



Global Olefins Feedstocks Trends

Stewart Hardy, Senior Consultant

January 2019

Introduction to Nexant

E&CA delivers key insights to energy and chemical companies, investors and lenders, giving confidence in decision making

Energy & Chemicals Advisory	What We Do	Industries Served
Services	Our Services team comprises industry experts giving independent analysis and insight to assist with strategic planning, technology evaluation, feasibility and market studies, business and asset reviews, transaction due diligence support (M&A/project financing) and expert witness.	Power and Renewables Gas and Upstream Oil
Subscriptions and Reports	Subscriptions and Reports provide comprehensive analytics, forecasts and insights regarding markets, technology and economics across the energy and chemicals industry.	Downstream Oil C₁ Chemicals and Fertilizers
Training	Training creates and provides world-class training courses, both public and in-house, that aid progression, development and a greater understanding of today's chemical industry.	Petrochemicals and Polymers Intermediate and Specialty Chemicals

Nexant provides global knowledge and regional expertise



Our people

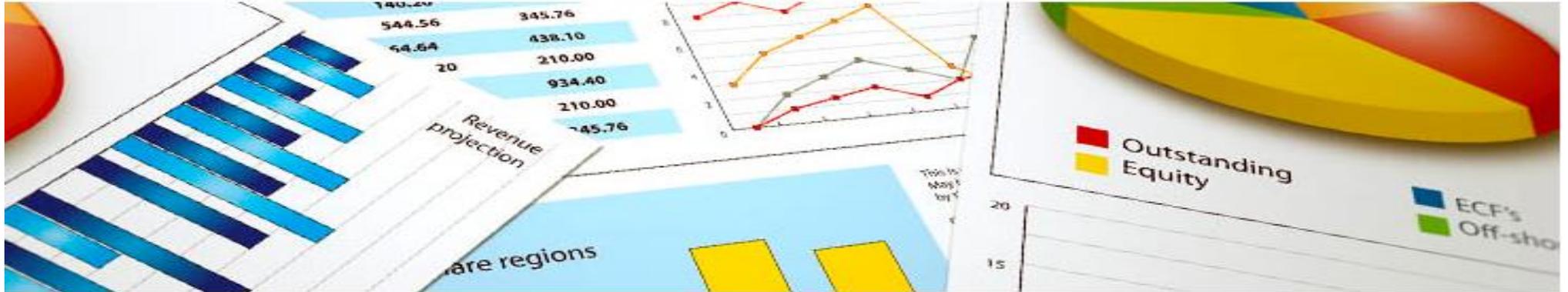
- Nexant Energy & Chemicals Advisory is a multinational business with over 120 experienced industry professionals based in all key regions providing **consultancy, subscriptions and training services**
- Our consultants blend strategic, commercial, operational and technical expertise with deep energy and chemicals sector knowledge

Proven track record

- For over 50 years, through a combination of our business and technical expertise, we have been enabling management teams, investors and lenders in these industries to make better decisions

Nexant E&CA has over 120 knowledgeable and responsive consultants that focus on energy and chemicals, providing global coverage and regional expertise

Nexant has a strong track record as Lenders' Independent Market, Technical and Environmental Advisor



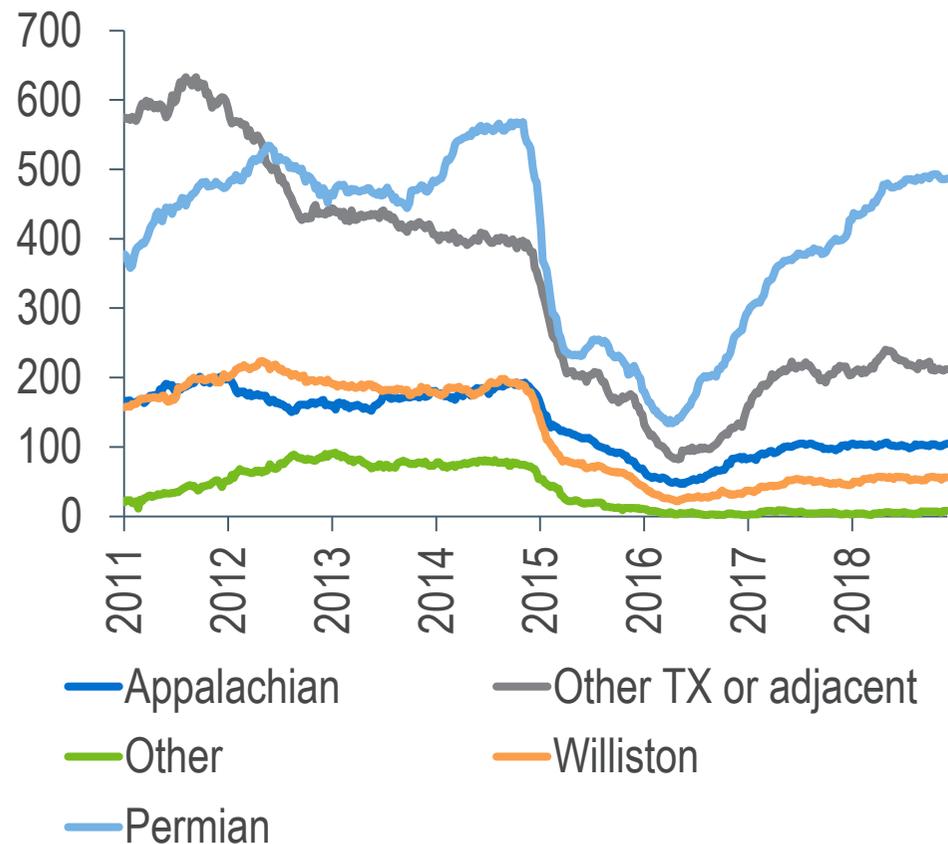
- Active as **Lenders Independent Advisor** since 1977
- Team of **Lenders Independent Advisor** with extensive experience advising on investments
- **Lenders Independent Advisor and Credibility** advising on Market, Technical and Environmental issues in the Energy and Chemicals sectors
- **Fully familiar with project implementation** from initiation of Financing through to monitoring project performance during construction and operation
- **Known and trusted by ECAs** for their Market, Technical and Environmental due diligence

Nexant's record includes acting as advisor in over \$100 billion worth of successfully financed engagements

North America

The focus of activity in the Permian is favourable for USG chemicals

US Drilling Activity by Basin Active drilling rigs

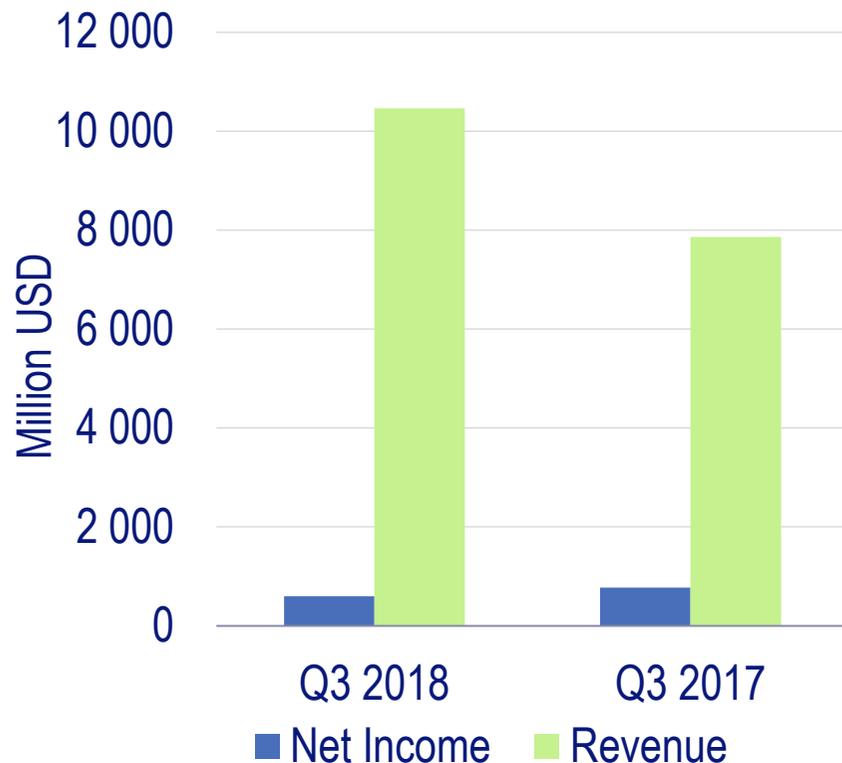


- The current rig count is around half of peak levels, although output continues to grow.
- Ongoing growth in well bore length. The number of frac sites per day and per well continue to increase.
- “Cube” development of stacked plays credited with some of the highest production figures, with some frac pads now approaching 20 kbpd oil equivalent

