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- **October** – Crude Feedstock - Oilfield Implications on the Refining Processes
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Molecular Management in the Gasoline Pool – Looking to the Future

January 27, 2021

American Fuel & Petrochemical Manufacturers

High Level Agenda

1. Market Views - NexantECA
2. Technology – Axens
3. Q&A

Speaker

Chirag Kothari
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Molecular Management in the Gasoline Pool – Looking to the Future: Market Views

AFPM Tech

Prepared by: Chirag Kothari

January 2021

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Agenda

1. NexantECA Introduction
2. Markets for FCC Products
3. Summary

Live Polling Pre-Questions

- **To access the poll, use your phone to scan the QR code or visit the link and type in the meeting code**
- **Live results will be displayed in the presentation**
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NexantECA Introduction

Nexant Energy and Chemicals Advisory – at a glance

Company

- Leading, independent provider of mission critical market, technical, environmental and commercial advice and intelligence to the global energy and chemicals sector.
- Highly complementary offerings combining deep intellectual capital and proprietary data and analytics.

50+ years of institutional knowledge

100+ Industry experts

12 countries worldwide with physical presence

Clients

Leading energy and chemicals operators, financial investors and advisors

- Base Petrochemicals and Polymers
- C1 Chemicals and Fertilizers
- Intermediate and Specialty Chemicals
- Downstream Oil
- Gas, Midstream and Infrastructure
- Biorenewables and Circular Economy

Our Businesses

Three integrated solutions:

- Over 200 consulting engagements completed each year.
- Over 100 subscription reports published each year, providing analysis on more than 100 products.
- Online and in-house training, with 10-12 public training courses available throughout the year.

Locations

- Global knowledge and regional expertise; industry professionals based in key regions.

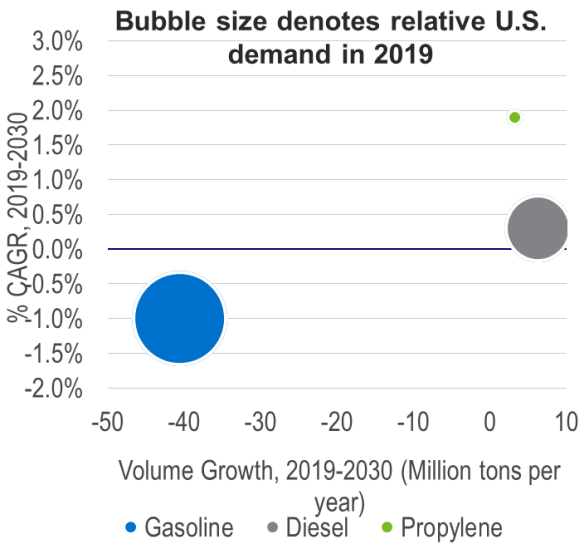
Consulting – A full service offering throughout a company lifecycle to help our clients make better decisions

	Our Consulting Proposition	Differentiation
Feasibility Studies	▪ Unbiased and independent assessment to underpin investment decisions ▪ Evaluation of market, technology and economic attractiveness ▪ Market entry and identification of current or future strategic opportunities	▪ Deep market and technology knowledge ▪ Credible methodology and reputed quality
Project Finance	▪ Lenders independent market, technical and environmental roles ▪ Project implementation and monitoring ▪ Completion test monitoring, analysis and certification	▪ High-quality risk and value focused approach
Mergers & Acquisitions	▪ Corporate development – buy-side due diligence; vendor due diligence ▪ Private equity commercial and technical due diligence support ▪ Environmental and social due diligence support	▪ Deep industry knowledge ▪ Identification of viable strategic options
Commercial Analysis	▪ Market assessment – supply/demand and trade-flow forecasts, price modelling ▪ Competitor analysis, market research (market interview programs) ▪ Financial modelling and valuations	▪ In-house database with proven methodology – accepted by Boards and banks
Technology Assessment	▪ Technology and operational benchmarking ▪ Cost of production modelling and benchmarking ▪ Technology evaluation and screening	▪ Led by Chemical Engineers with vast operational experience
Strategic Planning	▪ Corporate strategy development, innovation, sustainability, business planning ▪ Strategy analysis – portfolio analysis, market segmentation, feasibility studies ▪ Strategic options and screening – market entry, company/product acquisition	▪ Deep industry knowledge ▪ Identification of viable strategic options
Independent Expert	▪ Expert advisor/witness ▪ Litigation support ▪ Training in Chemicals, Polymers and Bio industries	▪ Highly experienced and credible ▪ Tailored to fit needs

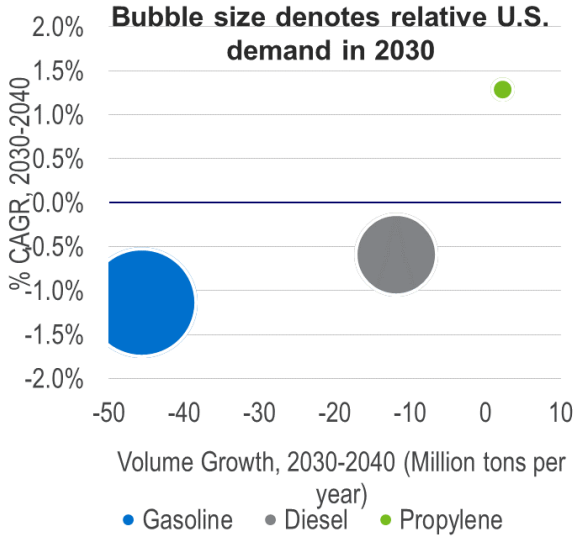
Markets for FCC Products

U.S. demand for transport fuels is expected to plateau and enter a long-term structural decline in the near future

U.S. Market Growth for Key FCC Products, 2019-2030



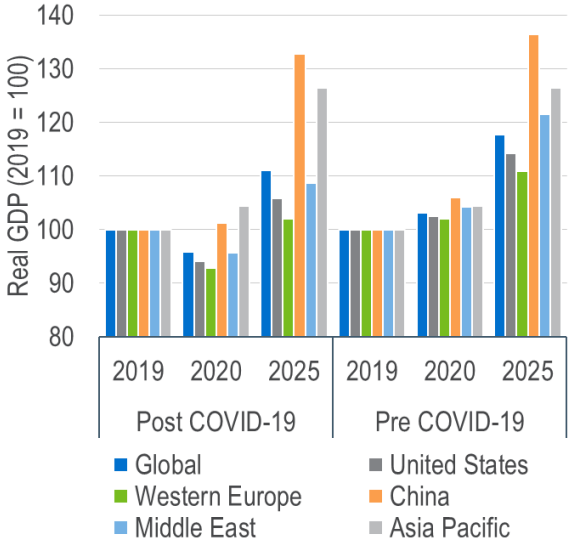
U.S. Market Growth for Key FCC Products, 2030-2040



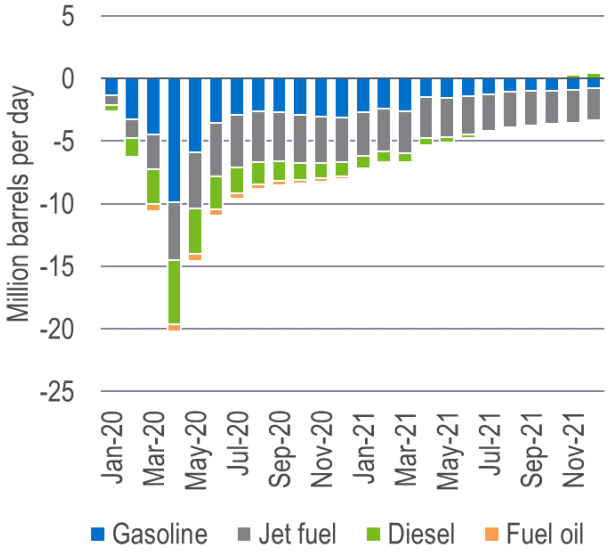
Demand for propylene (and other chemicals) is expected to remain robust over the long-term, albeit the market size is an order of magnitude lower than transport fuels

