

SPECIAL REPORT ON SINGAPORE

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Singapore's chemical industry

This report has been produced by Global Business Reports. Research conducted by Lorena Stancu and Maria Filippova Barnachinskaya. For more information, please visit gbreports.com, or contact info@gbreports.com. Main cover photo courtesy of Fluke Reliability; other photos courtesy of Henkel, SUEZ and Siemens.

POST-2020 PERSPECTIVES ON THE CHEMICAL INDUSTRY

COUNTING PROFITS AND LOSSES

As new waves and new strains of the virus meet uneven vaccination programs globally, hopes for a return to a pre-Covid sense of normality fade. But, while the previous year was marked by (often erratic) reactions to unfolding events, 2021 affords clearer before-and-after-2020 perspectives.

Upstream in the value chains of most industries, the global chemical sector offers a concise comprehension of 2020: by end-market application, the healthcare, pharmaceuticals, nutrition, and electronics were the most Covid-resilient industries. Meanwhile, the automotive and aviation sectors were - and continue to be - the most immediately and severely hit by the fall in demand. Performance was also mixed across industrial and consumer lines - the furthest from the customer and more com-



Ow Kai Onn, VP & Head, Chemicals and Materials, at Singapore's government agency Economic Development Board (EDB)

moditized, the greater the impact for the price-sensitive base chemicals.

Ow Kai Onn, VP & Head, Chemicals and Materials, at Singapore's government agency Economic Development Board (EDB) shared that new pockets of opportunities are found particularly in the specialty sector: "There has been a wave of interest from MNCs looking at Covid-resilient areas like nutrition, food and beverage, hygiene products, and also electronics and semiconductor sectors."

WHAT STAYS, WHAT GOES

Regardless of the star sectorial or even geographical performers, these results are not deterministic of the outlook going forward. The main task for the industry at large will be to correctly identify what are temporary, lasting or permanent, accelerating or decelerating changes. This appraisal cannot be easy, since it depends on the success of vaccination campaigns, shifting consumer behaviors, unpredictable government reactions, and the mobilization of different verticals - be it pharma or automotive.

What's more, the full extent of the global recession and the corporate distress is not yet fully visible, salient effects creating further unpredictability. When the forbearance on loan repayments expires, subdued bankruptcies and the share of non-performing loans will indicate how far, and how deep, the marks of 2020 stretch.

Putting aside the economics, the pandemic also created a deep societal change, affecting how people work, interact, relax, spend, and what they care for. According to Accenture, 79% of consumers will seek products that are healthier and better for the environment.

Another legacy is the growing reliance on digital tools. From a "nice-to-have", digital platforms have turned into a neces-

sity. The pandemic created the perfect set of conditions to propel the use of digitalization and drive investments in automation. But digitalization may do more than allowing companies to close the physical gap created by lockdowns: "We see more enterprises pivoting into new businesses made available through e-commerce platforms. I believe the digitalization process will continue in the new business environment, driving overseas growth," said Lee Pak Sing, assistant CEO, Trade, Connectivity & Business Services at Enterprise Singapore (ESG).

In 2020, business continuity mostly consisted of reactive measures, not least with a certain degree of defensiveness; but enough time has now passed for chemical players to move into a stage of acceptance and look at long-term business continuity planning. Besides reading how Covid-19 affected balance sheets, portfolios, or global supply chains, this long-term thinking exercise also entails situating these players within a wider timeframe that positions them wisely within megatrends. With the global population set to increase to 10 billion people by 2050, the global chemical industry is supported by a strong demographic factor that secures its long-term growth. On the back of this projection, global chemical production is expected to double by 2030, as suggested by UNEP.

Overall, total global chemical revenues are estimated to have dropped by 9% in 2020, and expect a rebound of 10% this year, according to the American Chemistry Council. The bounce-back is aligned with global economic recovery; the IMF is projecting global growth at 6% for 2021, and India and China head the estimates with 12.5% and 8.4% respectively. This region stood out as the most resilient during the pandemic, and is the quickest to recover. ■

SINGAPORE'S JOURNEY

A CASE-STUDY OF TRANSFORMATION

“Little Red Dot” is Singapore’s nickname, inspired by how the small city-state appears on maps. It also goes to say that, despite its size, this is a dot of prominence on the global stage. The 20th smallest country in the world, Singapore is also the 4th richest per capita. Singapore stands at the top of the Index of Economic Freedom and Human Capital Index, as well as being the world’s most competitive economy, and second in the world for Ease of Doing Business. More remarkable is the journey underwent by the city-state to achieve this global status: “Singapore underwent a transformation in the past decades, growing from a manufacturing base into a logistics and financial hub and the smart city that it is today,” remarked Dirk Lorenz-Meyer, Member of the Board at Behn Meyer Group, the oldest German company present in Singapore.

At the time of its independence in 1965, the 700 km² island was isolated, half of its population illiterate, and not only did it lack any natural resources, but its land and water resources were heavily strained. Perhaps one of the best illustrations of how a nation can overturn its limitations and transform them into unique strengths is Singapore’s petrochemical industry: despite having no oil,



Dirk Lorenz-Meyer, Member of the Board at Behn Meyer Group



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Singapore has the fifth largest refinery in the world; it is also the world's biggest bunkering hub and busiest transshipment port. A prime example of innovative sharing of land, water, and energy is the country's emblematic Jurong Island, the manmade island resulting from successive land reclamation works and the amalgamation of seven offshore islands. This serves as an integrated petrochemical complex and the home of the country's chemical industry.

Today, almost 100 chemical companies congregate on the island. ExxonMobil's Jurong Island refinery is the company's largest in the world, with a capacity of over 500,000 barrels per day (bpd). Together with the two other refineries operated by Shell and Singapore Refining Company (SRC), the country boasts a refining capacity of 1.5 million bpd. Together with pharmaceuticals, chemicals are the largest contributor to the country's manufacturing sector - which accounts for 21% of the country's GDP, according to the Economic Development Board (EDB).

But big changes are underway. Singapore's first refinery, Pulau Bukom, operated by Shell, will have its capacity reduced by half over the next two years, and it will be transformed into one of Shell's six Energy and Chemicals Parks globally and the only one in Asia: "Bukom will pivot from a crude-oil, fuels-based product slate towards new, low-carbon value chains," Andreas Krobjilowski, general manager of Shell Singapore (Jurong Island) told GBR.



Arun Nair, Managing Director, Fluke Reliability APAC

FORWARD TRANSFORMATIONS: GREEN & SMART NATION

In 2021, the government unveiled the Singapore Green Plan 2030, charting ambitious goals for its sustainability agenda. As part of reaching these goals, Singapore will require that all car registrations be cleaner-energy models from 2030. In the food space, the country's 30/30 strategy aims to secure 30% of national nutritional needs locally by 2030. Whether it is reducing internal combustion engine (ICE) cars or the impetus on waste processing technologies, these developments directly or indirectly involve the chemical industry.

The vision of a Green Nation closely coexists with that of a Smart Nation, launched back in 2014. Singapore is already considered one of the smartest nations in the

world, but it continues to advance forward-looking initiatives. Under the Energy and Chemicals Industry Transformation Map (ITM), announced in 2017, the Singaporean chemical industry is encouraged to boost productivity and diversify into higher-value products like elastomers, styrene-butadiene copolymer, or ultra-high molecular weight polyethylene (PE).

