EXECUTING TRANSFORMATION AND INVESTING IN GROWTH
Energy Transition & Circular Economy
Friend or foe to the Middle East chemicals sector?
Alan Gelder & Gordon Haire, November 2018
Agenda

1 Energy Mega-trends
2 Outlooks for oil demand growth
3 Crude to chemicals
4 Petrochemical demand in the circular economy
5 Risks to our base case view
Renewables and electrification are the primary drivers of the energy transition.

There are multiple enablers and barriers in both categories.

### Renewables

**Enablers**
- Storage
- Decarbonization
- Renewables Policy
- Costs
- Sustainability Trends

**Barriers**
- Intermittency and Grid integration
- Business Case / Economics
- Reliability and Resiliency / Market Design
- Cybersecurity
- Grid Edge Technologies and Retail Rates

### Electric Vehicles

**Enablers**
- Batteries
- Decarbonization
- EV Policy
- AEVs & Rideshare
- Sustainability Trends

**Barriers**
- Alternative Technology
- Raw Materials
- Charging Infrastructure
- Cybersecurity
- EV Technology
There will be no peak for gas and oil demand before 2035

Coal is hit hardest by the energy transition. Regional primary energy demand growth overwhelmingly an Asia Pacific story

Source: Wood Mackenzie
Light vehicle fuel efficiency standards cover countries or regions that account for almost 75% of global gasoline demand

Source: ICCT, Wood Mackenzie

Canada is currently aligned with the US. Will it remain aligned if the US eases standards?

US CAFE and GHG standards for 2022-25 are under review and may be weakened

California has state standards, which are currently aligned with federal standards. It is opposed to any easing of federal standards

Mexico introduced standards for 2016 based on US regulation. They were carried over to 2017/2018, as no further regulation has been introduced

EU standards mandated to 2021, with new targets to 2030 announced at the end of 2017

Brazil’s Inovar Auto programme (2012-17) had tax incentives to support efficiency in vehicles; Rota 2030 is to replace the programme but has still not been signed off

China Corporate Average Fuel Consumption standard is in place until 2020, with potential target proposed to 2025

India’s ‘Average Fuel Efficiency Standards for Manufacturers’ is set through to 2022, with proposed standards thereafter

Japan and Korea both have standards running through to 2020

Australia’s fuel efficiency standards are under discussion

Source: ICCT, Wood Mackenzie
Falling battery costs enable rapid EV penetration in the passenger car market
We expect costs to fall to US$100/kWh by 2027, three years earlier than previously forecast

Battery cost outlook

Costs are falling more aggressively than previously forecast due to rapid technological advances – especially in new battery chemistries

US$100/kWh is a key threshold when EVs are able to compete with ICE cars

Cost of a 60-kWh battery

A 60-kWh battery provides sufficient range over 200 miles for most cars

Technology trends suggest that costs could be up to five times cheaper by 2040, making EVs competitive across all car market segments

Source: Wood Mackenzie Power & Renewables, GTM
Global EV sales accelerate in the 2030s but it takes time to impact the global vehicle fleet

Even with the shift to EVs in the developed world, the global ICE vehicle stock does not peak until the early 2030s

Source: Wood Mackenzie
Global gasoline demand is forecast to peak by 2030

We estimate 4.5 million b/d of oil demand will be displaced by EVs by 2040

Global demand for gasoline

Global demand displaced by EVs (excluding electric trucks) region

Source: Wood Mackenzie
Petrochemical feedstock demand to rise by over 7 million b/d to 2040, but a significant portion is satisfied by gas derived NGLs. NGLs derived from gas consumption contribute to petrochemical feedstock demand.

Global oil demand by sector:

- **Gasoline**: hybridisation, mandated fuel efficiency improvements, and rising EV penetration erodes demand.
- **Commercial diesel**: truck fuel efficiency regulations are more limited; some displacement by NGVs and electric trucks.
- **Aviation**: slow fuel efficiency improvements; no alternate fuels.
- **Shipping**: fuel efficiency improvements; rising LNG penetration post-2025.
- **Non-energy**: includes asphalt.