The COVID-19 pandemic continues to plague global economic growth and suppress near-term demand for refined products

Impact of COVID-19 on Global GDP Growth (Change to GDP Forecasts)



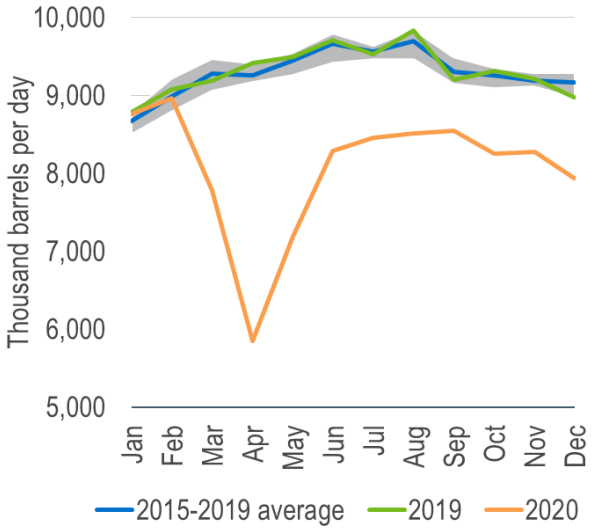
Global Recovery of Oil Demand to pre-COVID-19 Levels



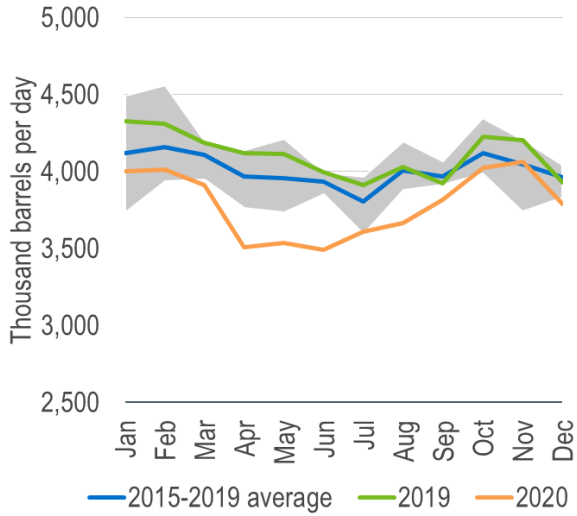
Although some recovery to pre-COVID-19 levels is expected, the long-term demand prospects for transport fuels remain unchanged

In the U.S., gasoline demand remains considerably below the 5 year average, while diesel demand has recovered more strongly

U.S. Gasoline Demand during COVID-19 (Thousand barrels per day)



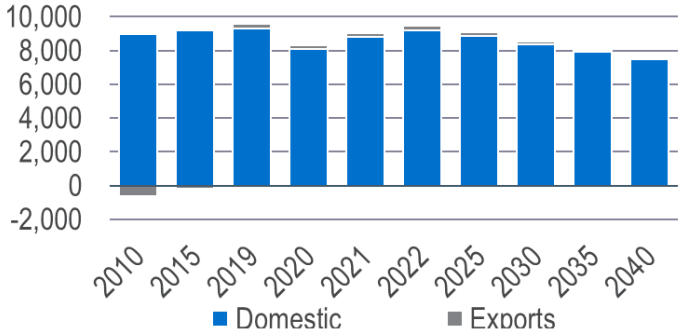
U.S. Diesel Demand during COVID-19 (Thousand barrels per day)



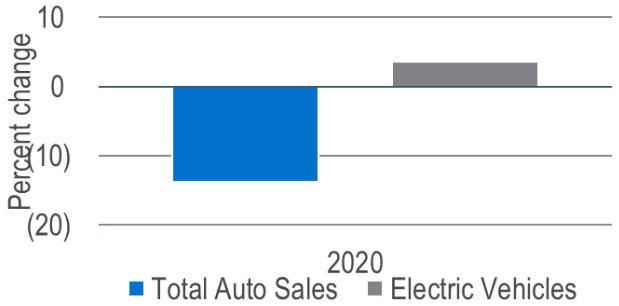
After an immediate resurgence, gasoline demand has stagnated due to continued lockdown measures while diesel has benefitted from strong commercial transportation demand

Despite the pandemic, the long-term outlook for peak road transport fuels demand remains unchanged

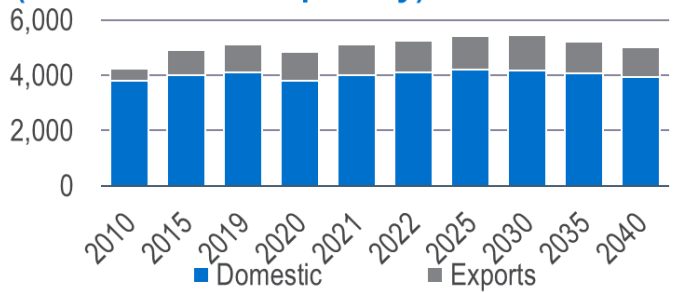
U.S. Gasoline Demand Outlook, 2010-2040 (Thousand barrels per day)



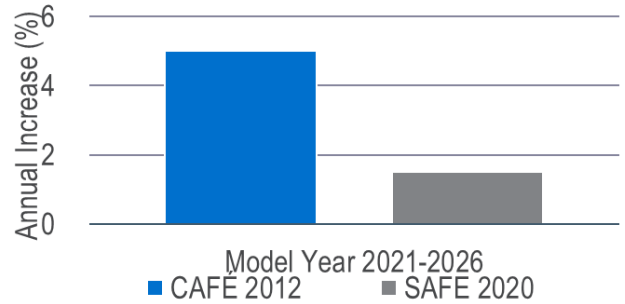
U.S. Vehicle Sales v/s Electric Vehicles Percent Change, 2020



U.S. Diesel Demand Outlook, 2010-2040 (Thousand barrels per day)

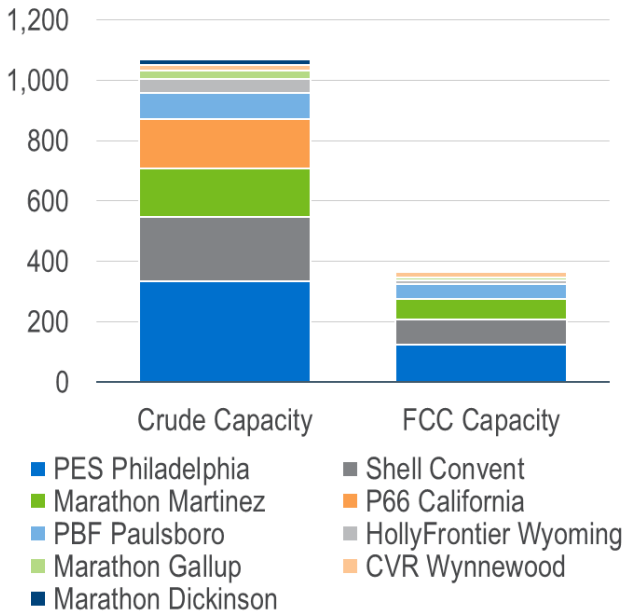


U.S. Fuel Efficiency, CAFÉ v/s SAFE

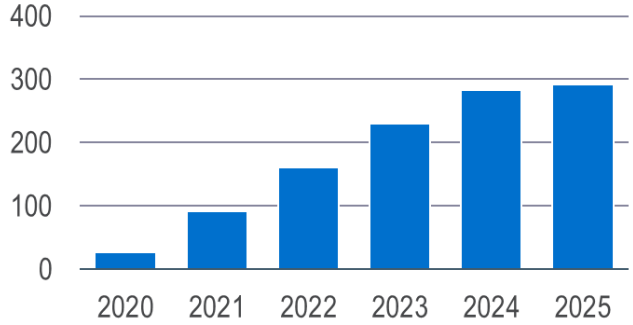


Although amongst the most competitive globally, the U.S. refining industry will need to adjust to the changing demand trends

