Catalyzing the Future
4 imperatives for chemical manufacturers
The chemical industry is embracing a digital future

Over 150 years ago, chemical leaders established an industry that quickly became the backbone of our daily lives. Large-scale chemical production was a key driver of the first industrial revolution—and since then, the industry has been a cornerstone of technological progress.

Recently, as businesses across the globe began to embrace digital processes, chemical firms were again at the forefront. They transformed their businesses, using technology to drive efficiencies while creating the blueprint for operational excellence. This transformation was a step towards embracing the principles of Chemistry 4.0—a transformative industry development driven by broad digitization and the need to address sustainability imperatives. This transformation—along with a high rate of consolidation within the industry—enabled the industry to deliver strong performance while other manufacturers struggled.

But even a few short years later, the chemical industry faces another revolution.

Customer demands are evolving at an unprecedented rate and their tastes and priorities are shifting just as quickly. As desire for more versatile products increases, addressing sustainability challenges becomes an integral part of doing business. Transparency into resource consumption will soon be an expectation for the modern customer. They will want to know where products come from, what they are made of, and what resources were used up along the way. This shift represents a tremendous challenge for chemical companies—but it is also a great opportunity.

Sitting at the head of the value chain, chemical companies are best positioned to address the challenge and demand represented by resource scarcity and environmental concerns. But they can’t do it alone.

By embracing future-facing technologies and adopting a leadership role in a global ecosystem of manufacturers, governments, and technology partners, chemical companies can proactively lead the world in embracing more sustainable economic practices. By leveraging the newfound efficiencies and capabilities future-facing technologies provide, chemical firms can rise to meet these challenges while continuing to thrive.

To assume a position of digital leadership and thrive in a modern ecosystem, chemical manufacturers must act on four key imperatives:

- Predict market trends and shorten cycles of innovation
- Enable a new level of responsiveness in production
- Embrace an as-a-service business model
- Address material scarcity in a circular economy

This paper explores each of these imperatives, outlining market drivers, how technology helps firms deliver on the imperative, and how responding to each imperative addresses the most urgent sustainability challenges facing the world.
Customer expectations continue to evolve. Improvements in services across industries have heightened customer expectations and established a culture of instant gratification. With innovative products hitting the market year after year, the appetite for advanced products has never been greater. These factors have created an environment where manufacturers across industries are expected to innovate more quickly and anticipate customer needs and demands.

But the chemical companies working with these manufacturers can no longer wait for a blockbuster chemical or material to be discovered. These companies must embrace technology to compress research and development cycles, anticipate customer needs, and develop flexible product portfolios.

**Accelerate product simulation and development**

Chemical companies must bring products to market faster. Doing so requires them to accelerate the process of experimentation. Thankfully, modern and future-facing technologies enable these manufacturers to achieve with simulation what was once only possible in wet lab testing.

Chemical companies are increasingly turning to dry lab testing as a means to accelerate product development. With the advent of high performance computing, the computer-simulated experiments conducted in these dry lab tests have become just as accurate as authentic wet lab experimentation—accounting for all necessary dependencies and conditions. By using digital twins that replicate the physical world, chemists can build models and test simulations as they would in a physical testing environment, bringing the industry ever closer to replacing wet lab experimentation altogether.

The true advantage of this method is the ability to run experiments in parallel, using machine learning to analyze the results of hundreds of thousands of experiments and determine the probability of success or suggest optimal experiment conditions. As these experiments run, they become more and more precise, enabling chemical companies to test and optimize new products in months instead of decades. This also supports sustainability goals, as simulation makes it faster to design chemicals that degrade easily, ensuring waste products are not environmentally persistent.

The primary factor preventing this form of testing from becoming even faster and more precise is a lack of available computing power. As an example, chemists have long sought new catalysts to accelerate ammonia production. A key component in fertilizers, ammonia can currently only be produced using the expensive Haber Process, which has been in use since the first half of the 20th century. Using present day conventional computing power, discovering a more efficient replacement for this process could take centuries.