"Countries like Singapore are reaching towards the concept of 'Smart Nation', but what makes it a truly smart nation are the people and their know-how," commented Arun Nair, Managing Director, Fluke Reliability APAC. Not a cheap manufacturing base, Singapore's competitiveness comes not only from its well-developed digital infrastructure, R&D capabilities, and strong IP system, but also from a highly educated and diverse workforce.

FUTURE-READY IS CLIMATE-READY AND DIGITAL-READY

The chemical industry tends to look at the 2008 crisis as the closest comparison to today's environment. According to KPMG research, businesses that did well before the 2008 crisis did not necessarily do well afterward. A big disruptor like the pandemic creates profound change and expects nothing short of profound change to stay relevant and competitive.

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Joseph Lee Ching Hua, Head of Co-Innovation Centre & General Manager of Development Centre, Yokogawa Southeast Asia

ity projects. Arkema chose Singapore to build its bio-based polyamide plant. The investment, amounting to €300 million, is one of the first green bonds placements issues by a chemical company, and it was oversubscribed by 10 times. The project will double Arkema’s bio-based high-performance polymers and is due to be complete in 2022. Neste, the world’s leader in biodiesels, also picked Singapore to make the biggest single investment in the company’s history. The €1.5 billion investment will grow Neste’s global production capacity of biofuels by 1.3 million mt/y, bringing it to a total of 4.5 mt/y by 2023.

In anticipation of greater demand for green plastics, the world leader in green PE, Braskem, is tripling its 200,000 mt/y capacity at its Brazil facility. “Braskem began bio PE production 10 years ago, and we are scaling up to be prepared for a buoyant demand in the next decade,” said Roger Marchioni, Asia director for chemicals and polymers, Braskem.

Though currently Europe and Japan are the main markets driving bio-polymers production, Marchioni believes more countries, including Singapore, South Korea, and China will become increasingly more open to renewable polymers that will help them reduce GHG.

Preparation for a lower-carbon, smarter future also unravels through investments in digitalization and automation. Evonik inaugurated its Digital Labs Asia in 2020, designating a team of scientists to study AI and advanced digitalization.

With about 80 of the world’s top 100 technology companies present in Singapore, the opportunities to spur digitaliza-

tion and automation have been present for longer; what changed since last year is the pace of adoption. Yokogawa, a leading engineering and software MNC, opened the first-of-its-kind Co-Innovation Center in Singapore, and the largest outside of its Japanese headquarters: “Two years ago, Yokogawa started the digitalization (DX) journey through our Co-Innovation Center together with several regional customers, yet the uptake was slow as the indus-

try tends to adopt a ‘wait and see’ attitude. However, Covid-19 acted as a powerful catalyst to what a fully autonomous future can look like. In our most recent survey, 80% of respondents in the manufacturing business argued that they expect to see their companies fully autonomous in the next 10 years,” said Joseph Lee Ching Hua, Head of Co-Innovation Centre & General Manager of Development Centre, Yokogawa Southeast Asia. ■

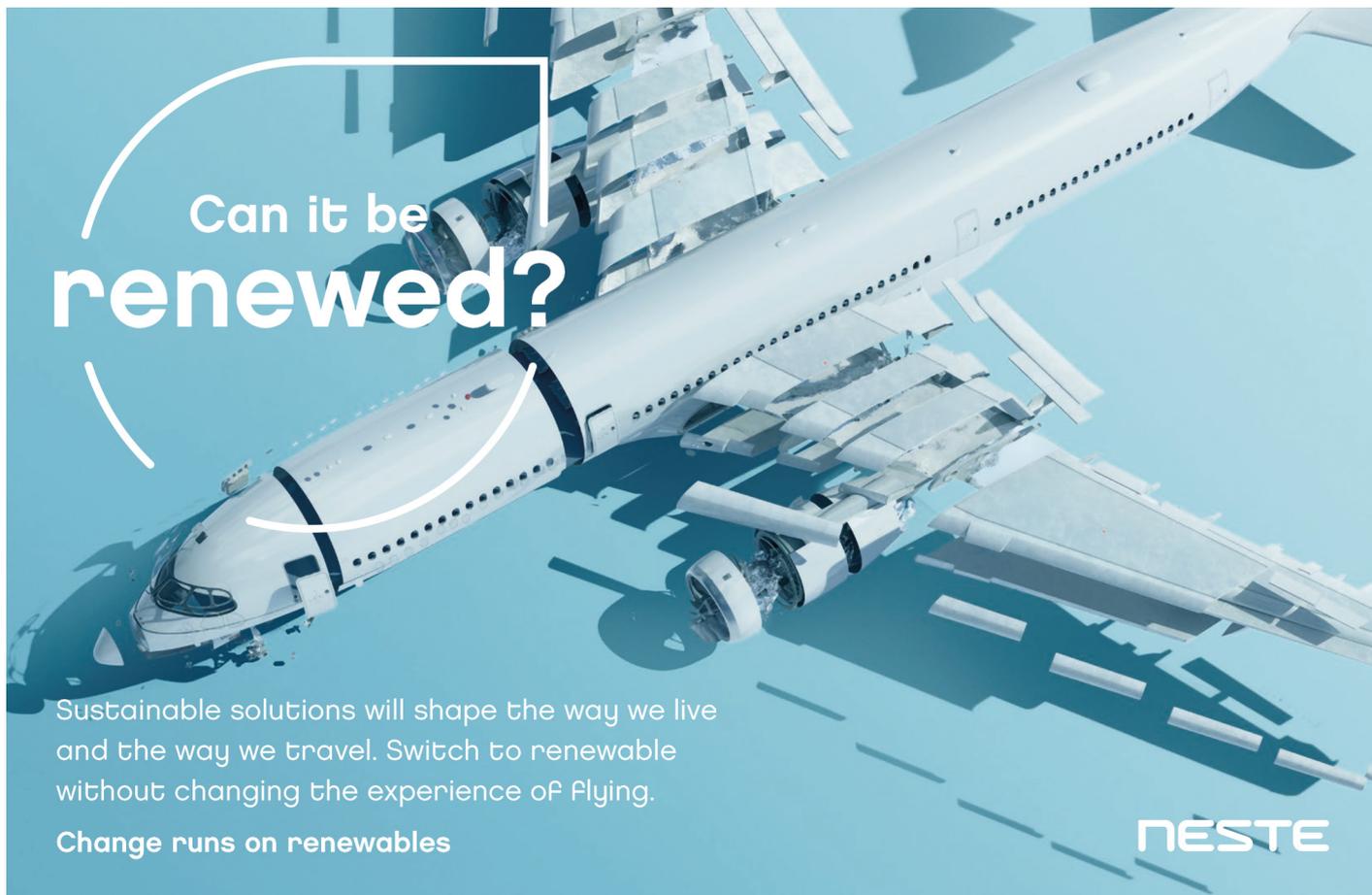
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PORTFOLIO RECONFIGURATIONS

MOVING UP THE VALUE CHAIN

Hosting total investments of over S\$50 billion, Jurong Island works as a plug-and-play integrated system feeding more than 100 chemical companies via a pipeline network. Though the island also produces advanced formulations, Singapore is still largely an upstream and middle-stream chemical sector, producing feedstocks, intermediates, and derivatives. To circle the full value chain, the next step for the industry will be to grow its downstream segment.