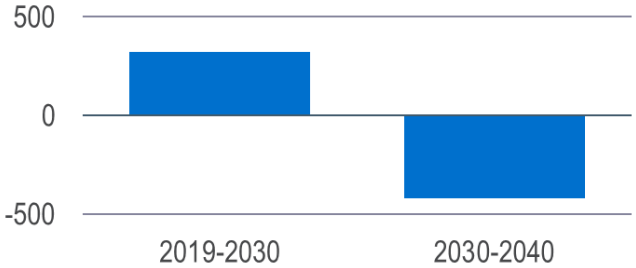
U.S. Refinery Closures / Modifications (Thousand barrels per day)



Announced Renewable Diesel Projects (Thousand barrels per day)

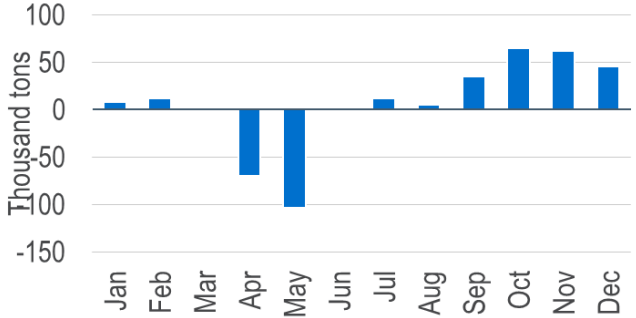


U.S. Diesel Demand Change (Thousand barrels per day)

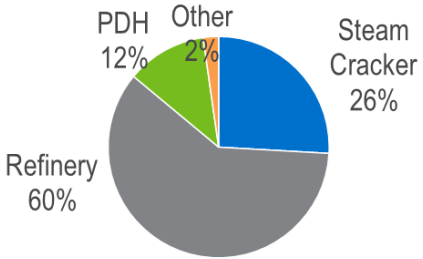


Demand for propylene (and other chemicals) has remained relatively resilient during COVID-19, and long-term prospects remain strong

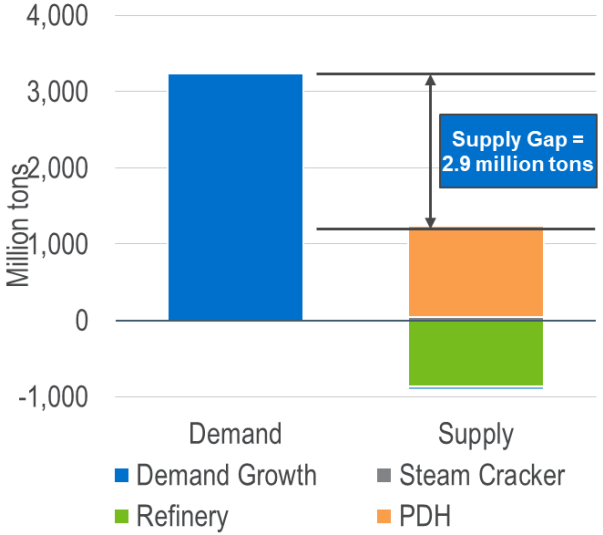
U.S. Polypropylene Demand Change, 2020 (year-on-year change)



U.S. Sources of Propylene, 2019 (2019 supply = 15.2 million tons)



U.S. Propylene Supply Demand Gap, 2019-2040



Chemicals markets offer opportunities to U.S. refiners seeking alternative growth markets

Summary

Summary

Consumption

- U.S. demand for gasoline and diesel is expected to plateau in the near-term and enter a long-term structural decline
- EV sales have remained relatively resilient during COVID-19; automakers continue to pivot their vehicle fleet towards newer EV models
- A return to CAFÉ standards of 2012 could further accelerate a demand decline for gasoline
- Diesel demand in the near term will be underpinned by strong commercial transportation demand, but will be increasingly affected in the longer term by trends such as vehicle fuel efficiency and electrification
- Markets for propylene and other chemicals, although an order of magnitude lower than the market for transport fuels, offer one of the few growth opportunities

Supply

- U.S. refiners will need to adjust to the changing domestic demand trends for transport fuels, with export opportunities offering limited respite
- Further closures of uncompetitive U.S. refining capacity and/or modification to renewable fuel projects are increasingly likely

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Molecular Management in the Gasoline Pool - Looking to the Future

Axens
Powering integrated solutions

Agenda

- FCC Product Composition
- Introduction to Oligomerization
- Flexene™ Solution Overview
- Case Study
- Summary
- An alternate look at FCC

Live Polling Question #1

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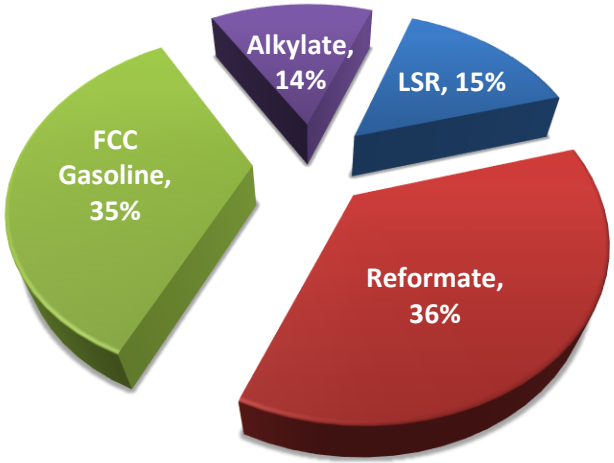
Composition of Gasoline Pool