**Example: Syngenta**

Using its trademarked Enogen genetic biotechnology, Syngenta develops seeds for ethanol plants with key traits such as water optimization—Enogen-enabled efficiencies in corn can save a 100-million-gallon plant 68 million gallons of water and 10 million kilowatt hours of electricity. Syngenta uses Connected Services to monitor the growth of Enogen-based seeds on behalf of its customers, provide recommendations and advice, and provide insight that their customers can use to optimize their own businesses. Learn More.

“The Syngenta approach to digital innovation is—and always will be—rooted in providing value to our customers: the farmers who produce crops and the resellers and channel partners who advise them.”

Bill Danker
Head of Seeds Research and Breeding, Syngenta

“In the past, we could deliver an update maybe every four months. But now [with Azure], we can develop new color technology and release it within three weeks. It’s a really big change compared to the past.”

Pim Koeckhoven
R&D Manager Color, Performance Coatings, AkzoNobel
Innovations in quantum computing, however, hold the promise to solve this longstanding challenge. Able to perform millions of different calculations in a single moment, the speed and power of these computers enables chemical companies to tackle problems in our lifetime that were once considered impossible.

**Get ahead by predicting future trends**

As customer needs evolve, it is not enough for chemical companies to simply accelerate development. In a rapidly changing marketplace, even an accelerated research and development process can prove inadequate if those efforts are targeted at meeting the needs of today. To stay ahead of demand, these companies need to accurately forecast the needs of tomorrow. But how can chemical companies see into the future?

Modern technologies such as machine learning use complex algorithms to interpret historical data and identify patterns of demand for products. As this technology becomes more sophisticated, these forecasts become more and more accurate—incorporating data from 3rd party inputs to cast accurate predictions over time, geographic markets, and socioeconomic segments. With the addition of AI, these analyses incorporate unstructured data from molecular modeling, text, and publicly available data sources such as patents to improve prediction accuracy further. Eventually, these predictions will even account for economic cycles, geopolitical developments, and weather patterns. Using the outputs of these calculations, chemical companies can project market demand and determine which products they need to develop next.

As new, disruptive trends loom on the horizon, it becomes more important for chemical companies to forecast how these trends will impact market demand. For example, how will the impact of increased urbanization affect consumer attitudes towards sustainable manufacturing? How will car-sharing impact the market for raw materials in the automotive industry? How will the development of meatless meat—meat grown from animal cells in a lab—impact the way chemical companies interact with their agricultural customers? It is impossible to predict the future, but chemical companies can use the technology at their disposal to prepare as well as they can.

**Stay ahead with a robust, flexible product portfolio**

Even with radically short innovation cycles and powerful predictive analytics, manufacturers can’t always foresee exactly what a market might do. The most reliable way to stay ahead of demand and better prepare for unforeseen disruptions is to diversify and extend product lines.

One way research teams can do this is by focusing on single-step innovations that alter or find new applications for existing models and products. An example of single-step innovation is the discovery of nanoscale materials, such as silicene developed from silicon and graphene from carbon. These two-dimensional, single-atom materials are lighter, stronger, more malleable, and more temperature-resistant than existing materials. While these materials are yet to be fully monetized, innovators researching applications are finding promising opportunities, positioning themselves to capture early revenue.
Enable a new level of responsiveness in production

Traditional mass-production manufacturing is no longer sufficient to meet modern customer demands. Customers have an increased appetite for personalized products, forcing companies to figure out how to produce the differentiated goods customers want. On top of this, the world is now focused on instant gratification—no industry is immune from customer expectations of on-demand, timely delivery. The balance of keeping excessive, expensive inventory on hand while struggling to maintain customer service levels is an elusive yet necessary endeavor.

Meet demand with mass customization

The only way chemical manufacturers can meet the demands of today's customer is to embrace the concept of mass customization and made-to-order production. Companies are shifting away from mass production, which inevitably yields suboptimal inventory levels, to become more agile and responsive to specific customer needs. This approach involves producing smaller batches at industrial scale, combining the flexibility and tailoring customers want with the lower unit costs of mass production.