In many ways, growing the share of higher-value products is a natural progression for Singapore. In the 80s and 90s, oil and gas giants dominated the industry. ExxonMobil, for example, started its first cracker on Jurong Island 20 years ago, marking its entry into the chemical space. Last year, however, the company announced a multi-billion-dollar invest-

ment to convert fuel oil and other crude raw materials into higher-value lubricants base stocks and distillates, a project expected to be complete in 2023.

Many specialty chemical heavyweights have now established a base in Singapore. BASF, the world's largest chemical player by sales, operates four production facilities in Singapore, as well as a nutrition and health (Newtrition) lab for the APAC region out of the city-state. Evonik Industries, a leading specialty player, has four plants in Singapore, including two specialty chemical plants in Tuas. Back on Jurong Island, Solvay operates the largest specialty alkoxylate surfactants plants in APAC.

The availability of feedstocks on the island and the connectivity between different players give rise to advantageous synergies. For instance, Linde's investment of US\$1.4 on Jurong Island will quadruple the company's capacity for hydrogen and syngas; most of the surplus will be sold to its neighbour on the island, ExxonMobil. This will be the single largest investment in Linde's history.

At the same time, Singapore must develop a value-driven chemicals model alongside its volume-based traditional pet-

rochemicals business. 2020 brought some hard-hitting headlines in the petrochemical space. Shell's restructuring away from hydrocarbon dependency came with 9,000 job cuts worldwide, as announced last September. ExxonMobil, responsible for over US\$17 billion in fixed asset investments in Singapore, will also let go of around 300 people in the country by the end of this year.

Meanwhile, prospects in non-cyclical specialty chemicals are ripe for growth. According to Research and Markets analysis, the global specialty chemicals market will grow at a 6.5% CAGR between 2020 and 2024. More specifically, demand for electronic applications, biodegradable products, and construction lead growth projections. APAC takes 36% of this market by revenue, of which China alone accounts for 40%.

"In 2021, many players have been rethinking their portfolios to capture a greater share of the specialty chemicals in an attempt to balance the negative yield on basic chemicals," Apparao Myneni, strategic industry manager at SICK Sales and Service (SICK AG), observed.

MCAP (Mitsui Chemicals Asia Pacific), for example, currently dedicates 90%



Shamsheer Zaman, Managing Director, Linkers Far East (LFE)

of its APAC portfolio on the mobility and food & packaging sectors, but is looking at healthcare and R&D investments for its next-gen business growth: “Over the years, we have progressively diversified our portfolio from a petrochemicals-base to specialty chemicals like specialty polymers and healthcare ingredients, ramping up production in these two categories,” said Ikunori Sakai, CEO of MCAP.

In the distribution space, German player HELM Asia wants to balance off its portfolio in petrochemicals, such as methanol, glucose, styrene and propylene, with more intermediates and performance chemicals, with an eye on the surfactants market. Similarly, Linkers Far East (LFE), traditionally focused on commodities, is diversifying its portfolio to be present in both segments: “Ideally, we would like to have a mix of commodities and specialty chemicals, and we started by introducing special additives for plastics and other performance chemicals used in rubber, paints and coatings,” said Shamsheer Zaman, Managing Director, Linkers Far East (LFE).

CONSOLIDATIONS AND CARVE-OUTS

Chemical deals amounted to about US\$37.7 billion in 2020, compared to the US\$182 billion in 2019, Young & Partners reported. Travel bans and complex pricing scenarios slowed M&A activity last year, but returning business confidence with the rollout of

the vaccines and economic restart, as well as a promising borrowing regime, allow M&A transactions to make a strong comeback in 2021. Paul Kau, EHS technical director for Asia at Golder, explained: “The stimulus injected by economies around the world, together with low interest rates, led to increased liquidity in the market, which drive M&A activity as stressed chemical companies, amongst others, seek support through market consolidation.”

Companies in specialty chemicals, particularly in flavors and fragrance, personal care, healthcare, or water filtration technologies, command high multiples and positive arbitrage as they are highly sought after. At the opposite end, assets in the fertilizers, lubricants and additives, as well as paints and coatings marketplace, are more prone to consolidation.

One prominent trend that is likely to encourage M&A activity is the preference for pure-play. Marking a re-commitment to core assets, carve-outs have been popular. BASF sold its pigments division in Europe to DIC Group: “DIC and BASF



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are global leaders in this sector. The acquisition, valued at €1.15bn, will synergize our portfolio and support our vision to ‘color’ the world,” Paul Koek, Managing Director, DIC Asia Pacific.

BCG.com analysis found that focused-specialty companies do better in terms of TSR (total shareholder returns) compared to multi-specialty companies. The same source indicates that commodity chemical players saw double-digit TSR losses in the first half of 2020. Indeed, in the petrochemical space, pure-play petrochemicals were less impacted by the pandemic compared to integrated oil supermajors, many of whom have still not seen their share price recover.

“Everyone needs to choose their battles,” said Raymond Sinnah, President of Mineral Specialties Division, SEQENS GROUP. Sinnah highlighted that common trends like sustainability and digitalization affect the commodities and specialties segments differently: “Typically, for commodities, cost position and cash flow are detrimental; fluctuations in the price of crude oil and taxation of CO₂ emissions announce bigger financial hits in this sector. In specialty chemicals, there is a growing focus on more diversified products, more value chain integration



Raymond Sinnah, President of Mineral Specialties Division, SEQENS GROUP

(and moving downstream), and thinking ‘solutions’ instead of products.”

This philosophy is notably popularized by Arkema, which announced its intention to become a 100% pure specialty player by 2024. The company will pursue targeted divestments and acquisitions as part of this strategy, having already divested its PPMA (poly-methylmethacrylate) business to Trinseo. Danny Foong, general manager at Arkema Singapore, told GBR that the company will be focusing on six main platforms hereon: bio-based products, new energies, water treatment, electronic solutions, lithium-ion materials, and home efficiency & insulation.

Brenntag also marked this differentiated approach, by unveiling a new company structure in 2021. Brenntag Essentials and Brenntag Specialties will be operated as two separate businesses. Henri Nejade, COO of Brenntag Specialties, explained the rationale behind the move: “While the specialty sector requires a more customer-focused approach, basic chemicals call for a more product-and-service-oriented approach, with a high focus on logistics for the management of large volumes.”

M&A IN THE DISTRIBUTION SPACE

Faster to react to market changes, including higher demand for healthcare or food ingredients, distributors bought and sold with confidence in 2020. As the market moves towards greater consolidation, high-value distributors with a footprint in tiger-growth markets or key growth segments like healthcare were the most coveted. Brenntag acquired the largest Chinese food and nutrition ingredients distributor, Zhongbai Xingye, for a total of €90 million, as well as UK-based water treatment distribution company ICL Packed.

