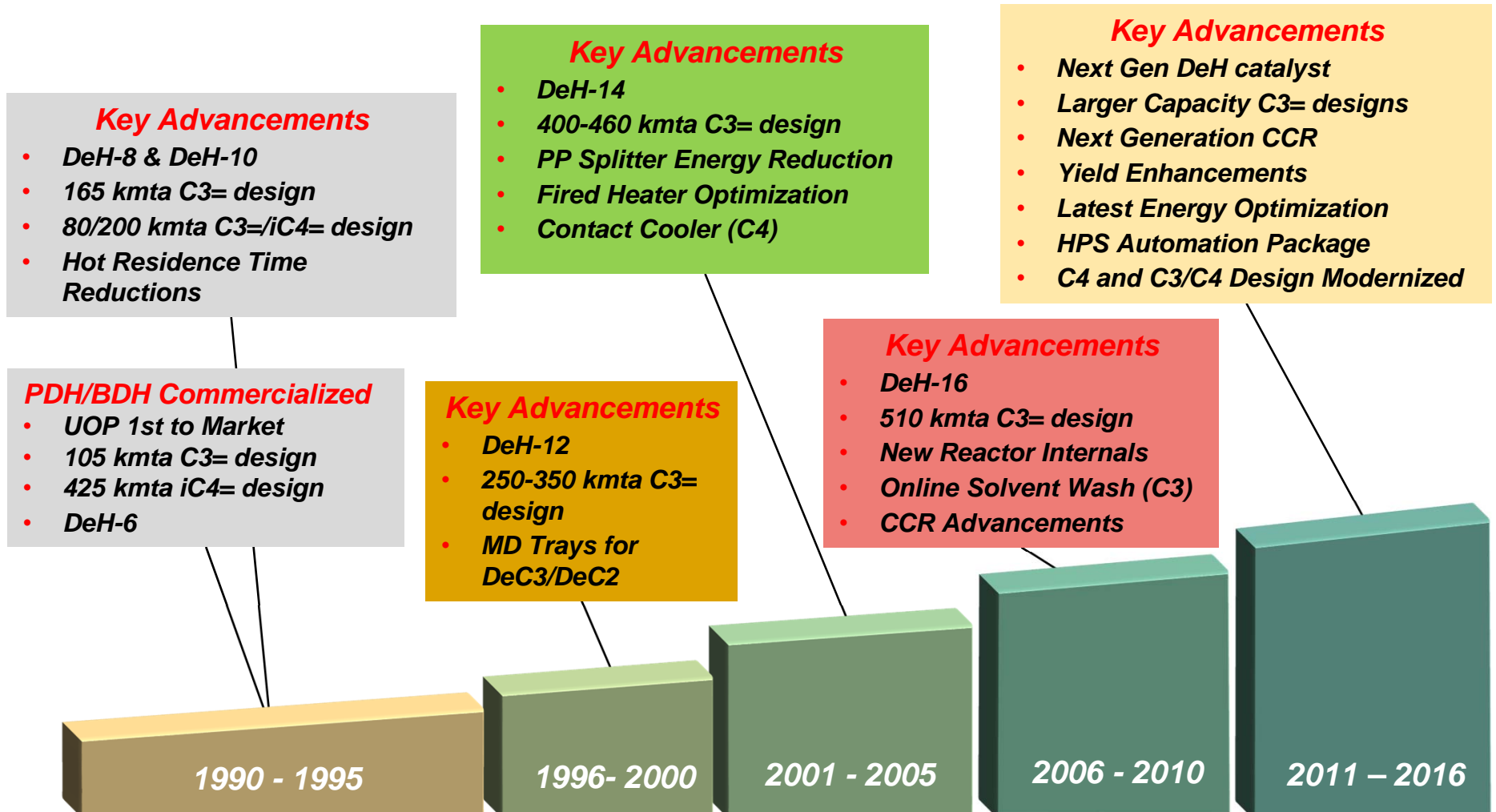
UOP Leads the Way in Dehydrogenation



- 8 repeat customers with two or more units
- 3 customers who already have a competitor iC4 unit selected UOP for their PDH project
- 2 Oleflex units announced in Europe in 2016