Source: Wood Mackenzie
Global oil demand is middle distillate and petrochemical feedstock oriented, supporting the development of “chemical refineries”

In our base case, the current refining yield structure is broadly in balance if naphtha is increasingly used for petrochemical feedstocks,

Global demand growth, 2020–2035, kbd

Gasoline – naphtha balance (kb/d, satisfying distillate demand growth)

Source: Wood Mackenzie
For the global crude market, ongoing production decline is a key feature in the ‘supply gap’

The 2025 supply gap

- **Dark blue bar**: 2018 demand is forecast to average 99.4 million b/d
- **Green bar**: Oil demand is expected to grow by 6.2 million b/d to 2025, reaching a total of 105.6 million b/d
- **Grey Bar**: Onstream non-OPEC fields are expected to decline by 13 million b/d to 2025. US Lower 48, China and Russia drive these declines
- **Light blue bar**: Projects which have already received an investment decision will contribute 3.9 million b/d by 2025. Around half of this comes from Brazil and Norway which both have world class assets under development such as Johan Sverdrup in Norway and Buzios in Brazil
- **Red bar**: The amount of new supply required to meet the growth in demand and offset onstream declines

**What about OPEC spare capacity?**

This analysis does not account for the crude capacity OPEC has withheld from the market. It is illustrative of the fundamentals, excluding changes in OPEC behaviour and is used as a guide for marginal cost of production (and price) analysis

The chart effectively shows a supply gap if OPEC spare capacity were to remain flat through time. For reference, OPEC spare capacity is estimated at ~4 million b/d this year

Source: Wood Mackenzie
Prices stop rising as oil demand peaks in 2036 and pressure on the industry to grow supply eases

Brent price outlook (real)

Global oil demand peaks in 2036 and begins a steady decline. Demand is pressured lower by the electrification of cars and increasingly, trucks, and the rising use of autonomous vehicles. Only demand from the aviation and petrochemical sectors continues to grow.

The market recognises the industry has less need to press into high cost frontier supply. Focus turns to the potential for reserves to be left in the ground, helping to take pressure off already high prices.

Brent price averages $80 in 2023, higher prices driven by increasing breakevens for US tight oil due to cost inflation and the need for more expensive conventional production to fill the supply gap, exacerbated by upward revisions to oil demand.

Upward price pressure re-emerges as higher cost supply is required to meet growing supply and to replace significant conventional and increasingly unconventional declines.

Downward pressure on prices 2024-2026 as conventional production sanctioned during the run up in prices to 2023 enters the market.
Crude to chemicals – second generation of Chinese mega assets approaching completion

Optimisation of refining and petrochemicals driven by chemical value upgrade

Fuel and product contribution to refinery complex, in percent

Increasing integration from crude to chemicals
PetroPlan optimises stream dispositions to model real-life integrated refinery-petrochemical sites

Reformer optimisation:
- severity level
- reformate disposition to BTX vs gasoline

C2, C3 & C4 disposition optimisation:
- refinery fuel gas
- direct LPG sales
- gasoline blend (C4)
- cracker feed

Light naphtha disposition optimisation:
- direct naphtha sales
- gasoline blend (via isomerisation or direct blend)
- cracker feed

Naphtha raffinate disposition optimisation:
- direct sales
- gasoline blend
- cracker feed

Toluene & C9+A disposition optimisation:
- direct sales
- gasoline blend
- PX (via transalkylation)

Cracker feedstock optimisation:
- LN
- FRN
- C3/C4
- ethane, LS gasoil, LS residue feedstock options also available

Pygas disposition optimisation:
- gasoline blend
- BTX extraction

Pyoil disposition to refinery fuel oil blend pool

Source: Wood Mackenzie Refinery Evaluation Model, PetroPlan
Middle East asset cost competitiveness

Deep understanding of emerging technology landscape and feedstock alternative values allows us to assess competitiveness of both existing and new assets in each region.

Global ethylene cost curve, 2023

Global paraxylene cost curve, 2023

Source: Ethylene Asset Cost Tool

Source: PX Asset Cost Tool
Emerging economies drives long term growth outlook at ~2.5% with the non-OECD nations contributions almost double that of OECD nations.

Risks to the short term outlook are increasing and governments lack policy options.

