Paraxylene is a key petrochemical intermediate used in the production of synthetic fibres and PET resins, which are used respectively in textiles and packaging applications such as polyester fabrics and fleece, water and soft drink bottles, films and thermoformed containers. Since its introduction in 1941, PET market demand was slow to grow, with only 1.75 million t of demand by 1970. However, polyester fibre and PET resin have been gaining strong market acceptance recently thanks to their superior technical performances coupled with economic and environmental sustainability. In 2014, demand for polyester reached 47 million t, making it the most commonly used synthetic fibre worldwide. In the same year, 22 million t of PET resin was consumed.

Polyester and PET resin are produced by polycondensation of purified terephthalic acid (PTA) and monoethylene glycol (MEG). MEG is derived from ethylene, while PTA is produced by oxidising paraxylene. Paraxylene demand, which is driven by the markets for polyester fibre and PET resin, almost doubled over the last 10 years and reached nearly 37 million t in 2014. It is projected to grow by approximately 6% CAGR over the next 10 years. This growth in demand has attracted significant investments by refiners, petrochemical producers and new investors.

Investment in paraxylene capacity has traditionally been cyclical, characterised by periods of overbuild when supply gets tight, followed by a subsequent drop in asset utilisation rates down.
The spread between paraxylene and naphtha is a leading indicator of industry profitability. The cyclicality of the paraxylene market is shown in Figure 1, which shows the correlation between profitability with the average operating rate of the global installed production base. The building cycle of new units coincides with the low operating rate of paraxylene assets.

In recent years, this phenomenon has been even more pronounced as technology evolution has enabled the installation of single train paraxylene production units in excess of 1.5 million tpy. Figure 2 shows the evolution of single train capacity.

Although recent crude price volatility has created uncertainties in the refining and petrochemicals industry, this does not have a direct impact on the paraxylene to naphtha spread, which is mainly determined by supply and demand market dynamics.

In 2014, approximately 8 million tpy of new paraxylene capacity was commissioned mainly in Northeast Asia to support the local textile industry in China. This is more than a 20% increase in production capacity over the installed base in a single year. China currently accounts for approximately 50% of the worldwide paraxylene demand, and the addition of this new capacity is putting downward pressure on the profitability of the paraxylene industry.

In the paraxylene industry, it is critical to start a new project during the downcycle to be able to take full advantage of the market as soon as paraxylene supply and demand balance becomes tight again. This requires foresight and some risk tolerance to make the investment decision when industry profitability is low and access to financing is more difficult.

The realisation of a world scale aromatics complex for the production of paraxylene is quite capital intensive. The ability to minimise investment costs greatly improves the chances of securing financing over competing projects, even in tight market situations.

Access to cost competitive feedstock

For a naphtha based aromatics complex, feed represents approximately 80% of paraxylene cash cost of production (Figure 3). Access to, and security of supply to cost competitive feedstock is critical to ensure the success of a new investment, and can be a substantial hurdle in the journey to secure financing. In this respect, the flexibility to process various feedstocks enables paraxylene producers to take advantage of market dynamics and source the most cost competitive feed available. However, flexibility must be balanced with higher investment and utility costs.

Use of latest technology that enables low production costs

In an increasingly competitive market, it is paramount that new investments are positioned to be the low cost producer in the
industry. Technology advancements in paraxylene production have been tremendous over the past five years, resulting in approximately US$100/t lower net cost of production of paraxylene compared to units designed as recently as 2010. Advancements in catalyst and adsorbent technologies have enabled much better capital efficiency with the ability to extend single train paraxylene complex designs beyond 2.2 million tpy. Figure 4 shows a reference schematic for a naphtha based aromatics complex using UOP technologies.

UOP’s next generation technology delivers more than a 15% reduction in installed cost of the inside battery limit (ISBL) portion of a reformate based aromatics complex. This is achieved by having 20% less equipment, substantially lower fractionation requirements and 25% less plot space. Leading engineering, procurement and construction (EPC) firms have validated and confirmed the reduction in total installed cost. The lower investment requirement not only improves the project’s internal rate of return (IRR), but it also makes it easier to secure financing.

Improved product selectivity has enabled substantially less feedstock per tonne of paraxylene produced, reducing production cost by more than US$19/t of paraxylene, as shown in Table 1.