In 2020, Azelis made two major acquisitions in personal care in China, one in the pharma space in India, and one in food ingredients in Indonesia. This year, the global specialty chemicals and food ingredients distributor also completed the acquisition of CW Pacific in Australia in the food space and announced acquisitions in Vietnam and the Philippines focused on personal care and CASE (coatings, adhesives, sealants and elastomers). Present in 50 countries, Azelis has doubled its business in APAC in the last five years, pursuing an agile and aggressive inorganic strategy.

DKSH Performance Materials also steered forward its M&A activity in 2020, acquiring specialty chemicals distributor Axieo, thereby deepening its presence in Australia and New Zealand. Distribution assets in the food and agriculture space also spark commensurate interest. Singapore’s Behn Meyer is scouting prospective AgTech (agriculture technology) and alternative protein technology start-ups in the agriculture-feed-food full value chain for acquisitions or partnerships. Rather than taking part in the typical petrochemical Jurong Island business, Behn Meyer seeks to become an integrated life-sciences company. ■

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A CLOSER LOOK AT THE PETROCHEMICAL SECTOR

STEADY FUNDAMENTALS

If specialized, downstream investments are Singapore's preferred growth trajectory, the petrochemical sector remains the bedrock of the industry and provides the material conditions for the specialty segment to develop. As Wim Roels, the CEO of Borouge, stated: "We still need ethylene, propylene, and other base materials to produce advanced chemicals."

The ubiquity of plastics used in construction, healthcare, or packaging support demand for the petrochemical industry. Globally, the industry is expected to grow at a CAGR of 5%, to a projected value of US\$651.1 billion by 2027, based on data from Grand View Research. Half of the petrochemical market by volume is found in APAC, China, India and Japan leading basic polymer demand. According to McKinsey, China has contributed to about half of the growth in the chemical sector in the past two decades. China also accounts for over 40% of chemical output, based on the same source. South China Morning Post reported in 2020 that China is building at least four mega refineries with a crude-processing capacity of 1.4 million bpd – almost the equivalent of Singapore's total capacity today. In India, the expansion of Reliance petrochemical refinery has almost halved India's need for imported glycols, and more production facilities are in the pipeline to increase the country's self-sufficiency.

Sudheer Vijapurapu, managing director at New Asia Shipbrokers (NAS) is worried about these developments: "There will be fundamental shifts as the world's largest consumers, like China and India, are becoming increasingly self-sufficient, focusing on backward integration of their plants, building



Wim Roels, CEO, Borouge

grassroots refineries, and importing the cheapest oil rather than relying on imports of processed chemicals."

However, while China may eventually balance supply and demand domestically, India is far from achieving parity. Also, Southeast Asia's 655 million people are a significant market that Singapore is well-positioned to serve. In the heart of APAC, Singapore's high standards of governance, world-class infrastructure, favorable business climate, and great connectivity with the rest of the region differentiate the country from its Asian competitors. As long as Singapore continues to assert itself along these strengths, the country's petrochemicals sector sees steady fundamentals.

Methanol

As one of the most important intermediate petrochemical products, methanol had a good 2020, even though higher supply has reduced the price of the product, hampering revenues. The methanol market is projected to grow at a CAGR of 5.5% between 2020 and 2025.

Mark Berggren, the CEO of Methanol Market Services Asia (MMSA), an independent consultant founded in 2004 in Singa-



Singapore Integrated Manufacturing Complex. Photo courtesy of ExxonMobil Asia Pacific.



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pore, shared with GBR that the production of olefins (like ethylene, propylene, and butadiene) from methanol has been a strong growth pillar for the methanol markets, especially coming from China. MTO (methanol-to-olefins) is the third-largest and fastest-growing derivative segment in the market: “Methanol has become the world’s most important base petrochemical. It has taken a great journey of both greater scale and wider application beyond its traditional uses, including blending into gasoline, converted to dimethyl ethers which are then blended into LPG, as a feedstock to make ethylene and propylene, and as an alternative fuel to produce biodiesel,” said Berggren.

Acetic Acids

Moving down to acetic acids, a derivative of methanol, the negative impact of 2020 on the price is likely to linger through the first half of 2021, said Harvey Zhao, senior commercial director, Acetyl Chain Asia, at Celanese. Zhao told GBR that “tiger” growth seen especially in some Southeast

Asian countries has helped the market overcome oversupply: “The acetyls value chain, from acetic acids to VAMs, emulsions and the powders business, is undergoing a process of restructuring. About seven or eight years ago, the market was characterized by capacity build-up, especially driven by China, which resulted in low profitability for a couple of years. However, the industry grew out of that saturation.”

Polymers: PE, PP, PC

For ethylene, the feedstock for the synthesis of derivatives like polyethylene (PE), ethylene oxides, or styrene, supply has been mounting, coming especially from Middle Eastern producers who benefit from crude oil and gas abundance. However, the oversupplied PE market is gaining momentum thanks to plastics demand in packaging and healthcare. Similarly, another basic polymer, polypropylene (PP), is expected to grow at CAGR 4% between 2020 and 2027.

Geraldine Chin, the chairman and managing director of ExxonMobil Asia Pa-



Geraldine Chin, Chairman and Managing Director, ExxonMobil Asia Pacific

cific, told GBR that demand for surgical gowns, masks, and the use of non-woven PP grew significantly during COVID-19, driving demand for PP: “At its peak, our team in Singapore reconfigured our production capabilities to be able to manufacture enough polypropylene non-wovens to support the production of an additional 300 million masks a month.”

SABIC similarly noticed higher demand not just for PP products used in making disposable gowns, masks, shields, coveralls, or intensive care equipment, but also for polycarbonate (PC), with application in Covid-19 test kits.

By the end of 2021, Borouge, the integrated polyolefin company with both PP and PE solutions, will be inaugurating a new PP plant to bring its total output to 5 million mt/y. The company invests in innovation as much as it does in capacity infrastructure: “In 2020, we launched a new LLDPE (linear low-density polyethylene) solution called Anbiq™ for flexible packaging and we also launched a new pre-compounded PE100 grade developed for drinking water pipes in China,” said Wim Roels, CEO at Borouge.

Roels expects growth in the infrastructure sector, as plastic-based water and gas pressure pipes are replacing the typical zinc and copper ones. In the agriculture sector, more sustainable solutions, such as irrigation pipes that afford greater water efficiencies in rice paddy fields, are also in demand. Borouge’s “differentiated products at scale” stratagem captures well the need for the plastics industry to tailor to specific trends, while also allowing for economies of scale. ■

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A CLOSER LOOK AT THE SPECIALTY SECTOR

INNOVATION ACROSS VERTICALS

The high-end version of the chemical supply chain, the specialty chemicals sector supplies products that are the closest to the consumer. Globally, this is a saturated, mature and highly regulated market, susceptible to fluctuations in raw material prices and regulatory developments. With all these factors outside of the industry's control, what chemical players can do best is tailor solutions for their customers, offer competitive sustainable products, invest in their channels to the market and in horizontal integration to improve their market position.