Another piece of customization is additive manufacturing, which gives manufacturers the ability to create customized objects with extremely complex geometries, optimized for a specific function. It reduces the amount of materials needed to build parts and shortens lengthy product development times. For example, plane manufacturers are using additive manufacturing and new materials to reduce overall plane weight for more fuel-efficient travel. Chemical companies are working directly with customers and 3D printing manufacturers to create materials that enable specific product customization, such as Dow’s liquid silicone rubber designed for 3D printers. This material has the beneficial properties of silicone such as water solubility, but incorporates the structural integrity needed to support printing of complex, custom designs.

Forward-looking chemical companies involved in creating materials right now position themselves to build market share in a larger ecosystem that supports on-demand 3D part production. Looking even further, chemical companies themselves may adopt additive manufacturing models, working in tandem with 3D printing companies to leverage devices like the Chemputer—a 3D printer that makes it possible to digitally program complex chemical systems and print synthetic products from a molecular level upwards. Scientists envision that products like small Unmanned Air Vehicles could be grown to exact military specifications in large-scale labs across the world.

Make customization possible by connecting the top floor with the shop floor

Implementing mass customization is key to meeting demands, but one of the biggest challenges for manufacturers is achieving customized production at mass-production costs. True mass customization only becomes a feasible business model when chemical manufacturers integrate business and manufacturing systems (design, analysis, planning, purchasing, accounting, inventory control), paving the way for automation.

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Automating from top floor offices down to the shop floor hinges on the adoption of industrial IoT. Petrochemical control rooms once had manual controllers along the walls to check readings on plant operations. Now, IoT-equipped sensors feed integrated systems, enabling companies to automatically monitor, record, and analyze everything that happens on the floor. Applying AI and advanced analytics techniques such as machine learning and cognitive services provide new insights to help optimize performance and prevent problems. Further, by integrating this analysis into business planning applications, the top floor gains the insight needed to make better-informed business decisions.

Automation adds efficiencies throughout production and gives manufacturers the ability to seamlessly create product variants. Without integration between business and manufacturing systems, producing one-off variants is prohibitively time-consuming and costly. By automatically triggering production line adjustments based on customer orders, for example, chemical companies can produce customized batches of chemicals at a reasonable cost. With this kind of integration, constant information flow between shop floor and business systems ensures that companies are producing exactly what consumers ordered, increasing customer satisfaction and reducing raw material waste.

**Streamline the ordering process for custom products**

Even if production is set up to support customization, custom ordering is often a complex and lengthy process. For customers, it can mean working through detailed specifications and long order conversations. For sellers, the process from quote to invoice usually involves a lot of clicking, copying, pasting, and manual data entry. Add in the requirements of IoT traceability and unique transportation needs, and mass customization becomes even more daunting.

Chemical companies can reduce complexity and smooth what could otherwise be a disjointed process using flexible pricing, quote to cash, and inventory management solutions. These systems integrate artificial intelligence into the quoting process to consolidate time-consuming tasks into simple bot conversations. Smart algorithms and big-data analytics enable dynamic pricing tailored to the customer scenario. Inventory management systems use additional data to track production and aggregate demand for finished goods, ensuring proper raw materials allocation and enabling batch jobs to be scheduled in advance.

These solutions also enable an unprecedented level of customer service. Machine learning helps sellers proactively analyze product performance and provides automated recommendations ahead of customer contract renewal dates. With integrated systems that provide a comprehensive view of all customer data at all times, companies can deliver the same high-quality service to customers anywhere, anytime.
Embrace an as-a-service business model

Chemical companies that want to be successful in the next decade understand that it’s not only about satisfying product demand, but helping customers use chemicals in a sustainable manner: maintaining ideal inventory levels, ordering only what is needed, and looking for ways to optimize chemical usage. This leads to fewer product sales, which will then be supplemented with new, digital-enabled services. With falling demand for chemicals, companies can no longer depend on volume to drive growth. On top of this, commoditization and emerging competitors are squeezing margins to new lows. At the heart of every chemical company’s business strategy is the question of how to compensate for the lost revenue.