**Permian oil production reached 3.75 million bbl/day in late 2018.
Ghawar is still the largest field at around 5.**

All companies project much better results

Combined Q3 18 Results of Key Operators



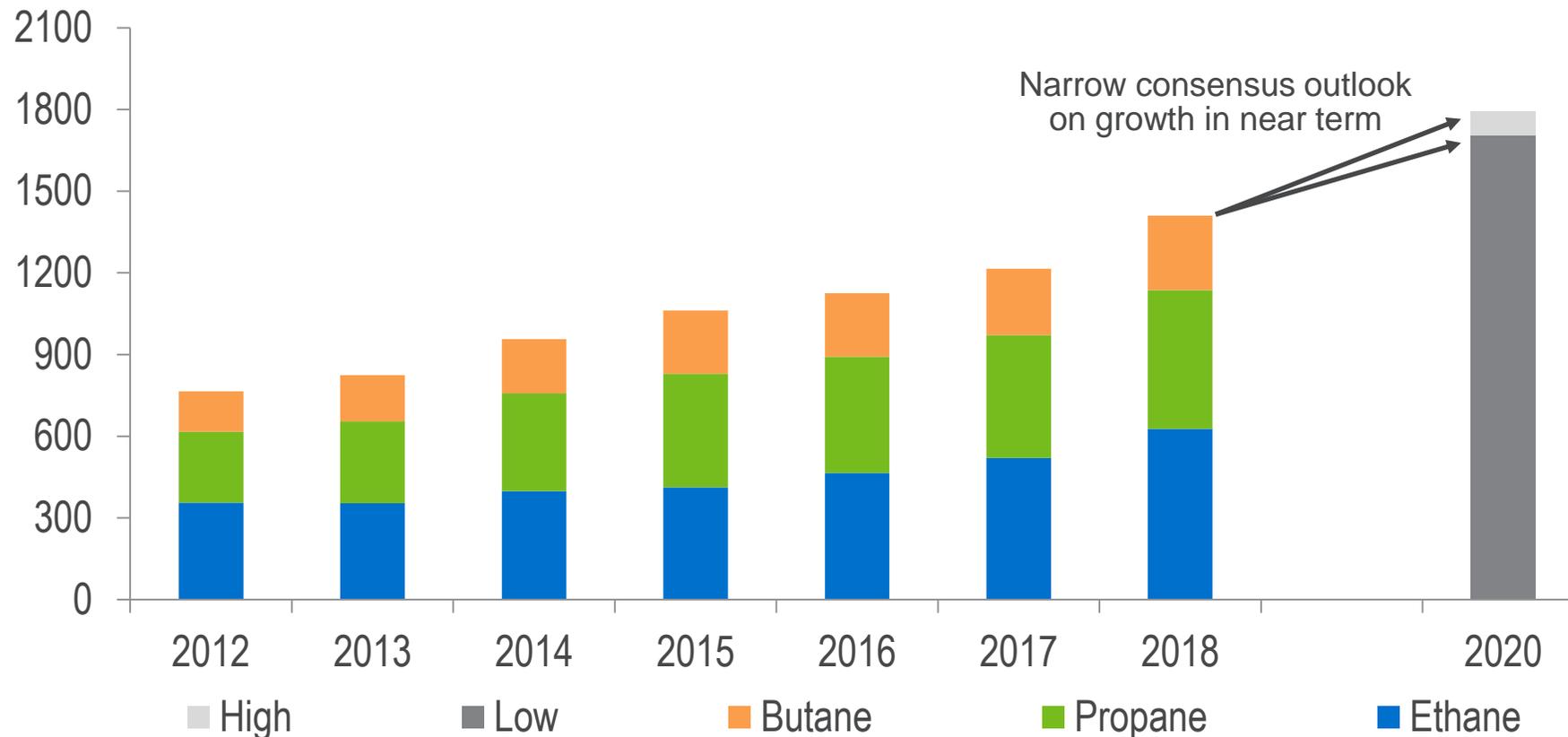
Includes Pioneer, Chesapeake, ONEOK, Antero, Encana

- Operators with greater focus in the Permian are performing better.
- Asset depreciation, marketing and transportation are large cost elements.
- Large benefits from divestment, or losses from impairments are the norm
- Companies provide convincing statistics on drilling performance improvement.
- Logistics improvements expected to provide higher returns per bbl.
- Supermajors are building their presence in the Permian.

CPChem and ExxonMobil considering 2nd crackers is maybe the best indicator on shale viability

NGL output accelerated over 2018

United States NGL production Million bbl

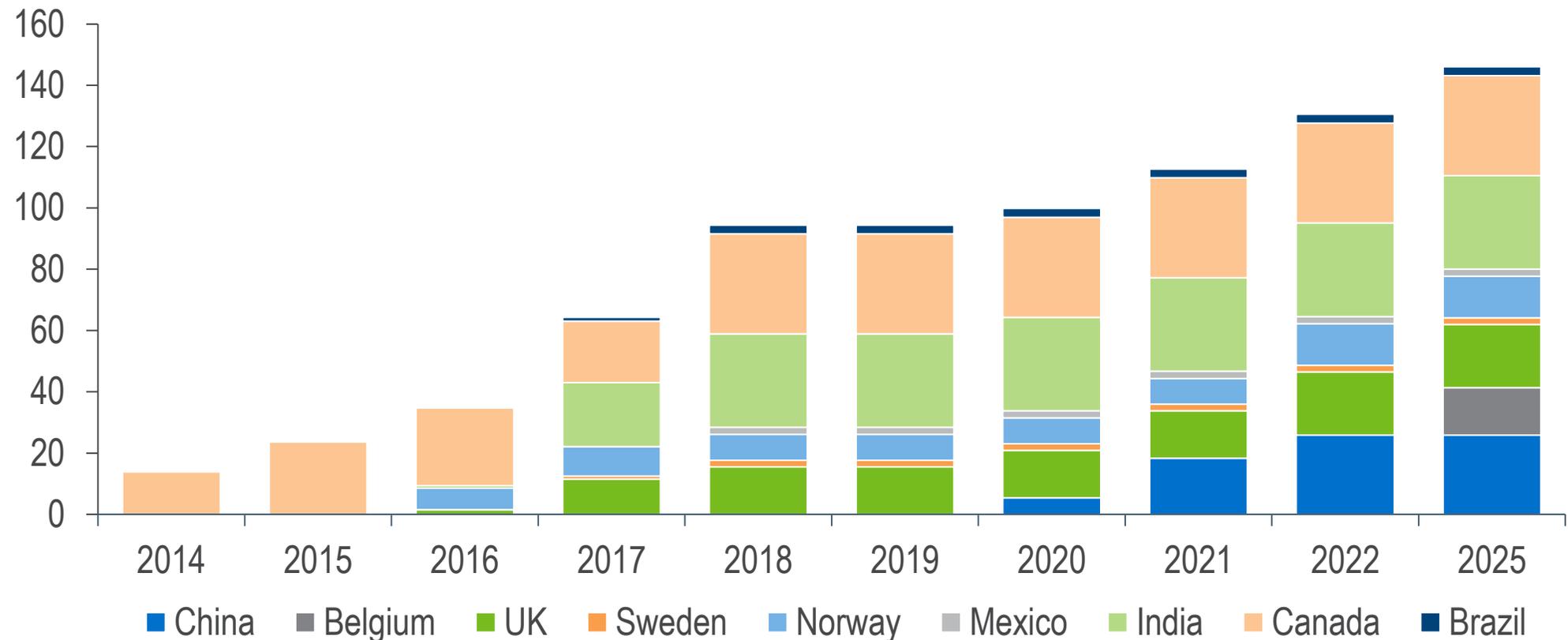


Source EIA, producer forecasts

E/P/B production is expected to grow by 20-24% over 2018-2020

Ethane export terminals are now well loaded

United States Ethane Exports Million bbl per year



Growth is contingent on INEOS investments in Europe, and normalized trade with China

Ethane/Ethylene terminal prospects

■ ETHANE

- “Orbit” has been created as a JV between Zhejiang Satellite and Sunoco/Energy Transfer Partners (ETP), to build a USGC terminal with an 800 000 bbl refrigerated tank, 175 000 bbl/day of refrigeration capacity, link to Sunoco/ETP’s Mont Belvieu storage. Estimated online 2020-2021.
- Mariner 2 has initial capacity of 275 mbpd, expandable to 450 mbpd, followed by Mariner 2X with 250 mbpd in 2019. Full utilisation can add ~500 mbpd NGL volume to flexible terminal at Marcus Hook.