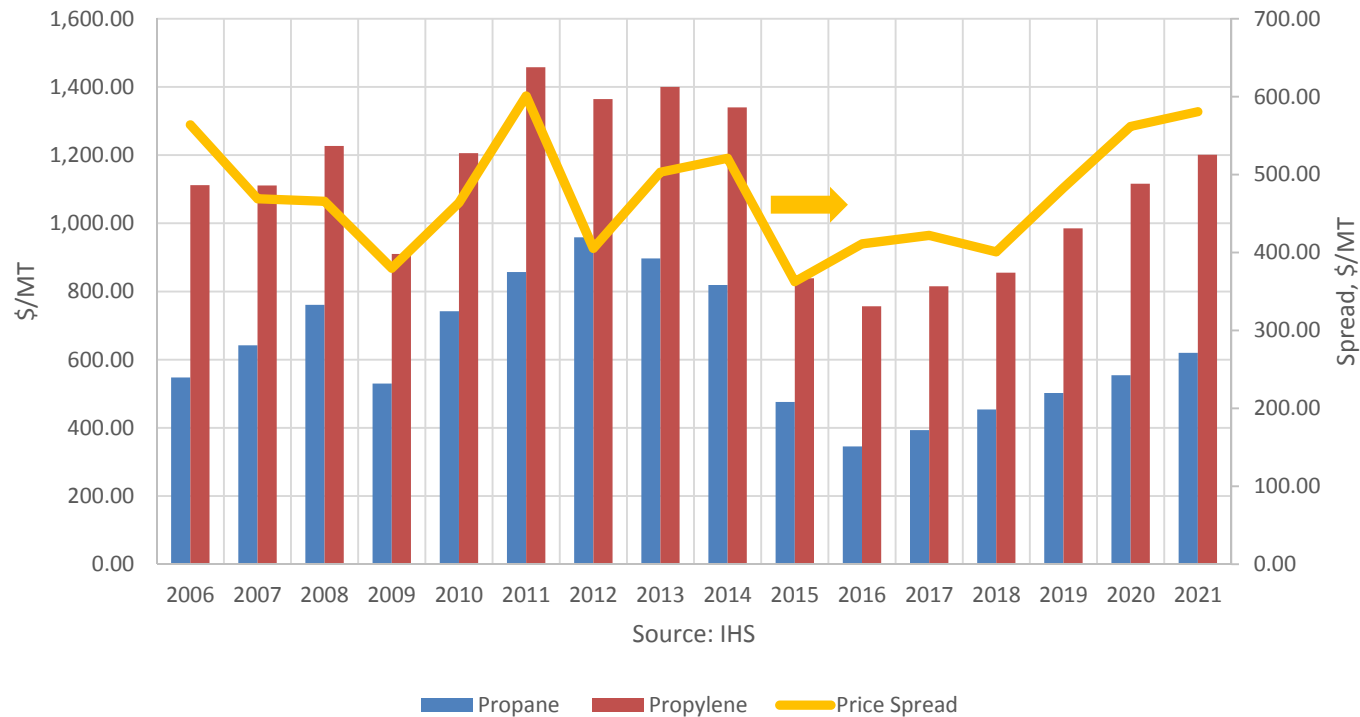
Oleflex Process is a proven investment. UOP is the market leader