Support a service-based business model by embracing digitization

For many companies, the answer to increasing revenue is providing new services that deliver ongoing value to customers. Improving operational efficiency can lead to healthier margins and a better customer experience, but the key to opening new revenue streams is offering value-based services on top of goods sold and embracing the “product-as-a-service” model in which a company provides a service in areas traditionally sold as products. Companies that quickly capture and respond to customer feedback can create significant service-related revenue opportunities through proactive service-delivery models, lifetime value-based services, self-service channels, and more flexible pricing models.

Five years ago, this type of business model wasn’t feasible—the technology wasn’t available to support it. Today, companies capitalize on a service-based model by leveraging IoT technologies, such as remote monitoring and connected field service, as well as the predictive capabilities of machine learning and advanced analytics. Bayer, for example, recently introduced a pest management services platform, revolutionizing an approach to rodent control that hadn’t changed much in over a century. The platform leverages IoT-enabled traps—often in numerous and hard-to-reach places—for 24/7 monitoring and real-time alerts. Data from the traps can also be collected and analyzed for trends, enabling pest management companies to place traps more effectively. In creating this platform, Bayer has expanded their traditional business to include selling connected devices, helping customers fuel profitable growth, stay ahead of industry regulations, and build business models grounded in long-term sustainability.

Ecolab is another company embracing a value-based service model. Like Bayer, Ecolab pivoted away from their roots as a chemical supplier to become a leader in water technologies and services through embracing digital technologies. The company is using developments in cloud computing, powerful analytics, and principles of smart manufacturing and sustainability to help industries around the world tackle water scarcity. To do this, Ecolab collects data from thousands of industries around the world to tackle water scarcity. This allows them to leverage IoT technologies to revolutionize an approach to rodent control that hasn’t changed much in over a century. The platform leverages IoT-enabled traps to provide a service in areas traditionally sold as products. Companies that quickly capture and respond to customer feedback can create significant service-related revenue opportunities through proactive service-delivery models, lifetime value-based services, self-service channels, and more flexible pricing models.

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Example: Ecolab

In partnership with Microsoft and Trucost, Ecolab developed the Water Risk Monetizer (WRM), the industry’s first, publicly available water risk analysis and financial modeling tool that translates water scarcity risks into financial terms. Armed with these insights, professionals can make better informed decisions in water management, develop locally relevant plans, and drive investment in water saving measures. This supports Ecolab’s mission to help companies improve production processes and prove that water-saving solutions make sound business sense, thereby benefitting the business and the communities where they operate. Learn More.

“The WRM provides a way for companies to incorporate water risks into their decision making to support smarter, more efficient manufacturing practices...It’s all about informing decisions to take action today to mitigate current and future risks.”

Emilio Tenuta
Vice President of Corporate Sustainability, Ecolab

“Every company is a software company. You have to start thinking and operating like a digital company. It’s no longer just about procuring one solution and deploying one. It’s not about one simple software solution. It’s really you yourself thinking of your own future as a digital company.”

Satya Nadella
CEO, Microsoft
of facilities worldwide, transforming it into insight by identifying the gap between what customers pay for water and the potential costs of inefficient water usage to their business. By combining chemistry, remote services, monitoring, and automated control, Ecolab services enable customers improve efficiency while reducing water and energy use.

**Connect operations across the business to better serve customers**

An integral part of the product-as-a-service model is providing employees with the right information at the right time no matter where they are. This especially applies to field service organizations, who are on the front lines with customers and are increasingly called upon to act as consultants. Dow, a leader in specialty chemicals, recognized that on-site access to data and insights would be crucial to the success of specialized agricultural products that maximize crop yields. Dow provided employees with mobile devices equipped with intelligent applications so they could advise farmers in real time on the best products for their specific location.\(^\text{v}\) By connecting the field team with fast and secure access to corporate information via the cloud, Dow facilitates better collaboration between employees in the field, researchers, and product developers, resulting in a superior customer experience.