Conventional Refinery Gasoline Pool

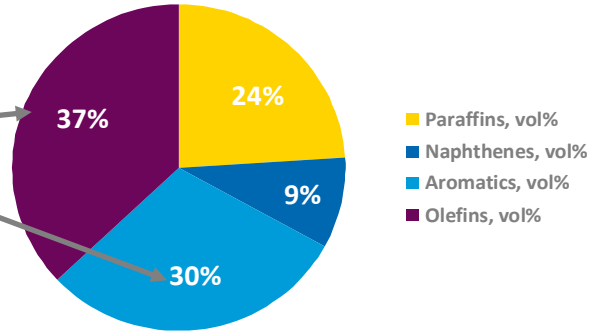


Gasoline Pool, v%

FCC gasoline typically constitutes ~1/3 of the gasoline pool in volume

FCC Gasoline Composition

High Octane Value



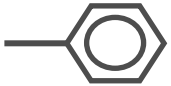
Olefins

Ex : CH3-CH2-CH2-CH=CH-CH2-CH3

Hept-3-ene

RON = 89.8

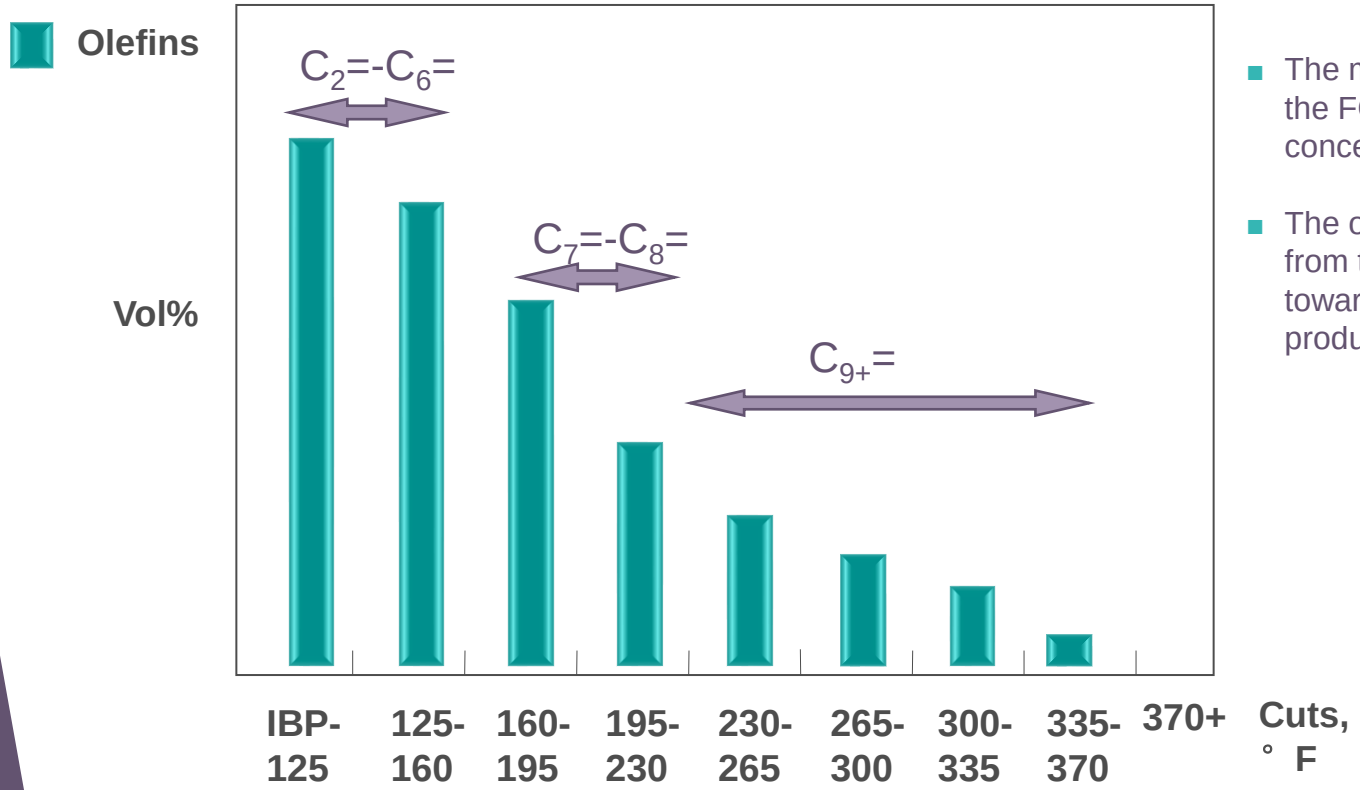
Aromatics



Toluene

RON = 120

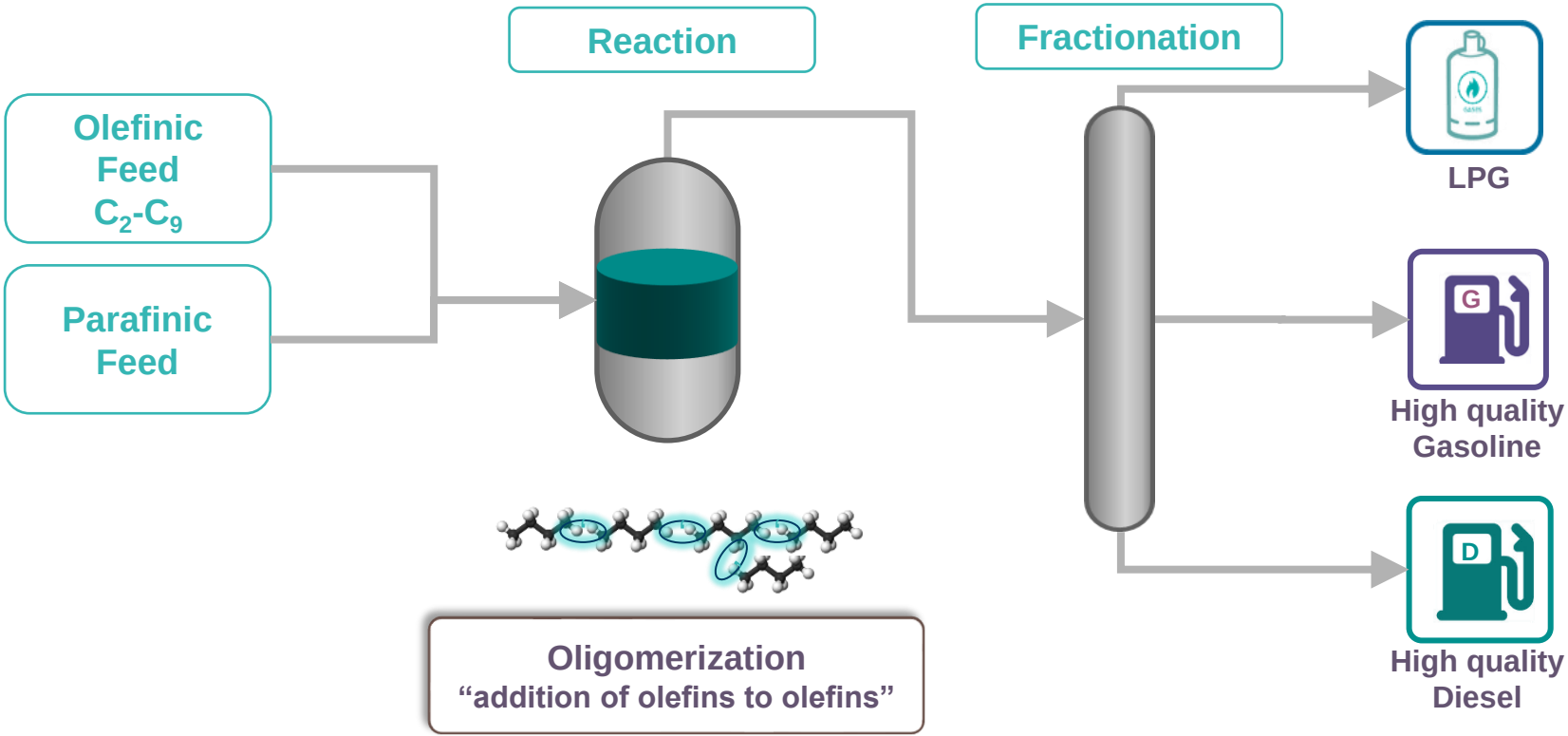
Distribution of Olefins in FCC Product Cuts



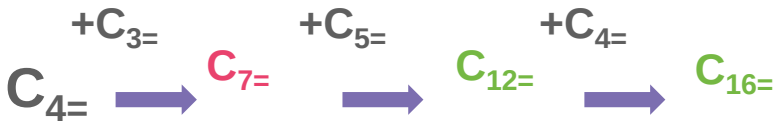
- The majority of the olefins in the FCC product is concentrated in C_7 and below
- The olefins can be reoriented from the gasoline pool towards more valuable products