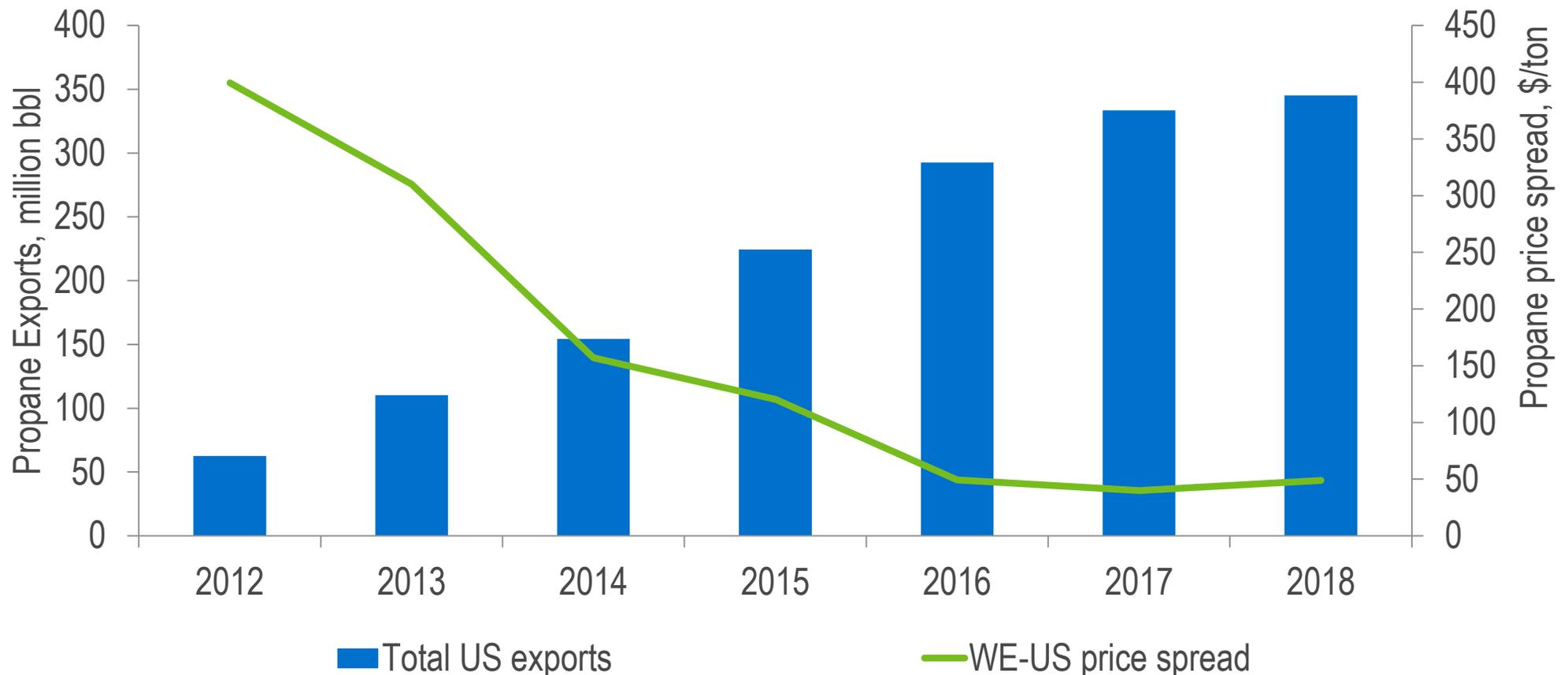
■ ETHYLENE

- Enterprise is building a 1m tons/year ethylene terminal alongside its ethane terminal at Morgan’s Point, TX.
- Odfjell proposes at 750 kt/yr terminal at Bayport
- NOVA proposes an 800 kt/yr terminal at an undecided USGC location, in partnership with ETP.

The Orbit terminal would roughly double US marine ethane export capacity, while the Enterprise ethylene terminal alone will increase capacity 4x.

Exports allowed US prices to realign with other regions

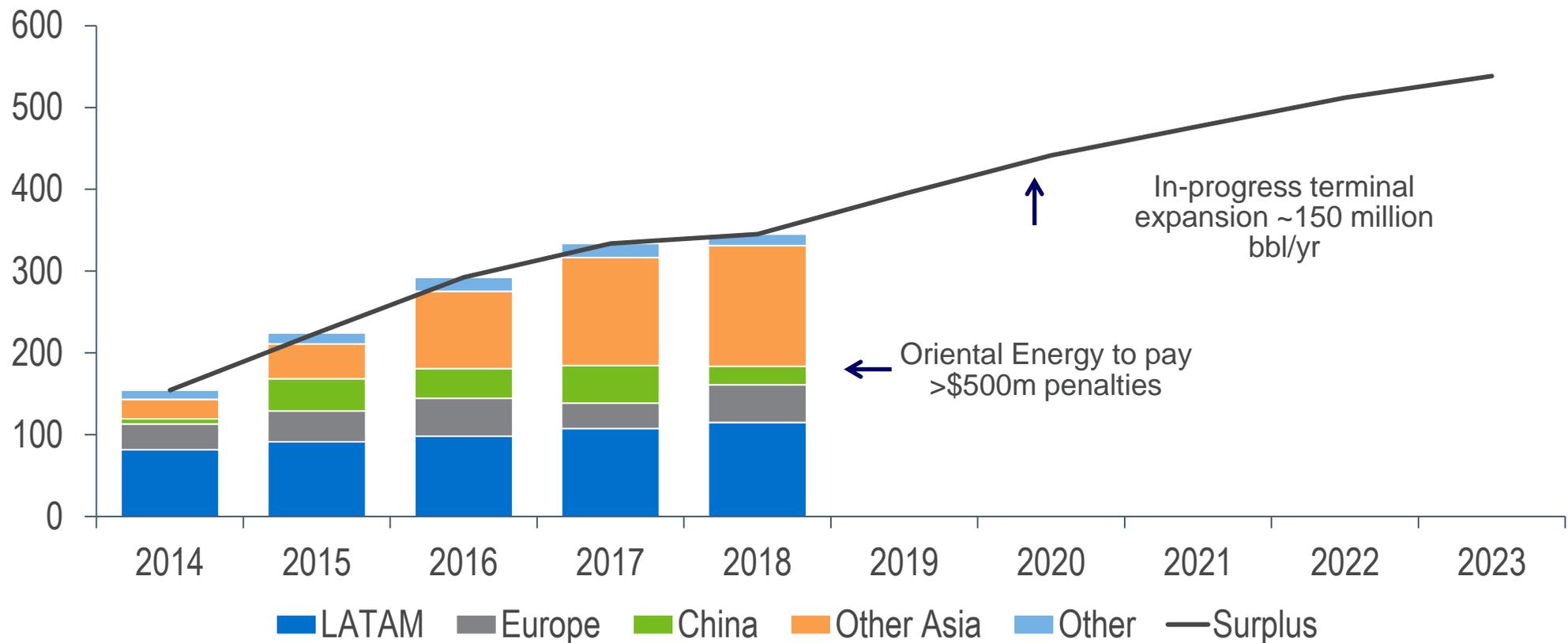
US Propane Exports versus price differential