Global GDP growth (annual)

Source: Wood Mackenzie
Demographic drag is a global phenomena

But developed economies still face the biggest demographic challenge

Change in working age population

Source: UN, Wood Mackenzie
Recycling mandates potential to subdue demand – but this will take some time to implement and will vary by polymer

Solving improper plastic waste disposal has moved from minority view to a broader consumer desire, putting pressure on governments, brand owners, and producers

Global commodity polymer market

Only PET is significantly recycled, HDPE is a distant second

<table>
<thead>
<tr>
<th>Plastic type</th>
<th>Single/multi</th>
<th>Recycled</th>
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<tbody>
<tr>
<td>PET</td>
<td>90/10</td>
<td>&gt;50%</td>
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<tr>
<td>Polyethylene</td>
<td>80/20</td>
<td>Some HDPE</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>40/60</td>
<td>&lt;1%</td>
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<tr>
<td>Polyvinyl chloride</td>
<td>20/80</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>80/20</td>
<td>&lt;1%</td>
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Source: Wood Mackenzie
Global polyethylene, polypropylene and PET recycle and virgin demand

Recycled polymer growth rates are expected to increase faster post 2025, in the base case. The chart does not show the hockey stick growth for recycle plastics as polyolefins tend to be used in film applications, are multi-layered and are challenging to accumulate in the large volume.
Capacity addition in China is closing the gap between supply and demand, ethylene derivative import requirement growth is slowing

**Source:** Wood Mackenzie Chemical Ethylene Global Supply and Demand Analytics Service

1. Self-Sufficiency Ratio is calculated as the ratio of total olefins monomer capacity divide by derivative demand in olefins monomer equivalent

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**Petrochemical demand in the circular economy**
The future is uncertain; numerous risks could materially change our long term view of the downstream industry

Risks to our base case view

<table>
<thead>
<tr>
<th>Drivers:</th>
<th>Environmental/regulatory requirements</th>
<th>Technology improvements</th>
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<tbody>
<tr>
<td>Policymakers / capital markets push a stricter decarbonisation agenda</td>
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<td>Wider adoption of CO₂ pricing difficult for fossil fuels; investors force change e.g. divestments</td>
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<td>Push for biofuels increases</td>
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<td>Lower carbon advanced biofuels encroach on transportation fuel pools</td>
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<td>Plastic pollution is the new climate change</td>
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<td>Targeting plastic waste could hit petrochemicals growth long-term</td>
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<td>Clean fuel regulations continue to accelerate</td>
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<td>Lower sulfur specifications across all products impact costs</td>
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<td>EVs reach cost parity with internal combustion engines sooner than expected</td>
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<td>Downside risk to gasoline &amp; diesel demand; upside to power demand, with possible grid issues</td>
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<td>Ridesharing and the “gig economy” redefine vehicle ownership</td>
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<td>Demand impacts likely to vary by market</td>
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<td>Autonomous vehicles transform transportation</td>
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<td>Massive step change in fuel efficiency balanced by increased VMT</td>
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<td>Digitalization results in step change improvements in refining operations</td>
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<td>Increasing level of operational sophistication drives margin advantage for “smart” assets</td>
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<tr>
<td>Crude to Chemicals scale overwhelms the downstream demand</td>
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<tr>
<td>Co-incident with increasing recession risk</td>
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Alan Gelder

VP Refining, Chemicals and Oil Markets
Downstream Global Content Lead

Biography

Alan is VP Refining, Chemicals and Oil Markets. As Downstream Global Content Lead, he is responsible for formulating Wood Mackenzie’s research outlook and integrated cross-sector perspectives on this global sector.

Alan Gelder joined Wood Mackenzie’s Downstream Consulting team in 2005 and became global head in 2009. He transitioned into research upon his return from Houston in 2011 and was Global Head of Refining and Chemicals.

Prior to joining Wood Mackenzie, Alan had 10 years of industry consulting after working for ExxonMobil in a variety of project planning and technical process design roles.

Alan has a first class Master Degree in Chemical Engineering from Imperial College, London, supplemented by an MBA from Henley Management College.
Gordon Haire

Head of Aromatics, Wood Mackenzie Chemicals

Biography

Based in the UK, with over 30 years experience in Petrochemicals in both Commercial and Technical roles.

In a previous career with BP spanning over 20 years, Mr Haire had commercial roles in Aromatics including Global Paraxylene Strategy, PX/PTA Business Development and Strategic Procurement of both PX and Mixed Xylenes. He has held major Manufacturing Management roles at BP’s PTA/PX site at Geel, Belgium and at the integrated Refining/Petrochemicals complex at Grangemouth, Scotland and taken part in various Manufacturing benchmarking exercises.

He has significant experience in Refining/Petrochemicals optimisation and in Paraxylene production economics and technology evaluation.

Mr Haire leads the Global Aromatics Research team for Wood Mackenzie Chemicals.

Mr Haire has a B. Sc. in Chemical Engineering, University of Strathclyde.
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