Technology Development Continues

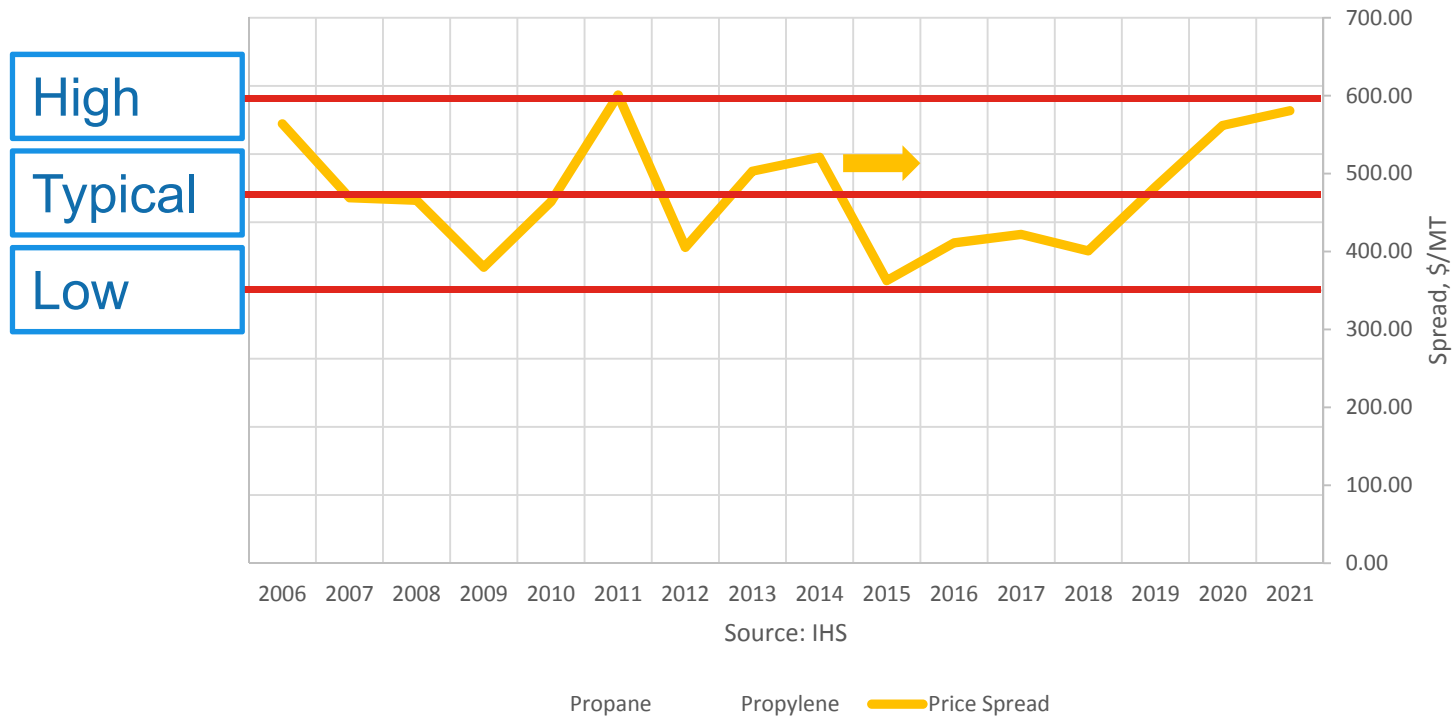


Significant R&D investment and Oleflex licensee interaction will continue to drive future innovation