Improved energy designs have lowered utility costs by 30% compared to a 2010 vintage aromatics complex. UOP’s next generation technology combines the latest catalysts and adsorbents with an energy efficiency design to reduce the cost of paraxylene production by more than US$42/t based on a US Gulf Cost fuel cost of US$6/million Btu, achieving the lowest cost of operation for paraxylene producers in the industry.

To help put the magnitude of the latest technology advancements into perspective, Figure 5 shows a comparison of UOP’s next generation technology versus 2009 - 2010 vintage technology. In this commercial example, the next generation technology provides a US$90/t advantage for the owner at the same IRR and provides a substantially higher statistical probability of maintaining profitable operation over the life of the plant.

Early adopters of the latest technology will enjoy a substantial competitive advantage over the large installed base of less efficient designs that bolster the market spread of naphtha to paraxylene, while firms with excessive risk avoidance return marginal performance. The recent step change advancements in technology economics are a strong driver for investors to engage in greater due diligence on technology rather than relegating themselves to the tired perspective of being the first to be fifth adopter, starting up a brand new unit that is already 7 - 10 years less competitive.

## Table 1. Catalyst and absorbent improvements

<table>
<thead>
<tr>
<th>Unit</th>
<th>Base product</th>
<th>Latest product</th>
<th>COP reduction excluding energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCR platforming process</td>
<td>R-264</td>
<td>R-334</td>
<td>US$12+/t pX</td>
</tr>
<tr>
<td>Isomar process</td>
<td>I-300/350</td>
<td>I-500</td>
<td>US$1 - 8*/t pX</td>
</tr>
<tr>
<td>Tatoray process</td>
<td>TA-20HP</td>
<td>TA-32</td>
<td>US$3+/t pX</td>
</tr>
<tr>
<td>Parex process</td>
<td>ADS-37</td>
<td>AD S-47</td>
<td>US$3+/t pX</td>
</tr>
<tr>
<td>Total COP reduction</td>
<td></td>
<td></td>
<td>&gt;US$19/t pX</td>
</tr>
</tbody>
</table>

*For complexes without transalkylation

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**Flawless and fast project implementation**

From the initial engineering design work to making on specification paraxylene, the faster an aromatics complex starts up, the faster the return on investment is realised. To quantify the impact, reducing the overall project schedule of a five year project by six months can result in upwards of US$80 - 85 million in additional net present value for a 1.44 million tpy paraxylene capacity complex. UOP has a proven track record of working with licensees and their EPC firms to meet this goal. For example, over the past
30 months, 4.18 million tpy of new paraxylene capacity based on UOP technology was brought on stream in South Korea by four leading petrochemical firms. The average project schedule for these four units was 32 months from kick off to production.

Reliable and sustained operations

UOP has licensed over 100 Parex units since market launch in 1970. 92 units are currently in operation and account for approximately 70% of global paraxylene production (Figure 6). The remaining Parex units are in various phases of design and construction.

UOP’s aromatics technology maintains greater than 97% on stream reliability. The heart of UOP’s Parex technology is the rotary valve (RV), with latest designs that enable single train operation in excess of 2 million tpy of paraxylene production. In 2015, RV systems exceeded 1600 years of operation without a single Parex unit being shut down due to an RV problem. These systems are reliable, simple and elegant.

While some of the earliest designed units are still operating with their original adsorbent and adsorbent chamber internals more than 40 years later, system designs have continued to improve to offer as high as 70% greater production from the same size asset. Reliability of the system design has proven that Parex systems do not need to be back flushed to maintain throughput on the unit, sustaining greater than 97% on stream reliability and enabling six year turnaround cycles.

Conclusion

While adsorption based paraxylene separation technology has been around since 1970, technology advancements over the past five years have outpaced every other period since its inception. Many firms have historically chosen to defer the advantages of new technology as the potential reward was not large enough to cover the perceived risk. With greater than US$100/t lower net cost of production of paraxylene compared to units designed as recently as 2010, this perspective is changing.

Unprecedented capacity additions to the market in 2014 have changed the competitive pressures for paraxylene producers, further encouraging early adoption behaviour. UOP’s new benchmark for the paraxylene industry will help ensure sustainable profitability in a world of increasing competitive pressures.