Pharma and healthcare

From plastics and latex to pharma active ingredients and medical gases, the chemical industry has been heavily involved in responding to the healthcare crisis triggered by Covid. For instance, Croda is one of the excipient suppliers for the Pfizer vaccine, while Linde supplies oxygen to medical units, and Cariflex is a global leader in isoprene rubber latex used in medical closures and surgical gloves.

Precedence Research expects the pharma chemicals market size to almost double in the next decade from a global value of US\$104 billion in 2020 to US\$197.4 billion by the end of 2030. Also, the growing awareness of healthy lifestyles will be driving the nutraceuticals additives markets, while compulsory mask-wearing is expected to continue in the next couple of years, driving demand in the polymers space.

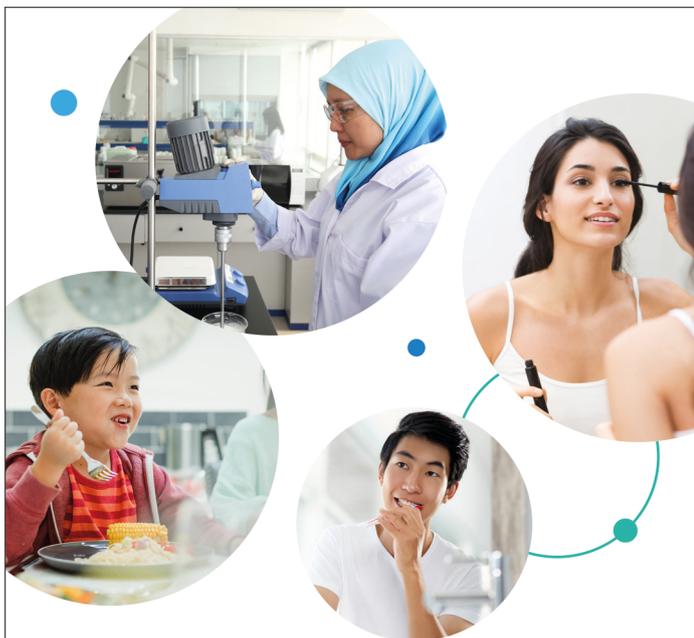
Home and personal care

Lockdowns had a big impact on consumer behaviors in the home and personal care segment, changing attitudes around hygiene, as well as shifting beauty rituals. Nevertheless, global demand for surfactants used in cosmetics and personal care products is expected to see healthy growth, supported by low prices and recovering consumer demand. The APAC surfactants market, with the largest application in detergents, soaps and cleaners, is poised to reach US\$7.83 billion by 2027, at CAGR 5.4%, according to Data Bridge Market Research.

"APAC is the world's biggest market for personal care and the home of many innovative beauty trends such as K-beauty (Korean), J-beauty (Japanese), C-beauty (Chinese), or the Ayurvedic beauty culture in India, each gaining more currency worldwide," shared Laurent Nataf, CEO & President Asia Pacific, Azelis.

Food and nutrition

Although the pandemic disrupted food supply chains, the outlook for the food industry is unchanged; food is the most basic need for a growing global population. The global food ingredients market expects growth at CAGR 7.8% between 2019 and 2027, of which APAC is the biggest market, according to Research and Markets. These projections give MNCs a great incentive to focus on the segment.



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Shirley Qi, President, Southeast Asia, Australia & New Zealand (SEAANZ) & Head of Nutrition and Care division, APAC, Evonik Industries

Shirley Qi, the new president of Evonik in the SEEANZ region, hinted that four out of six innovation growth fields for the company are in the life-sciences business: sustainable nutrition, healthcare solutions, advanced food ingredients, and membranes, completed by cosmetics and additives. “Our innovation strategy is heavily focused on biotechnology and is shaped under a sustainability mindset,” she said.

Electronics

In the electronics space, the pandemic left a mixed picture. Store closures and the slowdown in the automotive sector are levelled out by a boom in demand for data centers and other commercial infrastructure, as well as the heightened use of home electronics.

CMC Materials, the former Cabot Microelectronics, is a leader in consumable materials supplied primarily to semiconductor manufacturers. Kuo Chun Wu, global business director at CMC Materials, told GBR the semiconductor industry had a very good 2020: “(Growth) has been driven by demand from smartphones as 5G launches globally, as well as recovering automotive and industrial sectors. There are also additional signs of recovery in memory with both DRAM and NAND customers running at high capacity utilization.”

Owing to China’s dominance in electronics production, APAC holds a value share of 46.8% for electrical and electronics products, with many of the semiconductor manufacturers producing in the region.

Automotive

The automotive industry was already fretting about the economic slowdown and lower demand in 2019 while handling more stringent environmental pressures and adapting their portfolios for the EV transition. The pandemic brought a big blow to this sector in the first half of 2020, but the first signs of recovery are there. Sean Spencer, VP and MD, Afton Chemical Asia Pacific, an additive technologies supplier for lubricants and fuels, noted encouraging trends: “Demand for passenger car utilization is growing at a faster-than-expected rate, people making less use of public transportation and increased domestic travel as international flights became unavailable.”

The EV market is the fastest growing segment in the automotive space, posing new challenges to chemical suppliers. John Hong, Asia Pacific sales director at Infineum Singapore, believes the EV industry will entail radically different requirements for the chemical company. While mobilizing its R&D to prepare for this upcoming

future, Infineum’s commercial arm braces for positive growth in the traditional lubes and fuels additives industry: “This is certainly not a sunset industry and the outlook for the next five to 10 years is for strong and sustained growth. However, lubricants need to evolve to meet pressures for lower emissions,” said Hong.

Packaging

The packaging industry fosters growth in both the paper and pulp chemical industry and plastic additives. Innovation in the packaging industry is motivated by higher demand for sustainable packaging as well as greater safety and hygiene requirements. Innovating to support its customers in meeting their sustainability goals, Buckman, a global leader in the pulp and paper industry, introduced to the market a fiber modification enzyme technology through which papermakers can use less fiber. In the plastics space, Borouge is working on innovations around increasing the recyclability of its plastics by simplifying their composition to mono-materials. ■

DIC

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PASSION FOR TRANSFORMING

SINGAPORE, THE HUB

FROM SINGAPORE, TO APAC, TO THE WORLD

10 years since first opening its office in Singapore, Brazilian petrochemical leader Braskem decided to change its organizational structure this year to make Singapore the hub for the region. Rather than shipping from Brazil to APAC using traders and distributors, the company will now use the Singapore port to ship into the region, significantly reducing its lead times and time-to-market. A shipment from Singapore to China, Malaysia or Japan will take under a week.

A stable and low-risk tax haven with easy access to the region, Singapore acts as a supply chain hub and regional HQ for chemical MNCs from Europe, the US and Japan, which blend in with a rich local services and innovation ecosystem. After Shanghai, Singapore is the world's largest transshipment hub, with over 30.9 million TEU (twenty-foot equivalent units) of cargo capacity handled in 2019. For companies like SABIC, Singapore and Malaysia transshipment hubs manage 75% of the company's product volume in Asia.