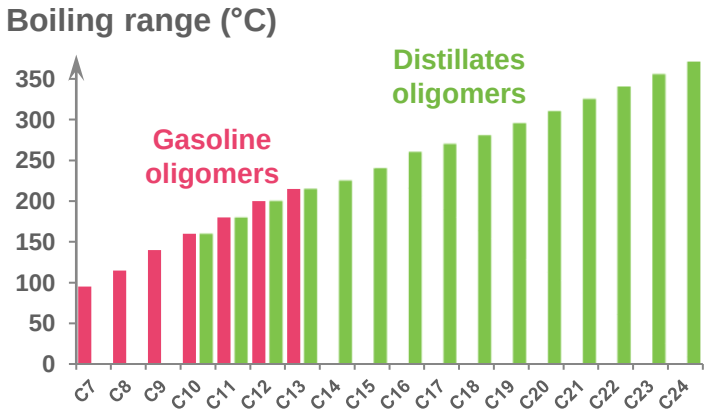
Axens' Oligomerization Technology

Turn Olefinic Feedstocks into High Value Products



Polynaphtha™ & PolyFuel™ - Main Features

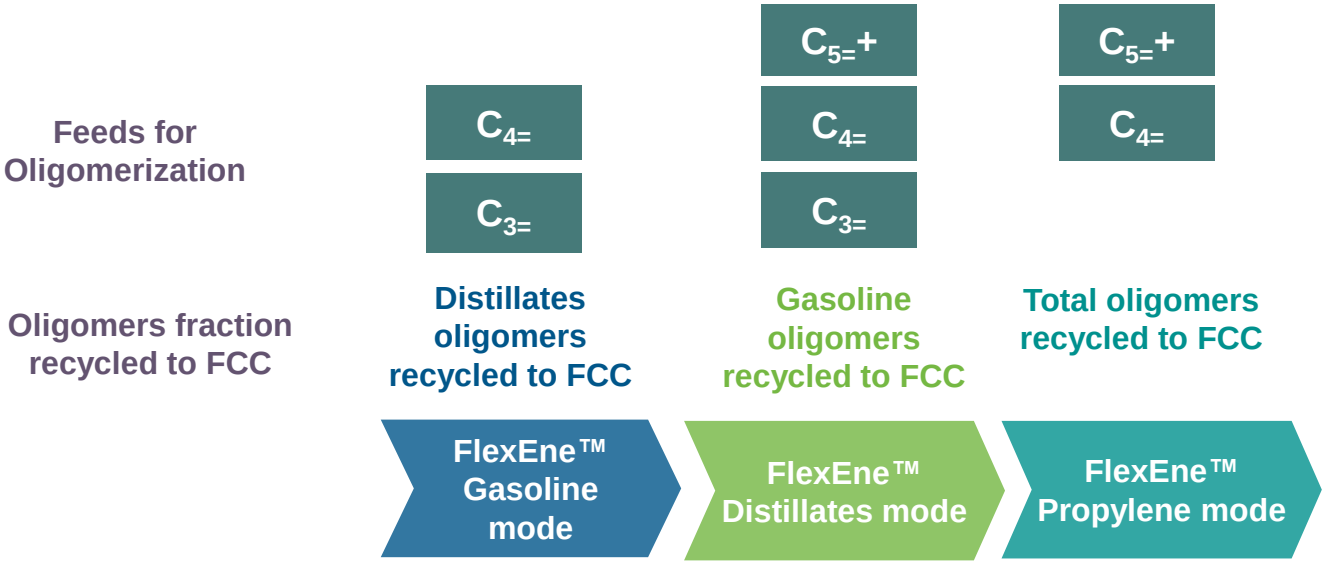




- Paraffins do not react
- Oligomerization reactions
  - Dimers, trimers, tetramers
- Oligomer distribution depends on feed & severity
- High conversion
- Mild operating conditions
- Long catalyst life

One Concept – Several Applications

Axens Oligomerization Offer coupled with FCC: FlexEne™ solution



Flexible Alkene Oligomerization and Recycle

FlexEne™ Light Olefin Processing Route

Step 1

- Light olefins are transformed into C8 & C12 olefins (oligomers) in the Oligomerization Unit

Step 2

- Oligomers are highly reactive and crack selectively toward propylene and butenes in the FCC

Live Polling Question #2

- **To access the poll, use your phone to scan the QR code or visit the link and type in the meeting code**
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- **Note: responses are anonymous**

Advantages of FlexEne™

- **FlexEne™ can be fed with any olefinic material, from FCC or other sources**
- **More efficient than direct LCN recycle to FCC**
- **Ability to cope with market changes**
- **Example of improvement in propylene production**
  - C4 feed (Polynaphtha™ oligomerization unit): +2.5 wt% in C3=
  - C5/C6 feed (PolyFuel™ oligomerization unit): +2 wt% in C3=

Live Polling Question #3

- **To access the poll, use your phone to scan the QR code or visit the link and type in the meeting code**
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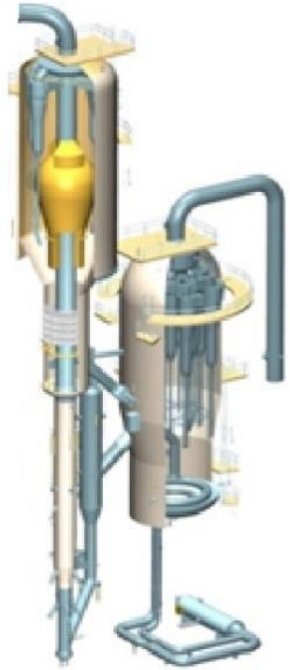
- **Note: responses are anonymous**