US prices may again drop if export capacity does not match growth in excess supply

The US propane surplus could increase by half over the next five years

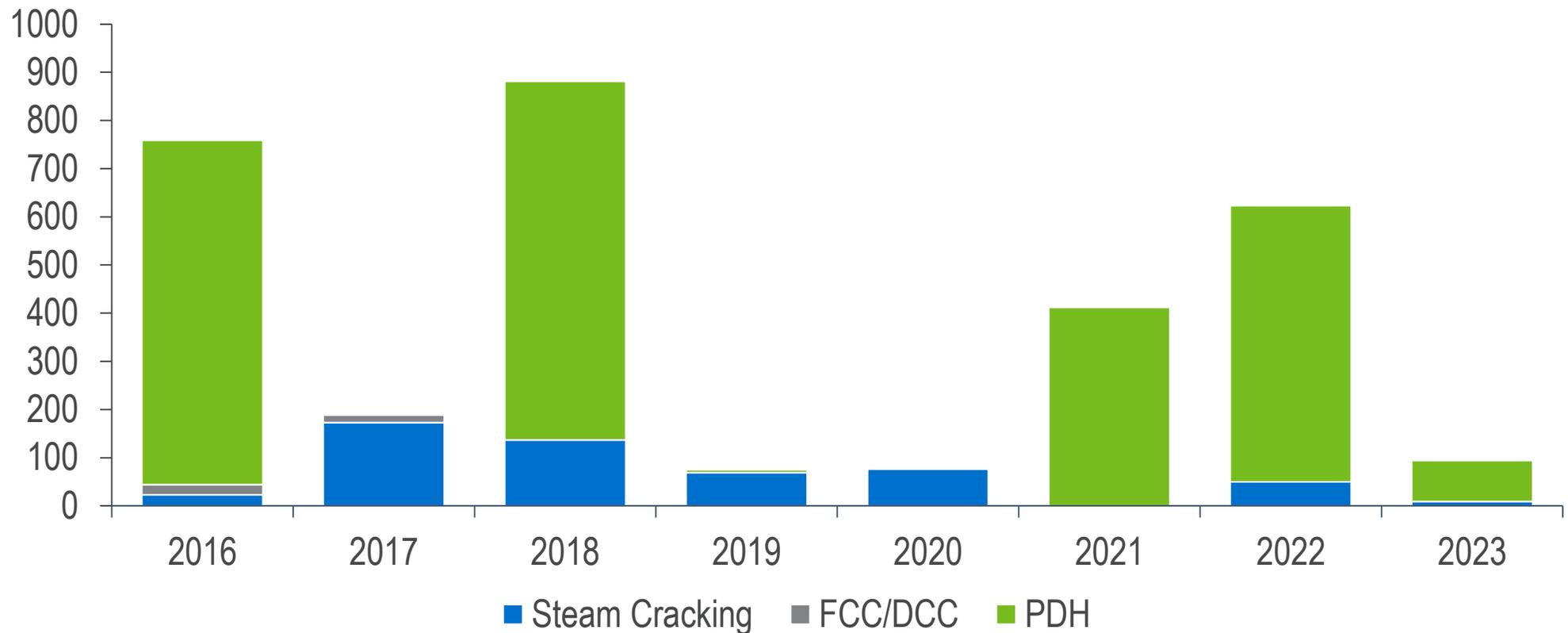
North American Propane Exports Million bbl per year



Export terminal capacity will need to grow beyond the current in-progress projects, butane volume also to rise

Formosa and Inter Pipeline PDH/PP projects are now firm

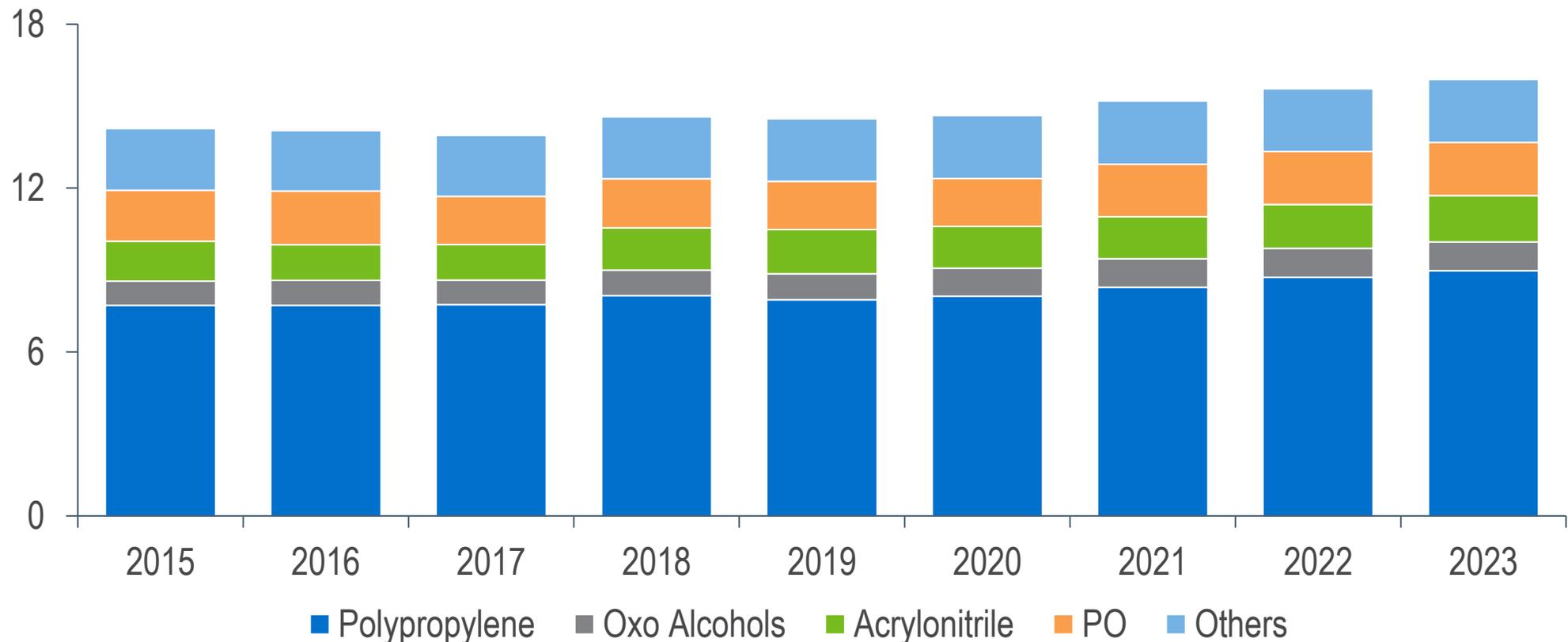
North America Incremental Propylene Capacity Thousand tons per year