As more countries develop their chemical industries, the value of Singapore as a regional hub could dilute over the years – yet, there are also strong arguments against this threat: The higher the export capacities of other nations, the greater the need to aggregate will become, suggested Bill Bryant, MD APAC & MEA at Stolt-Nielsen. Singapore lends itself as the best all-around hub candidate, said Bryant: "Other locations may offer a lower-cost environment for operations, but Singapore offers unrivalled ease of operations and of doing business from a tax, regulations, banking and legal perspective."

Asia remains the most important export market for Singapore's chemical industry. China accounted for 14% of Singapore's chemical exports in 2018, while Korea, Japan, Indonesia, Thailand, Malaysia and India together represented 34%. ASEAN (Association of Southeast Asian Nations) is seen as one of the next growth opportunities for the industry, with countries like Vietnam and Cambodia growing at over 7% GDP before the pandemic.

Singapore is perfectly positioned to tap into APAC's multi-billion market, not just by virtue of its focal geographical location, but also thanks to the country's open trade policies, transparent rule of law, pro-business tax system, and ease of doing business. Setting up a new business in Singapore takes 1.5 days, according to the World Bank Group.

In 2020, Singapore launched its variable capital company (VCC) scheme to allow for an easier injection and withdrawal of funds, as well as easy segregation of assets for tax purposes, to attract more businesses to place their funds in the country. Such policies have earned Singapore the nickname of "The Switzerland of Asia," turning the country into a magnet for FDI. According to the World Investment Report 2020, Singapore is the world's fifth-largest recipient of FDI inflows, after giants like the US and China.

Though the pandemic brought business travel to a halt, limiting international ventures, this has not stopped some players

from setting foot in new markets. German distributor HELM Asia, operating from a Singaporean regional head office, established a new distribution company in Thailand in 2020, to strengthen its position in ASEAN and respond to one of its partner's needs for a local distributor in the country: "We successfully obtained the necessary approvals and permits, as well as hiring the team and setting up local logistics infrastructure, all done remotely and in less than eight months," said Daniel Loh, managing director and Head at HELM Asia.

(MORE) OPEN-TRADE

Compensating for a small domestic market and a limited workforce, Singapore is one of the most open economies in the world, engaging in Free Trade Agreements (FTAs) with over 20 countries. Its biggest trading partners are China (13.8% of total exports), followed by the US, Europe and Southeast Asia. Nevertheless, when counted as a whole, 71% of Singapore's trade is intra-Asian.

Further consolidating its intra-Asian trade framework, in November 2020, Singapore signed the Regional Comprehensive Economic Partnership (RCEP) between ASEAN's 10 member states and and five dialogue partners - Australia, China, Japan, South Korea and New Zealand- somewhat controversially excluding India, who opted out.

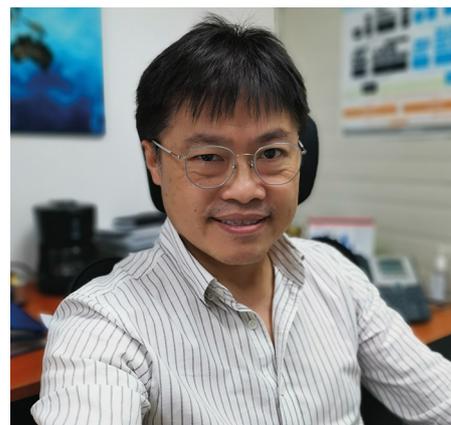
Even without India, RCEP covers a market of two billion people and represents 30% of all global trade. More interestingly, the new FTA sees ASEAN acting together in this signatory, strengthening the region's role as a fast-growing economic powerhouse. Paul Nai, general manager at Lubrizol Southeast Asia, a company that has been in Singapore since 1984, believes RCEP motivates stronger geopolitical relations: "RCEP will make ASEAN more of a unified, single market: over 650 million people, many of who are young and very aspirational, drive both volume and quality. This is a market that can grow fast."

Fortifying intra-Asian trade can also be read as a strategy to cushion against unpredictable trade inhibitors, like the pandemic or tariff wars. The WTO predicted that world trade would decline between

13% to 32% in 2020, on account of the pandemic. But even before the pandemic, the tariffs imposed by China and the US did not forgive the chemical industry, weighting significantly on price margins.

As the biggest single market for chemicals, China acts as a center of gravity for chemical producers. LyondellBasell acquired 50% in the Bora cracker and PE and PP project in China in 2020, reflecting a "producing for China, in China" approach. This "China for China" strategy has every chance to grow given the immense consumption market in China, but China can no longer win over manufacturers on a low-cost advantage. In fact, more producers are checking opportunities in Southeast Asia, which is more cost competitive.

Another factor that will contribute to a bigger shift from China to Southeast Asia is the chilling effect of Chinese policies. KPMG reported that more manufacturers are looking at alternatives in the region to ringfence China. Chemical Specialties Limited (CSL), a contract manufacturing provider based in Singapore, saw many of



Johnson Lai, Vice President, Chemical Specialties Limited (CSL)

its MNC clients with production in China considering outsourcing their production to Singapore to avoid the up-to-25% US tax on imported Chinese goods. Johnson Lai, vice president at CSL, noted that even domestic Chinese manufacturers look at Singapore as an alternative production base to bypass US fees: "Singapore is becoming an intersection not just for West-East chains, but also for East-West flows," said Lai. ■

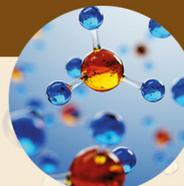


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LOGISTICS AND TRADE HUB

AFTER CHAOS AND QUIET: THE LOGISTICS SECTOR

In March 2020, Singapore was one of seven nations to issue a statement saying it will keep its supply chains open despite the pandemic. A year later, it can be said that the country stood by its promise. Container throughput for the island-state dropped by less than 1% in 2020 compared to the previous year, while cargo throughput fell by 5.8% year-on-year, mostly on account of the decline in oil cargo volumes.

Despite handling lower volumes, the second busiest port in the world was even busier in 2020, dealing with a global supply chain storm. An intermediate destination within Asia and between Asia and the rest of the world, Singapore experienced disruptions from all directions, as some coun-

tries were shutting down while others were turning their economic engines back on.

Storage suppliers came into focus in the first part of the year, as capacity build-ups for petroleum products in particular drove demand for storage. Global storage supplier Vopak operates five terminals in Singapore: Banyan, Penjuru, Sakra, Sebarok, as well as the Jurong Rock Caverns as part of a JV with the Port of Singapore Authority Corporation (PSA). Sjoerd Bazen, managing director at Vopak Singapore, told GBR that the company had to adjust to demand fluctuations; while occupancy levels for oil were higher, chemical throughputs were lower: “The pandemic has not been a walk in the park for chemical manufacturers. There have been factory closures, tensions, negotiations and, as a service provider, we are connected to each of these issues.”

Sjoerd described the situation as “showing the signs of a complete supply chain disruption.” When demand for some products became acutely low, shipowners and container companies reduced their

shipping schedules, making it difficult for chemical suppliers to secure transport.

From irregular or delayed demand to the phasing of shipments, supply chain disruptions led to big price inflations in the logistics and freight forwarding space. The price of air freight became insurmountable, while container prices rose enormously as more companies sought to restock, driving capacity build-ups. The abrupt reopening of economies further disrupted the logistics industry. Unexpected high demand saw the price for ISO tanks for multimodal transportation go through the roof. As a whole, spot freight rates were 264% higher for the Asia-to-North Europe-route, and 145% higher for Asia to the US West Coast, according to a report by supply chain risk firm Resilience360.