Integration of Proven Technologies: FlexEne™



FCC Feed

Product Recovery

Fuel Gas
Propylene
LPG
Gasoline
Distillate
Fuel Oil

LCN cut

Prime-G+®

Polynaphtha™ / PolyFuel™ Oligomerization

Raffinate

HCN cut

Oligomers partially or totally recycled to FCC: FlexEne™ solution

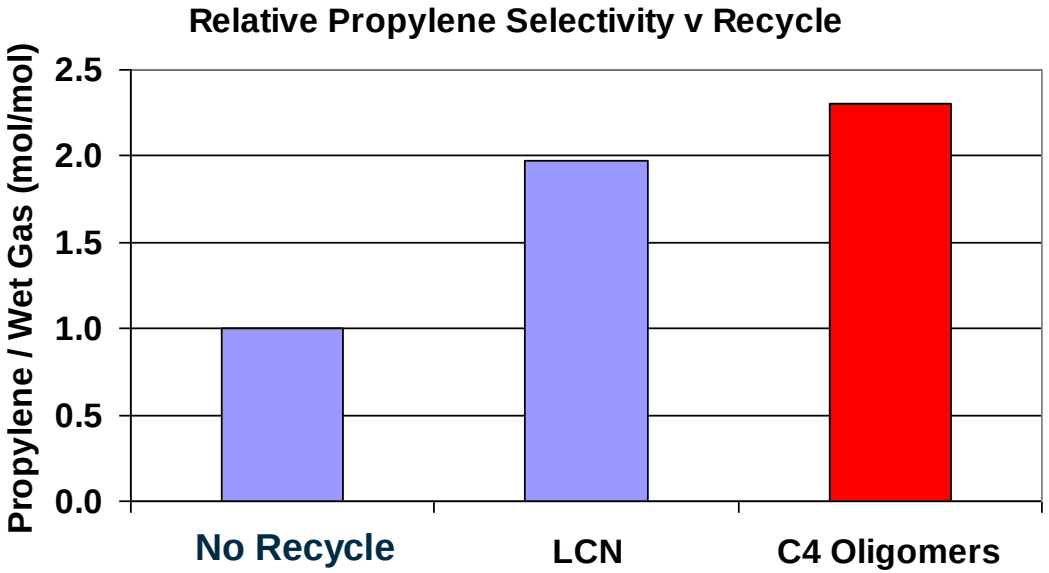
Gasoline /Distillate oligomers

Oligomers used as motor fuels

Gasoline

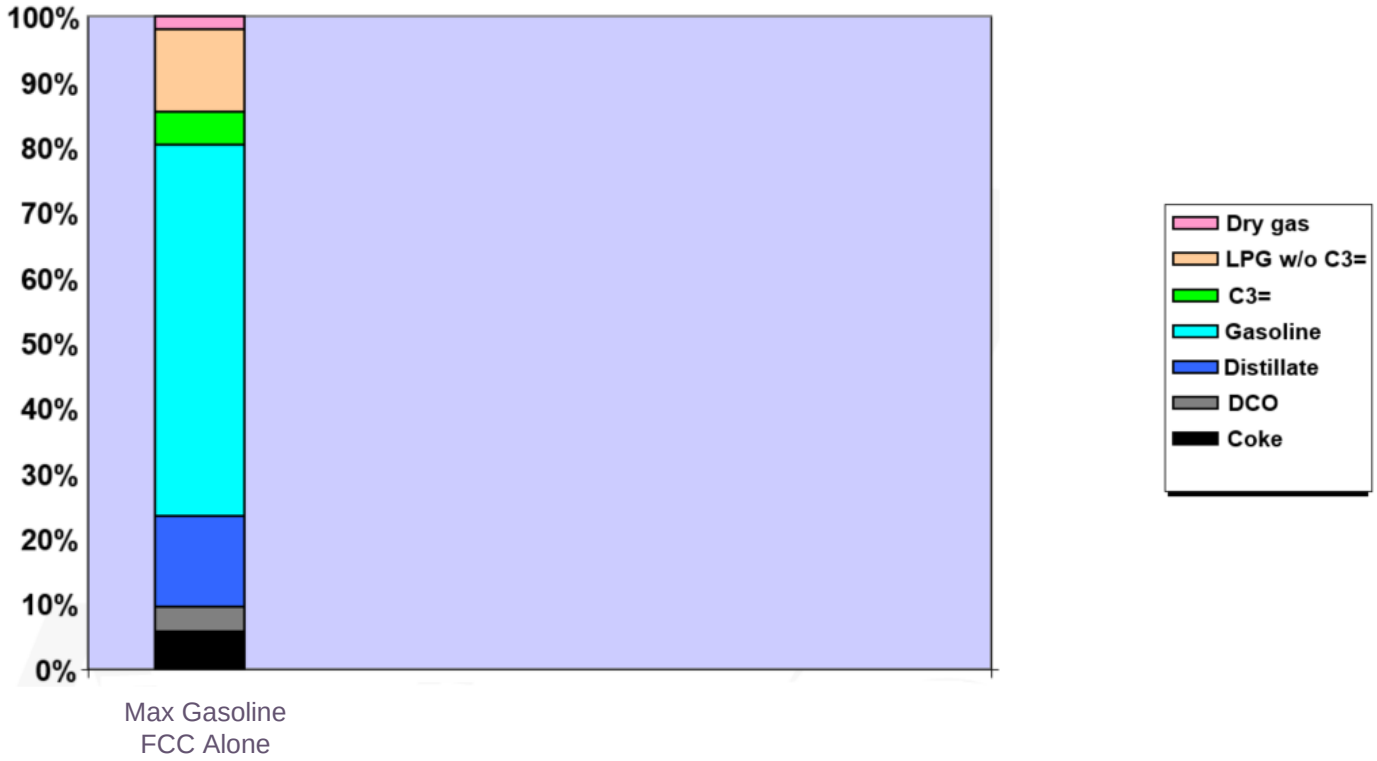
Distillate

High Selectivity for Light Olefins



- Oligomer cracking is more selective with lower impact on Wet Gas Compressor
- Less gas and aromatic formation for higher ultimate propylene yield when recycled to extinction