Enterprise lists two further PDH plants as potential opportunities

Three new PP plants are now planned

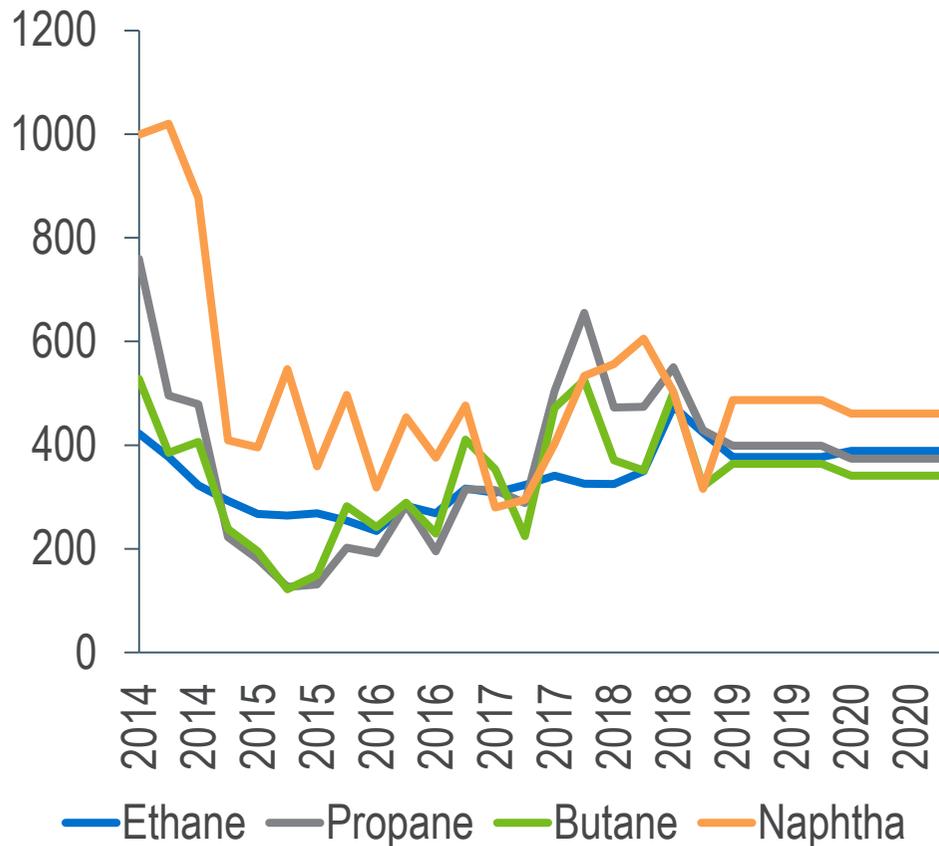
North America Propylene Consumption Million tons per year



Some propylene derivatives are underutilised as export business has been lost

LPG oversupply narrows the feedstock cost differential

US Cash Cost of Ethylene Production Cash Cost of Production US\$/ton

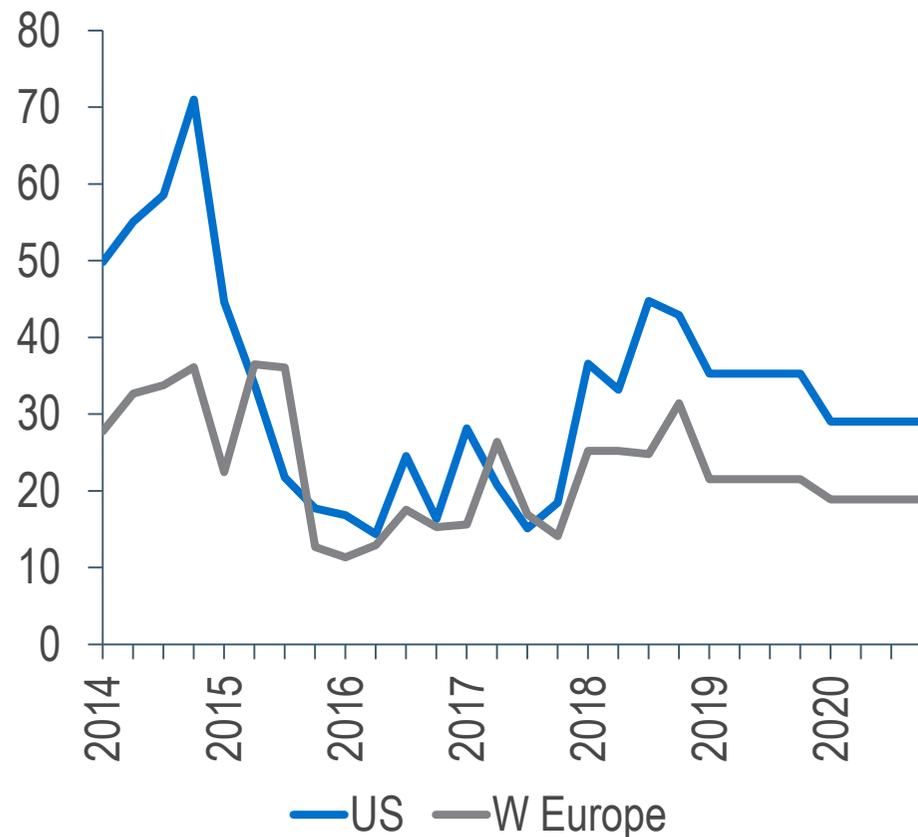


- Naphtha and butane were the lowest cost routes to ethylene in Q4 2018, due to local oversupply and high co-product values.
- The near term outlook is for a narrow spread between costs from E/P/B, partly due to oversupply of LPG.
- Some smaller crackers offline for most of 2018 due to ethylene oversupply.
- Already some signs of difficulty in marketing the new polyethylene supply.

Resilient co-product returns periodically make naphtha the lowest cost feedstock for ethylene

There are now two PDH projects in both the US and Western Europe

Relative PDH ROI ROI, percent

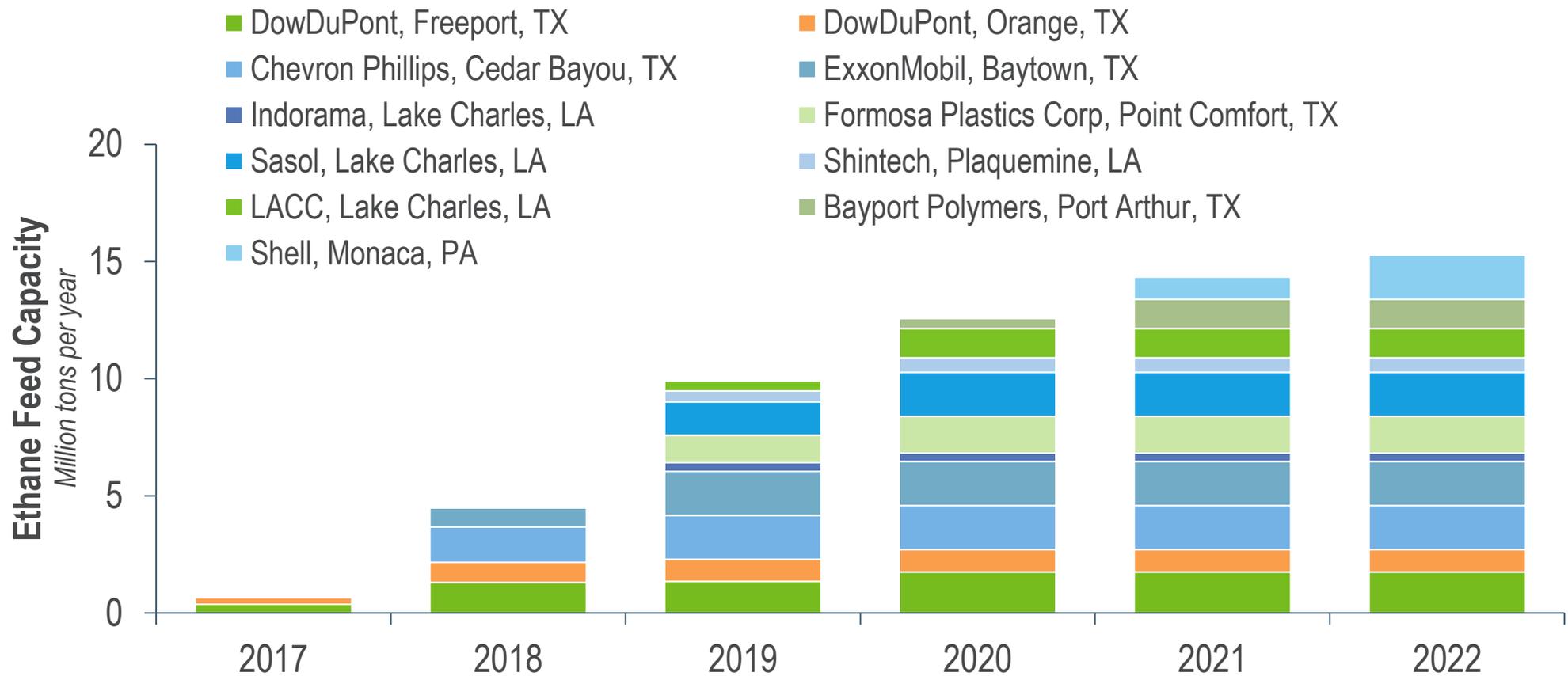


- Plant size in Western Europe is small, but the new 750 000 tons per year plants planned by Borealis and INEOS will provide ROI much closer to US levels.
- PDH Polska is also progressing, and will also consume imported propane.
- North America firm developments are linked with PP, and will mainly offset the existing market gap in Mexico and Canada.