The connection across different areas of a business further enhances potential to drive service-based models. Through a deepened engagement with the customer, companies can leverage data to improve sales processes, make production more agile, and accelerate innovation across the product development lifecycle. Vast stores of data are being generated from IoT-enabled products, creating a means to innovate product design and performance in real-time without waiting on customer surveys or sales and marketing data.
Address material scarcity in a circular economy

In the past, waste disposal was an inevitable part of the manufacturing process. Today, the linear, ‘take-make-waste’ model of resource consumption is no longer viable. If the usage of natural resources continues at its current rate, by 2050, we will need 3 more Earths to sustain the population. In contrast to linear models, circular economic principles assert that raw materials should be used, re-used, and recycled to minimize disposed waste and keep resources in use for as long as possible. While these concepts are hardly new, they have yet to be optimized and implemented at the scale needed to solve the challenges posed by resource scarcity.

**Lead the world in embracing circular economic principles**

Chemical companies operate at the head of the value chain, working directly with natural resources and producing the raw materials manufacturers use to build their products. This gives firms deep insight into the challenges associated with resource scarcity and means they are well-positioned to drive adoption of circular economic principles.

But bending the linear economy to adhere to these principles requires buy-in and collaboration across companies and industries—commitments that are difficult to secure without the assistance of regulatory bodies. Despite this, chemical companies cannot wait on these organizations to drive that change. Instead, they can proactively work with governments and regulators to provide education around the challenge of resource scarcity and push for a modern regulatory environment that responds to it.

**Spur economic transformation by demystifying resource consumption**

Leadership in a circular economy goes beyond a willingness to influence and cooperate with regulators. For circular economic principles to be implemented successfully there must be clear line of sight into how resources are consumed. In partnership with Microsoft and Trucost, Ecolab developed the Water Risk Monetizer (WRM), a tool to drive the awareness into resource availability that is needed in circular economies. The WRM translates water scarcity risks into financial terms and provides the insights needed to make drive investment in water saving measures.

Manufacturers can more easily repurpose waste materials if they have insight into where these materials are located, how they are being used, and what waste products are produced along the way. As a simple example, waste water from a food production company can be donated and used for another purpose where water quality isn’t essential, such as cleaning shipping containers. While examples such as these are already common practice internally, the challenge lies in implementing them across entire ecosystems.

**Example: Schneider Electric**

Agriculture uses 70% of the world’s available fresh water. Developed with Schneider Electric on Microsoft’s Azure IoT platform by WaterForce, a New Zealand irrigation and water management company, SCADAfarm is a mobile, cloud-based solution is transforming agriculture with remote controls and advanced analytics. It helps farmers analyze watering plans and comply with reporting regulations. Schneider Electric is incorporating SCADAfarm as part of its EcoStruxure to help partners empower the global movement of sustainable farming to conserve resources. Learn More.

"We’ve been helping transform the industry for a long time, and sustainable farming and water conservation are ways we’re delivering on our commitment to sustainability."

Rob McGreevy
Vice President of Information, Operations, and Asset Management, Schneider Electric

"If you have a problem then look to the innovators for your solution—The Yield are the innovators. This [solution] couldn’t happen if we didn’t have good cooperation between the government, innovators and private industry."

Lloyd Klump
General Manager, Biosecurity Tasmania
Using IoT and blockchain to assure accountability across a digital ecosystem

According to Accenture’s Technology Vision 2016, trust is a cornerstone of the digital economy.\textsuperscript{viii} When working closely with external stakeholders, gaining the trust of individuals, ecosystems and regulators is crucial.