FlexEne™ Case Study with C3/C4 Recycle



Product Flexibility – Gasoline Case

FCC
Gasoline Mode

FCC
Products

Proplyene

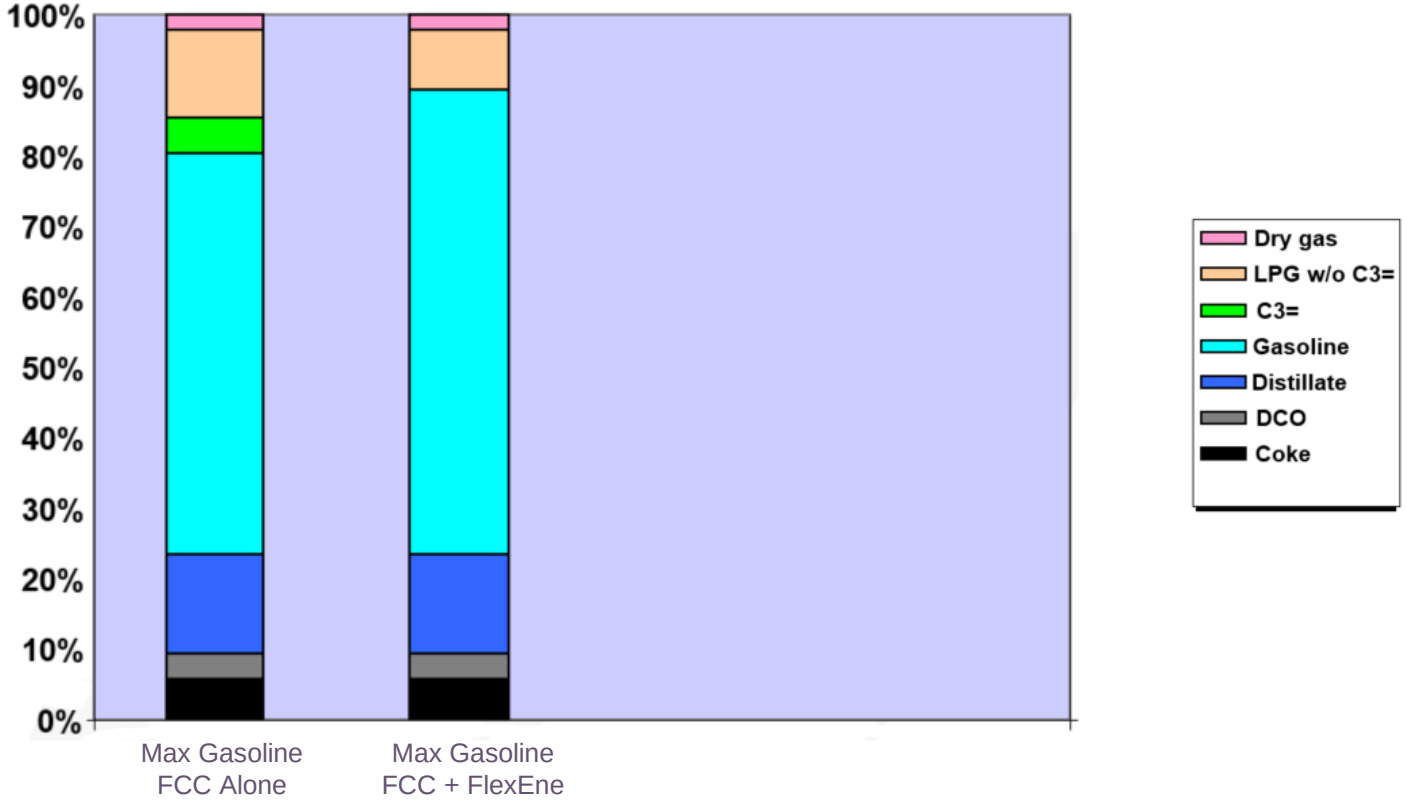
C4 Cut

Axens
PolyNaphtha™
Gasoline Mode

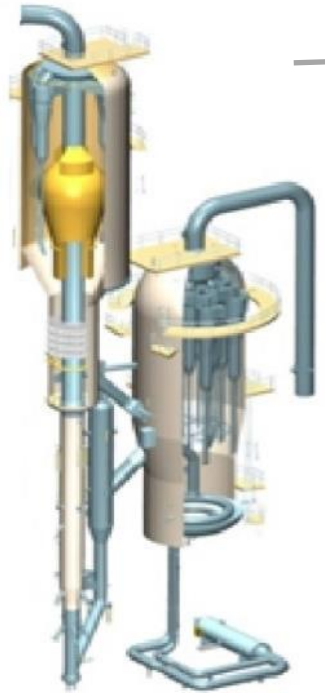
Gasoline
to Pool

Distillate
Recycle

Product Flexibility – Gasoline Case



Product Flexibility – Distillate Case



FCC Distillate Mode

FCC Products

Proplyene

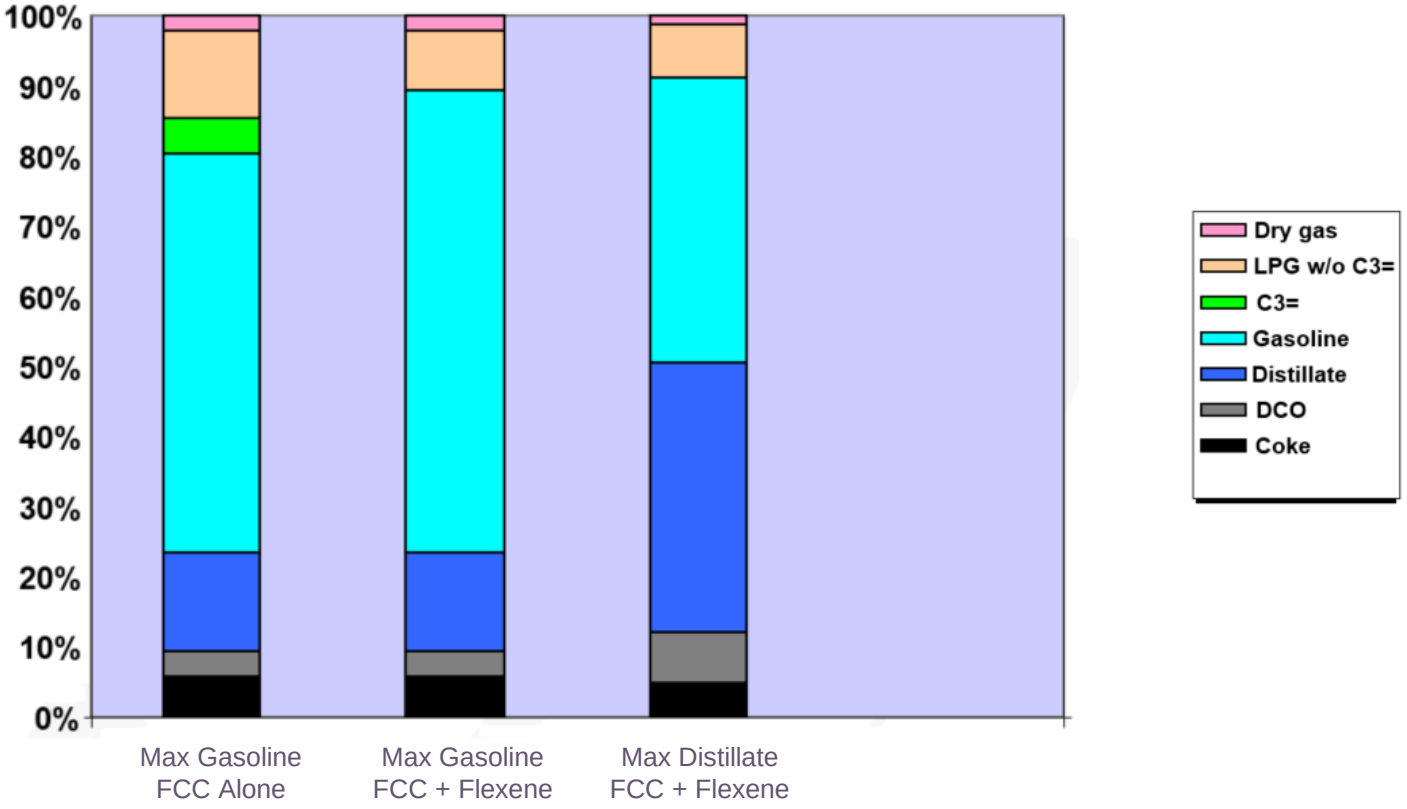
C4 Cut

Axens PolyNaphtha™ Distillate Mode

Gasoline Recycle

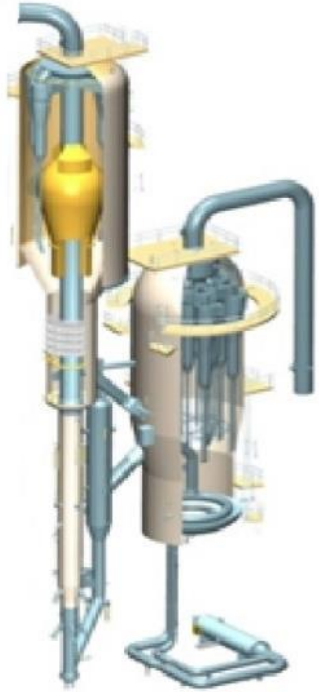
Distillate to Pool

Product Flexibility – Distillate Case



Product Flexibility – Propylene Case

FCC Propylene Mode



FCC Products

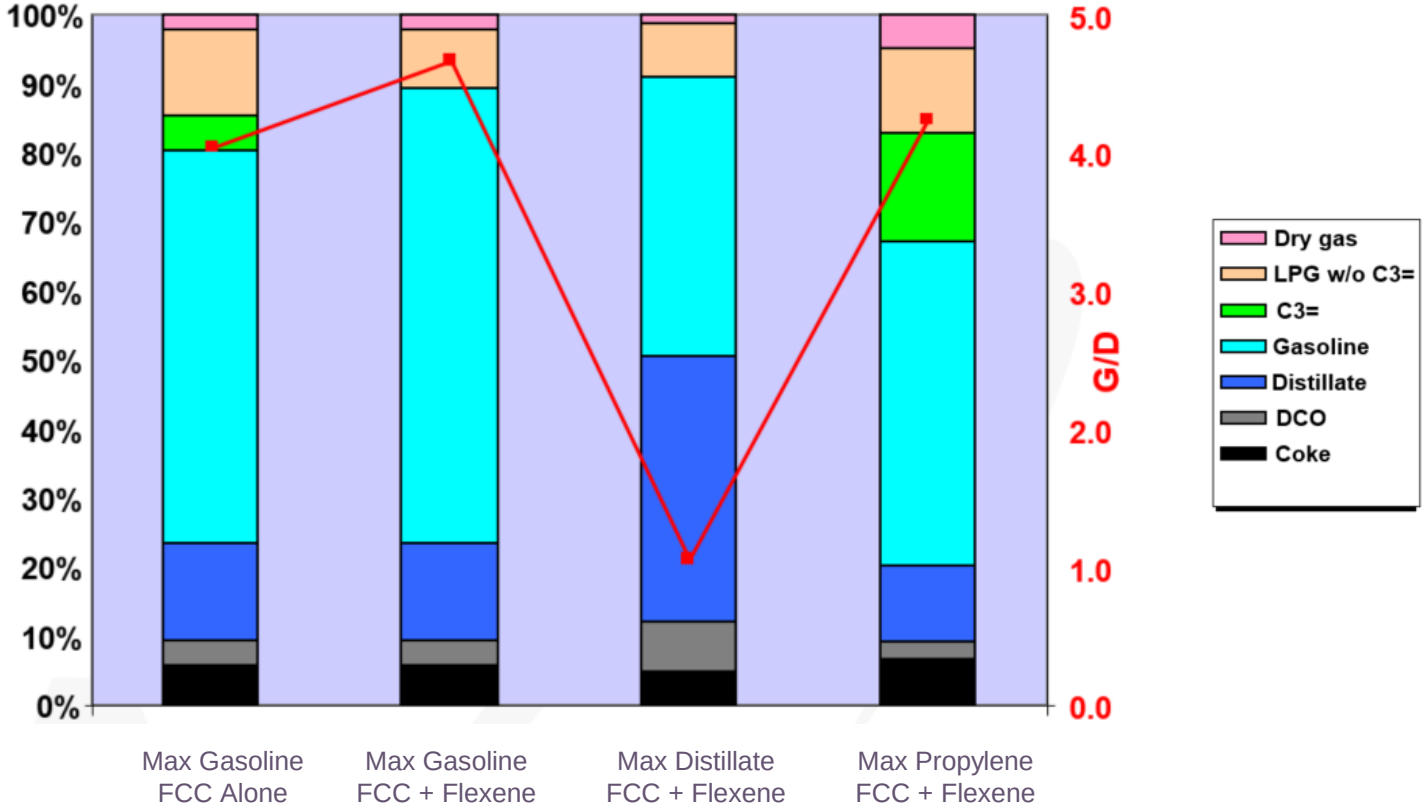
Propylene

C4 Cut

Axens PolyNaphtha™ Conversion Mode

Distillate & Gasoline Recycle

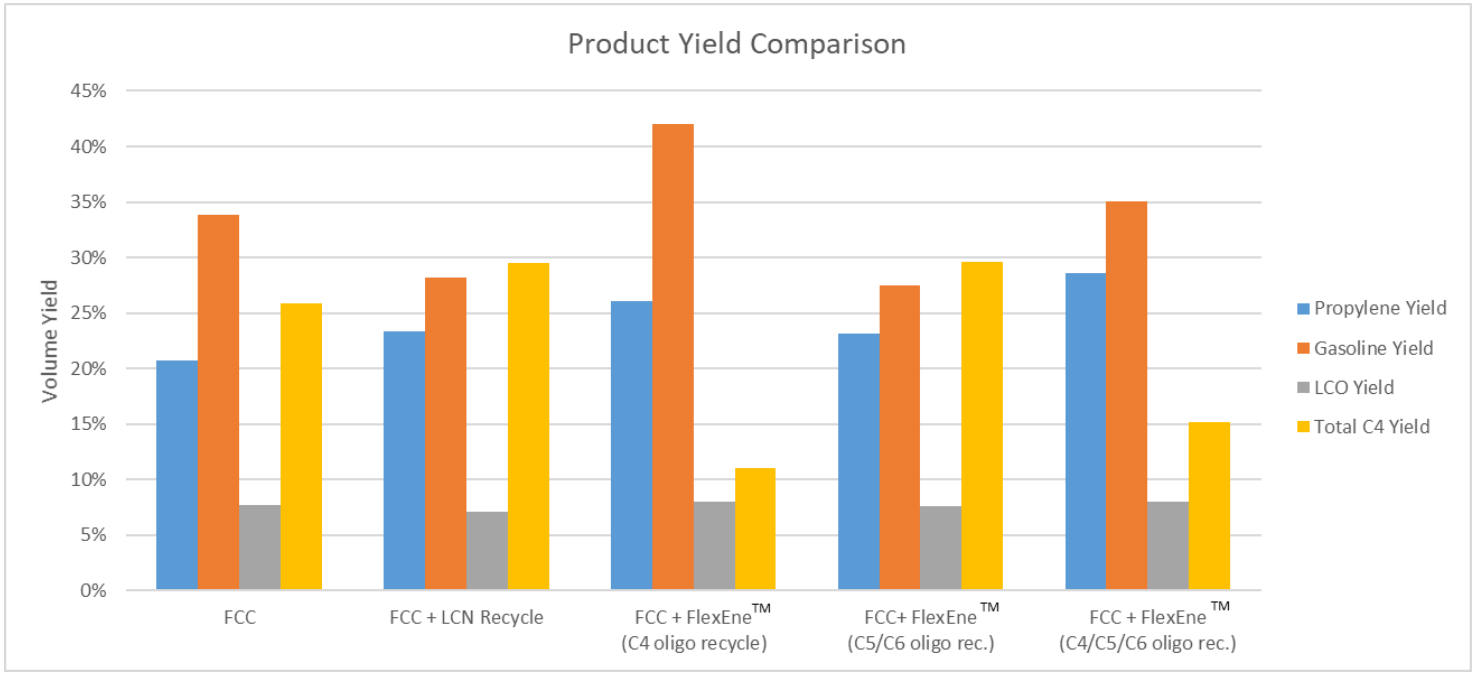
Product Flexibility – Propylene Case



Impact of Oligomer recycle on FCC

- FCC operating conditions will change based on the selected FlexEne™ mode
  - Max Distillate Mode : 940°F
  - Max Gasoline Mode : 977°F
  - Max Propylene Mode : 1005°F-°F1020
- Additional capacity recycle should be evaluated for potential bottlenecks
  - Impact of Wet Gas Compressor is minimized thanks to high oligomer cracking efficiency
- Oligomers are highly olefinic and easier to crack
  - Increased energy demand in FCC is minimized

Case Study: FCC Product Comparison



- FCC processing VGO feed with propylene as target product.
  - Client also wanted to produce high quality gasoline.

Axens

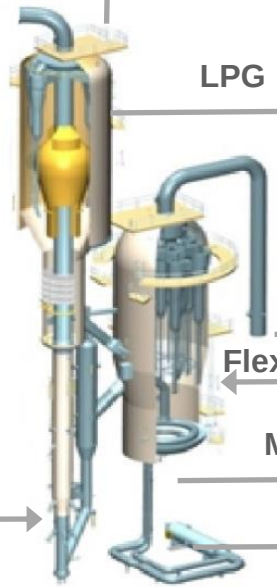
FCC Product Comparison

- Increased flexibility through implementation of FlexEne™ solution
- Propylene yield maximized by recycling C4/C5/C6 oligomers
- For all FlexEne™ cases, required recycle flow is less than LCN recycle.
  - Reducing recycle flow reduces impact on FCC.

Conclusions

- Changing market demands require shift in reorienting FCC products
- Ever changing demands require high flexibility with the ability to change products on the fly