PDH investment economics are strong on both sides of the Atlantic

Current firm developments add 15m tons/yr of ethane demand to the 2016 total of 23m tons/year

US Ethane Consuming Plants Million tons per year



Shell is still the only firm project outside USGC area

North America Summary

- Drilled uncompleted wells in the Permian have tripled to ~4000 since 2016, providing for high growth in NGL supply when logistics expansions are completed, also providing resilience to investment cycles.
- Permian-Mt Belvieu pipeline capacity is currently the bottleneck, but the distance is short, and major expansions are underway.
- Enterprise Shin Oak 550 mbpd NGL pipeline and Targa Grand Prix 300 mbpd pipeline operational Q2 2019.
- The outlook to 2020 suggests sufficient ethane supply growth for the new crackers.
- LPG could become more heavily oversupplied from 2019-2020 until export capacity expands:
 - Mariner East 2 in service December 2018, 2X due late 2019
 - Enterprise 175 kbpd LPG terminal expansion online late 2019

Market penetration for olefins derivatives looks likely to lag upstream developments, leaving US petrochemicals well supplied with feedstock

Western Europe

The West European market may not be able to absorb all of the new capacity

- INEOS plans to bring both Grangemouth and Rafnes close to 1 million tons per year, and add a new 1.2 million tons per year ethane cracker in Belgium.
- Both INEOS and Borealis plan 750 000 tons per year integrated PDH/PP plants.
- INEOS is working to reduce its massive ethylene purchasing requirement, but its current suppliers may have difficulty in placing the volume elsewhere.
- DowDuPont plans a new large scale HDPE plant, but may itself expand its Terneuzen cracker.

Although the market has shifted back into expansion mode, it remains possible that some older naphtha-based crackers could be forced out of the market.

Liquid Feed Developments

The market needs more chemicals, but less growth in fuels

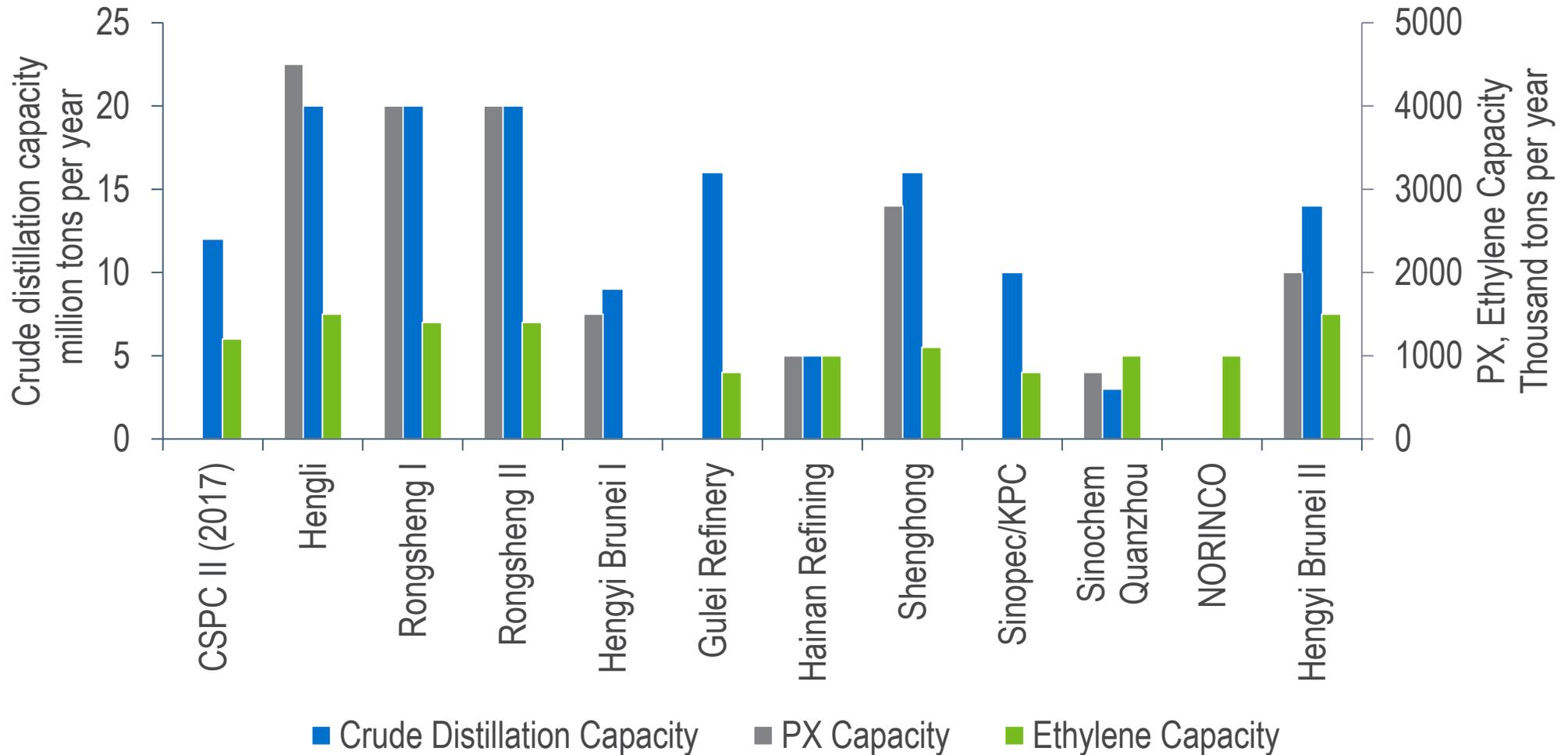
- Refinery investment is problematic due to the expected slowdown in demand growth for transportation fuels.
- Crude-to-PX and COTC provide unprecedented yields of chemicals, but still produce large volumes of fuels and base oils.
- The appetite for investment is currently strong, but may wane if margins are impacted by gasoline and diesel oversupply.
- As NOCs seek to place barrels, COTC emerges as a means to create oil demand, as well as generate value.
- As OPEC members face oil production cutbacks to support prices, COTC economics are more favourable if considering the very low marginal cost of oil production in the Middle East.
- Due to a lack of competitive merchant naphtha, some aromatics plants have been built with integrated condensate splitters and indeed hydrocrackers to provide reformer feed.

Some older refining capacity may need to close to make way for new chemicals-based refineries

China

Most new Chinese crackers are in “Crude-to-PX” refineries

Chinese refinery/chemical developments



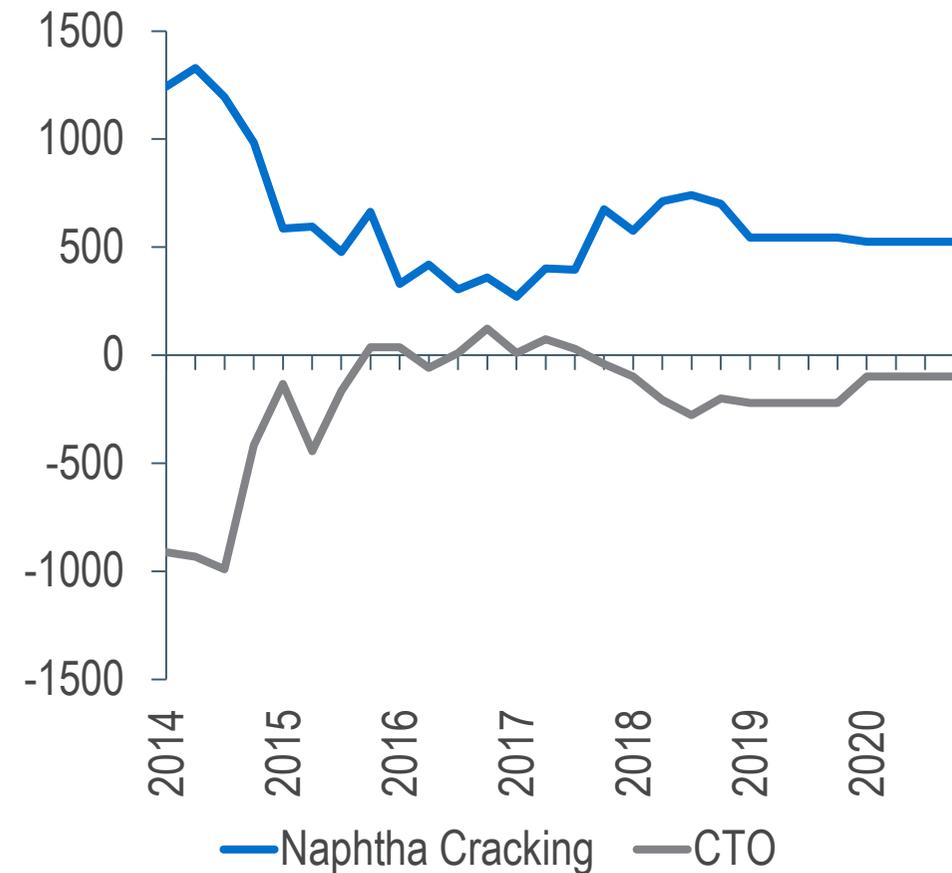
Some Companies are reconfiguring existing refineries towards chemicals