“We all landed in this ‘new normal’ unprepared, but thanks to existing digital infrastructure, we could overcome challenges and routinize new ways of work,” said Alexander Donau, regional head at Leschaco Asia Pacific. The company set up a working group to forecast demand trends.

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RETHINKING SUPPLY CHAINS

If one word can appropriately describe the most-tested quality for the logistics sector, that would be flexibility. The pandemic pushed these expert-problem-solvers to respond to the needs of a world shocked by how interconnected it has become.

The logistics industry learned to operate through the pandemic, but it still needs to learn the ways of a post-pandemic global supply chain, which some have dubbed “de-globalized”. The pandemic highlighted both perceived and legitimate weaknesses in global value chains; most poignantly, Covid showed how quickly events on one side of the world ripple through the global map. Before the first Covid case hit Europe, shutdowns at Chinese factories had already led to shortages for German car manufacturers. “For a while in 2020, it began to look like people understood how critical supply chains and shipowners were for the global and local economies and for day-to-day life, whether it’s transporting life-saving PPE, food, raw materials or other items,” said Gina Fyffe, CEO of Integra Petrochemicals.

Fyffe thinks the pandemic is a wake-up call for many industries that developed long and convoluted global supply chains. She believes we should see greater diversification and a shift away from prioritizing the cheapest –and often longest– supply chain; instead, the chemical and associated industries should go for geographical proximity.

De-globalization and the shortening and diversification of global supply chains have been the subject of much talk in recent months, but there are many doubts as to whether and how these could concretize.

Bill Bryant, MD at Stolt-Nielsen APAC and MEA, believes that once the tumults and traumas of 2020 have passed, the world will embrace a more realistic view of change, keeping the things that worked and letting go of other things that don’t make full sense. Bryant stressed that regionalizing supply chains is not so straightforward. While for packaged goods it makes sense to regionalize some products, chemical plants are fixed around feedstock and market requirements, so adding bulk liquid storage in more countries is not necessarily effective. More probable is that chemical companies will be switching from shipping tankers to tank containers to allow for more effective and faster management of capital. Also, some producers who relied on a single form of transport will be keener to diversify their transport modalities.

Higher interest in product localization could also benefit contract manufacturers that offer the flexibility of producing locally without CAPEX investment. Higher volumes require the remapping of production, shared Johnson Lai, VP at Chemical Specialties Limited (CSL): “The first concern of MNCs was to realize supply continuity, but the next step is to evaluate the possibility of regionalizing global footprints.” ■



EngLeong Goh, Managing Director, BASF (Malaysia) Sdn Bhd and Head of Malaysia-Singapore Business Area

SUSTAINABILITY: THE GREAT DISRUPTOR

FORCES AT PLAY

The chemical industry has a complicated relationship with sustainability. The exhaustion of mineral and organic raw materials, the release of toxic waste in waters, the planet’s inundation with plastics, all play against the industry’s reputation. But chemistry is also at the heart of responding to the environmental issues that the world faces, from feeding the growing

global population, to finding alternatives to fossils-fuels in transportation, energy, or plastics, as EngLeong Goh, Head at Malaysia-Singapore Business Area at BASF, reminded: “Chemicals are present in 95% of manufactured goods and there play a vital and enabling role in offering more sustainable solutions for a resource-efficient, carbon-neutral and circular society.”

Since the Paris Agreement came into force in 2016, 196 countries entered a legally binding document to bring global warming below 2 Celsius compared to pre-industrial levels. Individual countries set their own targets too: China, the largest GHG emitter, wants to level off emissions by 2030 and be climate neutral by 2060. The European Union and Japan targets are set for 2050.

Along with inter-governmental or national directives, chemical companies made their pledges: Producers like Lanxess and Henkel want to be carbon neutral by 2040, while Braskem and Mitsui by 2050. Since the pandemic and, serendipitously, with the turn of the decade, these targets seem to have been brought closer, calling for greater initiative and investment in the area of sustainability.

SINGAPORE’S SUSTAINABILITY MANIFESTO

Former Prime Minister of Singapore Goh Chok Tong once remarked that Singapore was probably the only country whose cabinet spent time reading gardening reports. Though a small country like Singapore has a negligible CO₂ footprint compared to other nations, the city-state is keen to become a trailblazer for sustainable development – and its ambitions closely involve the chemical industry.

According to Singapore’s National Climate Change Secretariat, Singapore contributes 0.11% to global carbon emissions. That said, Jurong Island represents about 75% to total industrial emissions in the country. Singapore became one of only 25 countries to institute a carbon tax, which will be pressuring decarbonization especially for Jurong Island players. The money generated through the carbon tax is re-invested in carbon abatement projects.

Zero-waste wannabe Singapore also set aside S\$25 million for waste-to-energy (WTE) R&D programs, working towards a circularity model that replaces the “take, use, throw” model with

a “use and reuse” one. As part of Singapore’s Sustainable Singapore Blueprint, the country aims to achieve an overall 70% recycling rate.

Singapore’s recycling ambitions are encouraged by the success in NEWater, through which the water-poor country managed to overcome its dependency on water imports by reclaiming wastewater. 40% of Singapore’s water needs are met through its five NEWater plants using

microfiltration, reverse osmosis and ultraviolet disinfection technology.

Singapore is also making important strides to shift to renewable energies, and it already ranks first in Asia for its progress in transitioning to cleaner energy, based on the World Economic Forum’s Energy Transition Index in 2020. Currently, one of the world’s largest floating solar energy systems is being built in Singapore by Sunseap Group. ■

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THE DECARBONIZATION TASK

WHAT TO DO ABOUT CO₂?

“Decarbonization” is an odd word choice when coming to think that the world is, chemically speaking, made of carbon, reminded Peter Nagler, head of the Institute of Chemical and Engineering Sciences at A*STAR. Nevertheless, CO₂ levels have become a currency for the measurement of climate change. To reduce CO₂ levels, the world will need to find and embrace carbon alternatives or different carbon sources, and process these in a way that is both energy and waste efficient.

In a context where carbon is increasingly quantified, heavy industries look at their carbon footprint more holistically, counting the significant CO₂ released during the transport of chemicals; in this sense, logistics suppliers are brought into the spotlight. Regulatory developments like the International Maritime Organization (IMO)’s greenhouse gas emissions (GGE) requirement to reduce GGE emissions by 40% between 2008 and 2030 has put more pressure on the shipping and related industry to explore alternative fuels.

THE FUELS OF THE FUTURE

Ammonia, LNG, methanol, hydrogen, and biofuels – these are the potential “future fuels” under the radar of the shipping industry, each having the potential to help shipments align with IMO regulations, and indirectly contribute to reducing the overall carbon footprint of their cargoes, chemicals or otherwise. The big question remains which of these will be brought into the mainstream since most are still at an early conceptual stage. Costs, scalability, safety, logistical aspects, but also CO₂ coefficients are considered in making these judgements.