C3 Oleflex Profitability – Resilient to Price Volatility

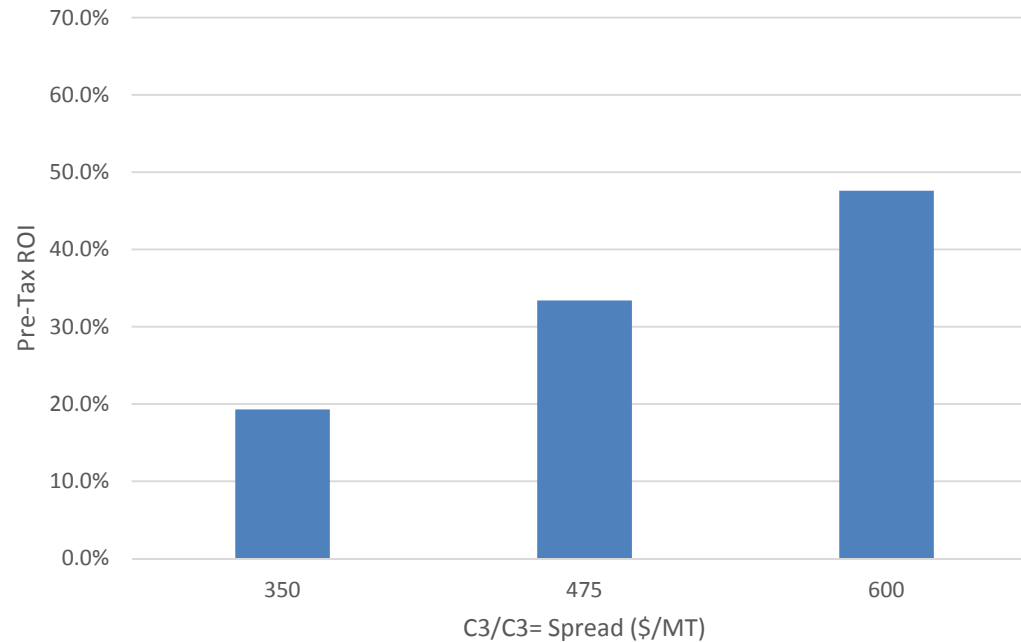


C3 Oleflex Profitability – Resilient to Price Volatility



- **Propylene-Propane spread remains attractive even with volatility in feed and product pricing**
- **Price spread is forecast to return to levels similar to 2007-14 by 2019**

C3 Oleflex- Profitable and Resilient to Price Volatility

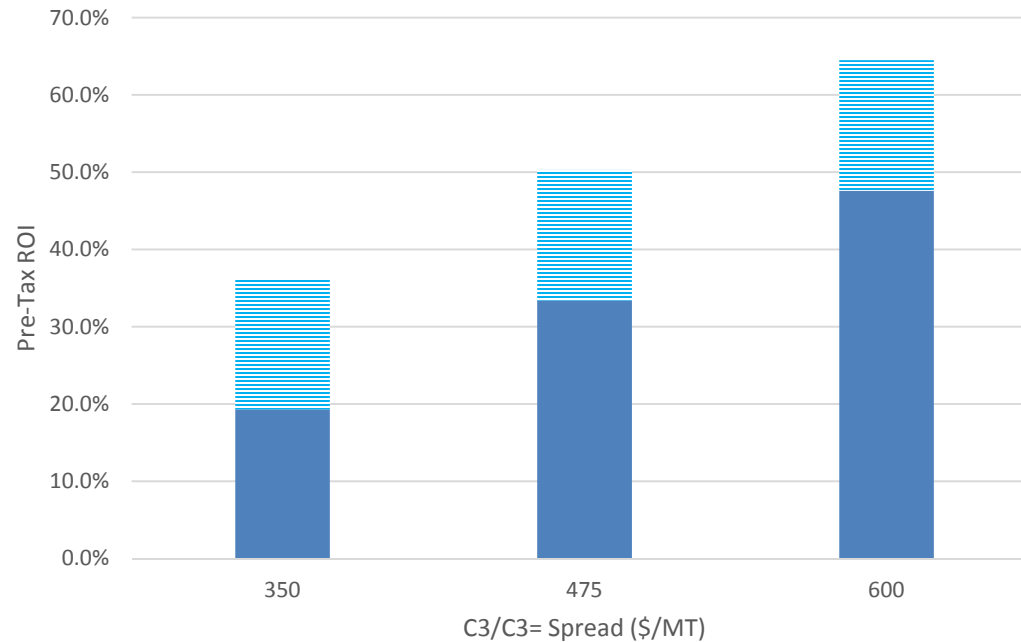


Basis: 600 KMTA Oleflex, Propane priced at 630 \$/MT, NE Asia Pricing, 100% equity

- **Oleflex technology delivers high ROI even when prices are low**

Attractive ROI across range of price spreads

C3 Oleflex- Profitable and Resilient to Price Volatility



Basis: 600 KMTA Oleflex, Propane priced at 630 \$/MT, NE Asia Pricing, 100% equity



- **Oleflex technology delivers high ROI even when prices are low**
- **Cost-advantaged propane provides potential for even higher return**

Summary

- Market fundamentals support attractive C3 upgrading projects
 - Propylene-Propane spread forecast to remain strong
- Oleflex process offers the optimum route from C3 to C3=
 - Lowest overall cost of production
 - Low capital cost
 - High on-stream availability
 - Proven technology with 14 operating C3 Oleflex units
 - Selected for 36 (80%) of the 45 dehydrogenation units competitively bid since 2011
- Economics of a PDH complex using the Oleflex Process are compelling
 - Strong return on investment that is resilient to pricing volatility