COTC (Crude Oil-to-Chemicals) Considerations

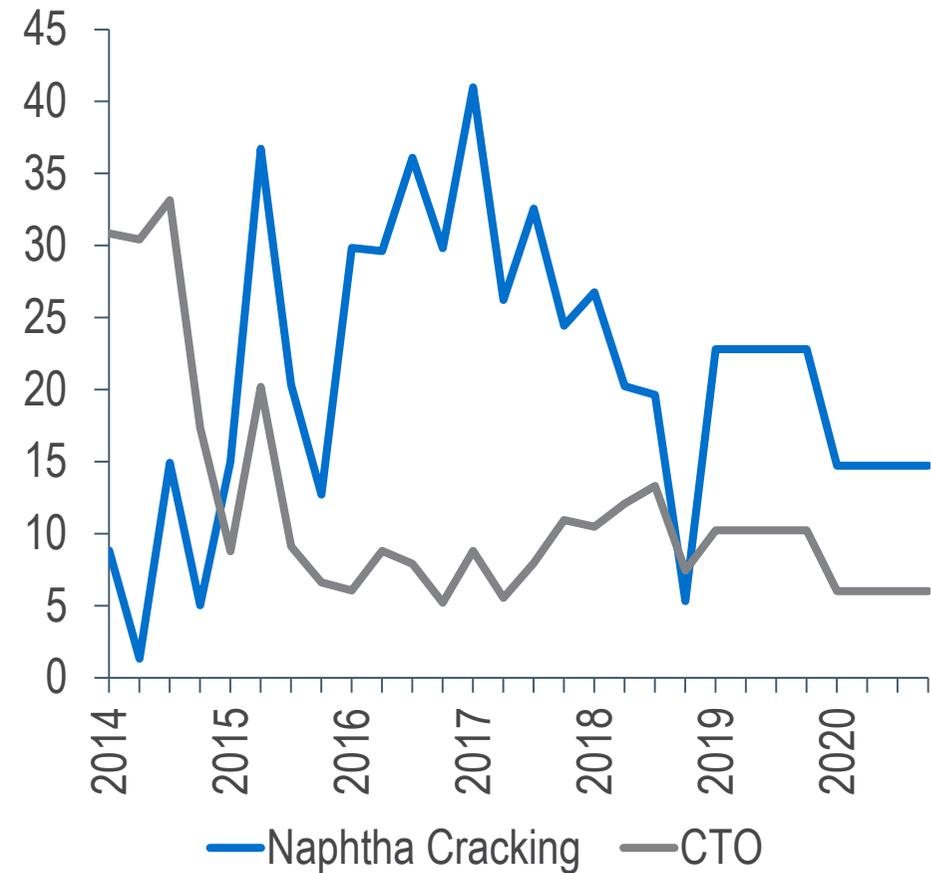
- Direct crude cracking is unattractive due to coking and low ethylene yield. Some plants can crack light crudes/condensate intermittently.
- Various configurations are possible, but most centre around feeding naphtha, LPG and ethane from the CDU straight into steam crackers, and hydrocracking the remaining products into steam cracker feed.
- Hengli uses 3 twin trains of hydrocrackers to process atmospheric distillation fractions (diesel, gasoil and residue).
- Not yet clear how much the direct conversion processes being developed by Saudi Aramco and partners will differ from existing refinery technologies.
- Reliance multi-zone cracking (MCC) is in development, but claims to produce around 25% ethylene and 40% propylene from vacuum residue.

Three years of strong cracker margins lead reinvestment

China Cash Cost of Ethylene Production
Cash Cost of Production, US\$/ton



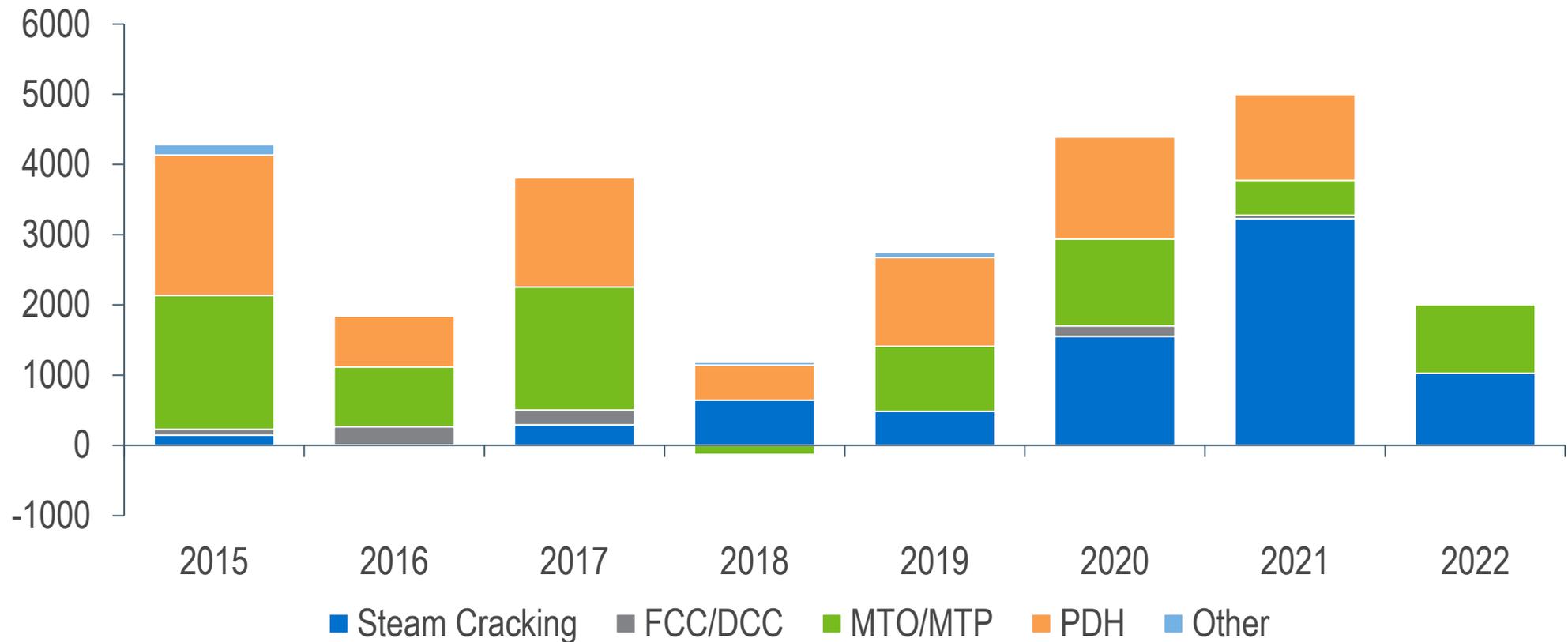
China Ethylene ROI
ROI, percent



Most cracker projects are integrated refinery plants, but are not the main reason for the projects

MTO development in China is tailing off

China Incremental Propylene Capacity Thousand tons per year



Refinery-based crackers are driving supply growth

Crude-to-para-Xylene is a new concept

- The developments by Hengli, Rongsheng and Shenghong represent a new kind of investment, where PX is the primary activity of the refinery rather than a small value-adding unit.
- The projects focus heavily on PX, producing a much higher ratio of aromatics to crude distillation capacity.
- By diverting most of the naphtha into aromatics, and some of the hydrocracker output into steam cracking, the projects maximise chemical production and reduce exposure to fuels markets.
- These configurations include choices which are not normally optimal for refiners, and could impact on the profitability of refinery.