Hydrogen aspirations

A clean fuel that only produces water when consumed in a fuel cell, hydrogen is a net-zero emissions fuel with high aspirations. The abundance of hydrogen in water, organic matter, and hydrocarbons

make it an attractive option, but difficulties around extraction and safe transportation due to its highly inflammable nature put to question its suitability for widespread use. Currently, blue hydrogen, or hydrogen produced from natural gas reforming and electrolysis, is the most common type, whereas green hydrogen made from renewable sources poses greater challenges around extraction and costs.

Linde, the world leader in hydrogen production, is investing in hydrogen re-fuelling stations (HRS), bringing the infrastructure closer to the consumer. The company believes that, once the use of carbon-based hydrogen is facilitated, the industry can work backward to make the fuel greener.

In the shipping space, green hydrogen will require world-scale infrastructure from one port to another, which is a commensurate task. Because of this, Bill Bryant, MD APAC & MEA at Stolt-Nielsen, believes that “(hydrogen) developments will realistically come through in the 2040s or 2050s.”

LNG, short-term reality

While the wide-scale use of hydrogen remains theoretical, LNG is already a reality; about 175 LNG-powered ships are operating in the world. With lower CO₂ emissions compared to other fossil fuels, LNG is considered a “bridging” fuel, and the handiest one until other GHG-free alternatives are found.

Though it is the only operational alternative fuel that can help in the race to IMO 2030 targets, LNG alone is insufficient to reduce GHG to the required level. Moreover, LNG emits methane, a gas that can be more dangerous than CO₂. Given these reasons, LNG as “transitional fuel” better describes its use as a compromise between heavier fossil fuels and green fuels.

Methanol, in the middle

If hydrogen is still too far from achieving market application, and LNG only partially answers the question of lowering GHG, methanol fits right in the middle of this equation, with better application viability, greater versatility in terms of production and uses, and a wider range to become “greener”, as it can be produced from both fossil fuels and renewables. When burned,

methanol only emits low levels of nitrogen oxide, without giving off sulphur or other particulates.

Like hydrogen, the decarbonization impact of methanol depends on its origin. Most of the methanol produced today is made from fossil fuels – gas, most commonly, and coal, in China. At the other end of this spectrum is e-methanol, generated from renewables, through which CO₂ is absorbed.

As a marine fuel, methanol is easier to handle compared to LNG, and is expected to reach parity with mainstream fuels faster than candidates like hydrogen.

With the growing usage of methanol as a marine fuel or in fuel blending, as an energy source, or as a feedstock, demand for the molecule on the rise. Following these trends, Canadian energy company Nauticol Energy identified an opportunity to supply blue methanol to Asia: Nauticol is developing one of the largest methanol facilities in the world in the natural gas abundant region of Alberta, in Canada. The Grand Prairie facility is a US\$3 bil-

lion investment with a processing capacity of 280 million cubic feet of natural gas a day, and 3.4 million metric tons of methanol per year. “The large scale capacity sets the site for global reach,” shared Mark Tonner, CEO of Nauticol Energy.

Nauticol Energy reached an agreement with Singapore-based Fortrec Chemicals & Petroleum, a commodity trading company, to market methanol in Southeast Asia and China. Michael Lambert, CFO at Fortrec sees multiple opportunities for methanol in Singapore and beyond: “Methanol could be a transition fuel and a viable greener alternative to heavy fuels for terminal operators and bunkering terminals.”

A joint report by Deloitte and Shell published last year concluded that there is no viable alternative deep-sea shipping fuel that allows the IMO’s 2030 agenda to be met. To have a shot at meeting these targets, the first net-zero ships would have to enter the global fleet by around 2030. Currently, the more feasible marine fuel options are dependent on hydrocarbons. ■

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THE SUSTAINABILITY VALUE CHAIN

OPPORTUNITIES IN A CIRCULAR ECONOMY

More than a passing trend, sustainability is an overall disruptive force creating new needs in the economy; the chemical industry has an opportunity to integrate itself along greener value chains. Take hydrogen, for example: chemical and energy companies can supply materials for electrolysis, run electrolysis plants, or provide hydrogen storage. Green chemistry can also offer solutions to the problems it is partly responsible for, for instance by commercializing plastic recycling solutions or capturing and converting CO₂ into syngas or benzene.

Climate action is creating its own economic value chain, and, like any economic contributor, it can lead to job creation and GDP growth. In Singapore, Minister for Sustainability and the Environment Grace Fu expects that agri-tech and waste management could create 55,000 new jobs in the next decade. For a sector closely tied in with the oil industry, the chemical indus-



Roger Marchioni, Asia Director for Chemicals and Polymers, Braskem

try is taking radical steps to redefine itself. British specialty chemicals player Croda already replaced its feedstocks with renewable raw materials in a proportion of 60% globally, and 65% in Singapore. In the next decade, it aims to bring this number to 75% globally. In a world exhausted by CO₂, bio-renewables such as virgin wood, energy crops, agricultural residues, municipal solid waste, and industrial co-products, and waste have become a next frontier feedstock in chemical production. However, crop-based feedstocks beg their own sustainability questions, and sometimes controversies, too. In 2019, the European Commission classified palm oil,

which is a feedstock for bioenergy, as a “high risk” crop, factoring in the loss of biodiversity, indirect land-use change, and GHG. This decision caused a backlash from palm-oil producing countries Indonesia and Malaysia, which together account for over 80% of the world’s palm oil production.

As an alternative, waste-based feedstocks do not only offer an alternative to carbon, but they also solve an additional climate challenge by bringing waste back into the economy. For Neste, waste and residues make up to 80% of renewable raw material inputs, and the company is investing to make this 100% by 2025. Known as the world leader in biodiesels, Neste is forging a presence in the world of renewable polymers and chemicals, having already built the world’s first industrial-scale volumes of bio-based polypropylene (PP) and polyethylene (PE), from liquified waste plastic: “Chemical recycling will complement conventional mechanical recycling and enable upcycling of those plastic waste streams that cannot currently be recycled, such as colored, multilayer and multi-material plastic packaging,” said Kenneth Lim, General Manager and Site Director at Neste Singapore.

The growing availability of both mechanical and chemical plastics recycling technologies have allowed petrochemical producers to introduce a greater range of green plastics to the market, whether these are recycled or made from renewables. Saudi Arabian multinational SABIC launched its Trucircle portfolio of renewable polyolefins made from recycled mixed plastic in Japan. Also in Japan, Borouge is marketing Borealis’ first renewable PP. Wanting to differentiate its sustainable food packaging products from others, MCAP (Mitsui Chemicals Asia Pacific) launched a new sustainable packaging website in 2021.

However, green plastic solutions are a small part of producers’ portfolio, reflecting the niche demand. Even if the market boomed, the availability of renewable feedstocks is insufficient for wide-scale production, and current production processes are complex and expensive. Roger Marchioni, Asia Director for Chemicals and Polymers at Braskem, thinks virgin and green plastics come with wildly distinct value propositions, which do not make them interchangeable: “Even when all three components - renewable resources, mechanical recycling and chemical recycling - are met successfully, green plastics will not 100% replace virgin plastics,” he concluded. ■

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