- Taking advantage of the oligomerization technology, FlexEne™ is able to shift olefinic feeds towards high quality gasoline, distillates, or propylene to meet market demand

Full Valorization of FCC Products



Steam Cracker

Ethylene Recovery Unit

Fuel Gas

$C_{2=}$

LPG

Propylene Recovery Unit

C_3

$C_{3=}$

C_4

LCN

FlexEne™

Oligomerization Unit

Raffinate

Mild Hydrocracker Revamp

MCN

Aromatics

BTX

HCN

LC

HYK

CLO

Slurry Hydrocracker

Carbon Black

Live Polling Question #4-5

- **To access the poll, use your phone to scan the QR code or visit the link and type in the meeting code**
- **Live results will be displayed in the presentation**
- **Note: responses are anonymous**

Q&A with the Speakers

Chirag Kothari
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UPCOMING WEBINARS –
SEE AFPM EVENTS PAGE FOR MORE DETAILS

"OPCAT Multiunit Optimization"

February 25, 2021
2:00 PM Eastern

Register Here

Description

Due to the dynamic nature of refining units and changing economic values involving intermediate streams, optimal targets for some units can not be determined by Planning group alone. This presentation presents an innovative way to tackle this challenge by planning/APC engineers working together. Case study provided.

Intended Audience
APC Engineers, Short Term Planners

Participants

- Catherine Bohanon, PE, Phillips 66
- Yangdong Pan, PhD, Phillips 66

"FCC Group – Renewables Focus"

March 25, 2021
2:00 PM Eastern

Register Here

Description

Part of the Spring Renewables Focused Series. Additional details to follow.

Intended Audience
Process Engineers, Strategic Planners, Refiners and Midstream, Investors

Participants

- Members of AFPM's FCC Group

"Decarbonizing Hydrogen Production – On Your Way to Net Zero"

April 28, 2021
2:00 PM Eastern

Register Here

Description

Part of the Spring Renewables Focused Series. Continuation of the Hydro Group's December webinar.

Intended Audience
Process Engineers, Strategic Planners, Refiners and Midstream, Investors

Participants

- Representatives from
  - Matheson
  - Johnson Matthey
  - Haldor Topsoe