The new crude-to-PX complexes will still need to succeed in the refining/fuels business

The role of Middle Eastern NOCs

Saudi Aramco is driving much of the next phase

- US\$44 billion capex allocated for Ratnagiri by Saudi Aramco and ADNOC
 - Partnership with IOCL, HPCL and BPCL, target start-up 2025
 - 60 million ton/year refinery/chemicals capacity, up to 18m tons/year of chemicals
 - May proceed in 3 phases – still not certain to proceed
 - Timescale estimate ~2x recent China developments, due to problems with land acquisition, etc.
- COTC first development in Saudi Arabia partnered with SABIC
- US\$10 billion refinery/chemicals projects proposed in Pakistan and South Africa.
- Refocus of existing refinery capacity towards chemicals (Motiva, Amiral/SATORP).
- Discussions with Reliance for refinery/chemicals developments in Saudi Arabia and India.
- Plans for future gas-based expansion in Saudi Arabia, including from unconventional gas exploitation.

“We are expanding this business both in Saudi Arabia and in fast-growing overseas markets, with the aim of converting two to three million barrels per day of crude oil into petrochemicals.”

ADNOC is currently the other main mover in the Middle East

- Borouge 4 will raise polymers capacity to circa 10 million tons per year, doubling current capacity.
 - Ruwais developments to create “World’s largest integrated refinery/chemicals complex” including a new 1.8 million tons per year mixed feed cracker.
 - The feedstock will include naphtha, which is currently exported.
- ADNOC is also taking a 25% share in Ratnagiri
- MOU to explore downstream investment opportunities with the government investment vehicle Mubadala.
- Major investment in gas could also provide NGLs for additional crackers in the longer term.
 - New sour gas developments, unconventional fields and unexploited conventional formations are being pursued to achieve production of ~2.5 billion scf/day

“Adnoc will convert 20 per cent of its crude to chemicals, tripling petrochemical production capacity to 14.4 million tonnes per year, by 2025.”

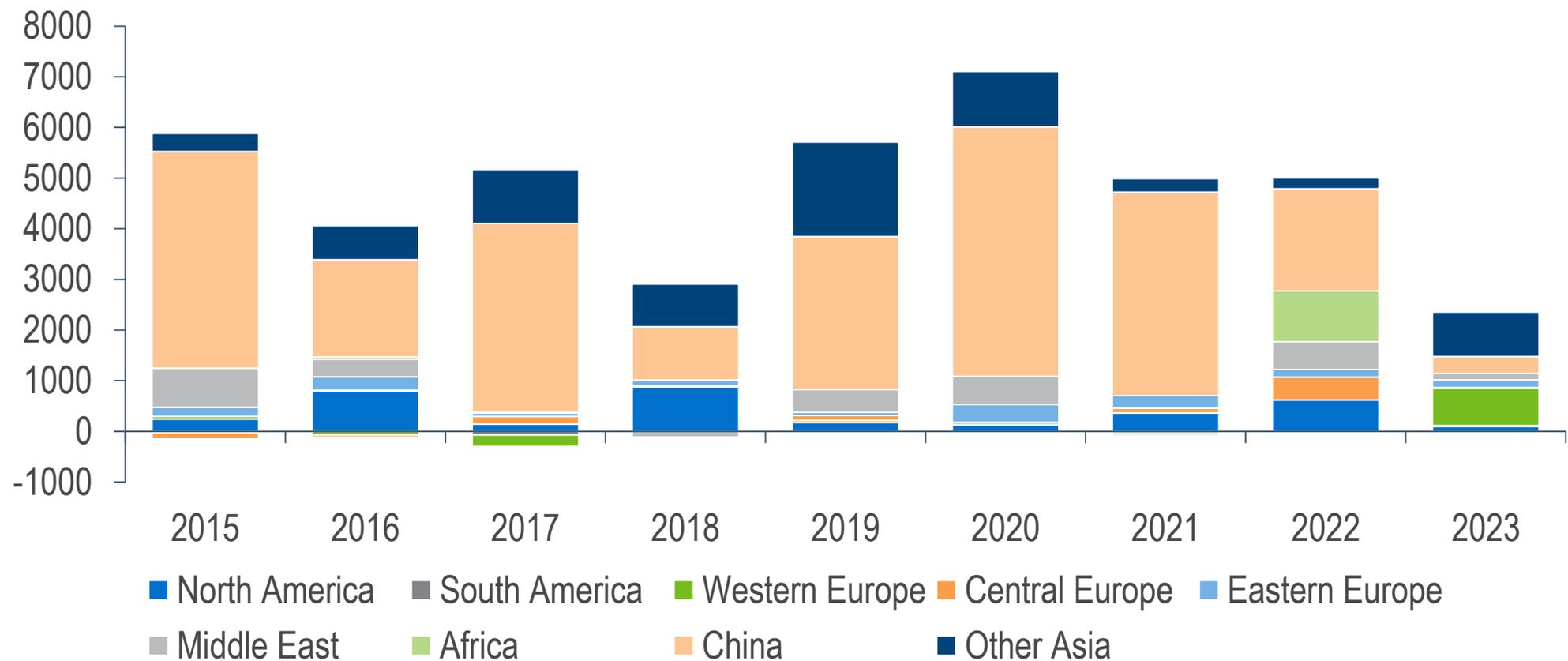
Iran's capacity growth will be based mainly on gas

- Renewed sanctions have further delayed new projects.
 - Problems both in producing and marketing products
 - Selling from inventory in Europe on cash terms to avoid LC problems
 - Several longer-term olefins/polyolefins projects have stalled over 2017-2018 and now have no firm date for completion
- In the longer term, olefins from methane are likely to be significant, both from methanol/MTO, and other options such as syngas or methanol-based MEG
- Private sector companies are driving an increasing share of capacity growth, and NIOC is not promoting oil-based projects.

Global

China continues to dominate supply growth

Global Incremental Propylene Capacity Thousand tons per year



Supply growth is low in those regions already exporting propylene derivatives to China

Conclusions

- Continued improvement in drilling performance contributes to higher forecast NGL output in the United States.
- US exports of ethylene and propylene will increase, as well as NGLs.
- Around two million tons each of ethylene and propylene capacity are being built in the EU, based on imported US NGLs.
- Eight new large-scale liquids crackers under construction in China, most as part of new PX-focussed refineries.
- Saudi Aramco is leading the next phase of development, which will include a greater proportion of olefins production.

So far, C2C is mostly about novel configurations to convert crude to feed for conventional crackers



1 King's Arms Yard,
London, EC2R 7AF

Telephone: +44 20 7950 1600
Facsimile: +44 20 7950 1550

www.nexant.com

"This presentation was prepared by Nexant Limited ("Nexant"). Except where specifically stated otherwise in the presentation, the information contained herein was prepared on the basis of information that is publicly available and has not been independently verified or otherwise examined to determine its accuracy, completeness or financial feasibility. Neither NEXANT, nor any person acting on behalf of NEXANT assumes any liabilities with respect to the use of or for damages resulting from the use of any information contained in this presentation. NEXANT does not represent or warrant that any assumed conditions will come to pass.

This presentation is integral and must be read in its entirety.

The presentation is given on the understanding that the recipient will maintain the contents confidential except for internal use. The presentation should not be reproduced, distributed or used without first obtaining prior written consent by NEXANT. This presentation may not be relied upon by others.

This notice must accompany every copy of this presentation."

Nexant, Inc.

San Francisco
New York
Houston
Washington
London
Bahrain
Bangkok
Shanghai
Kuala Lumpur

www.nexant.com