To drive accountability and trust, companies first need visibility. As an example, IoT sensors placed throughout the supply chain can track the location of materials and waste products while providing insight into resource consumption. This data can also be used to track the availability of waste products that can be repurposed as raw materials by others in the ecosystem. As an additional benefit, accumulating this data over time enables chemical companies to track how a product fares across its lifecycle. Using this information, companies can refine and optimize its design to maximize longevity.

But how can you ensure this data remains accurate when distributed across a broad ecosystem? Blockchain-based solutions are designed to address that very need.

Blockchain technology is poised to disrupt a number of industries. One of blockchain’s most promising use cases is its ability to drive transparency and accountability. The pharmaceutical industry, as an example, has begun leveraging blockchain to combat the circulation of counterfeit drugs—which currently make up 10-30% of medicines sold in developing countries.\textsuperscript{ix} By creating a distributed ledger to record and share records with the assurance that these records cannot be manipulated, blockchain is a powerful tool to combat fraud and drive accountability. The accountability this technology assures opens new business opportunities that were once not possible due to a lack of trust.

By taking data from IoT sensors and adding it to a blockchain, chemical companies can securely and accurately provide insights into resource use and location across their supply chains—such as tracking carbon footprints. This creates an impartial system of accountability that ensures resources are optimally used and re-used throughout the ecosystem. In an ideal circular economy, companies within an ecosystem can exchange materials and products across connected supply chains—re-using materials wherever possible and holding themselves accountable to sustainability standards. The transparency blockchain provides is critical to realizing this ideal. Consequently, blockchain can help companies to stay compliant since it can track necessary information needed for government required reporting.

The shift to a circular economy provides clear benefits to chemical companies. By donating or selling waste products that would otherwise be thrown away, these companies position themselves as leaders in the fight to address resource scarcity while potentially adding new revenue streams. By collecting data across a product’s lifecycle, they can build new, longer-lasting products that remain in rotation for longer. But the greatest impact happens at a global scale. As natural resources diminish, embracing a circular economy becomes necessary to build a sustainable future. By leading this charge, chemical companies can spark a revolution that could—quite literally—save the world.
Why Microsoft

Companies across the chemical industry deserve a trusted technology partner as they shorten cycles of innovation, achieve new levels of responsiveness, add services, and address resource scarcities.

So why are some of the world's leading chemical firms already working with Microsoft?

Impactful research and innovations. Research teams at Microsoft are constantly innovating in ways that have enormous impact on the chemical industry. One of these is the development of Microsoft Genomics, an easy-to-use, cloud-based service for the secondary analysis of genomes. We are also making ground-breaking progress towards building a full-fledged quantum computing system, creating hardware and a complete software stack for chemical researchers to program and control quantum computers.

Industry-leading cloud platform. As a cloud-first organization, Microsoft understands the need for chemical manufacturers to have a cloud platform that supports new digital business models like mass customization or product-as-a-service. The Microsoft Azure cloud is designed with enterprise business needs in mind and supports companies looking to integrate on-premises solutions with cloud technologies.

Comprehensive solutions. Microsoft solutions span the full spectrum of business needs, from data access, to advanced analytics, visualization, and business process automation. On Azure's flexible platform, applications and services support manufacturers wherever they work with their data, from development labs to remote farms to the factory floor.

Global ecosystem of chemical industry partners. When companies work with Microsoft, they work as part of a larger partner ecosystem of strategic advisors, system integrators, independent software vendors, and emerging technology firms. Microsoft also supports a broad range of industry initiatives such as AI for Earth, a $50 million program dedicated to investing in projects that accelerate innovation in AI to achieve sustainable environmental solutions. Partners in programs like this design and deploy innovative solutions built on Microsoft technologies, giving manufacturers best-in-class technology coupled with deep industry expertise.

No other technology provider offers a comparable end-to-end portfolio as well as an open and flexible approach. It's with this unique perspective that Microsoft works alongside chemical manufacturers to build a more sustainable environmental and economic future.
Call to Action

Work with Microsoft to extend and develop solutions that will transform your business today. Use our knowledge and expertise in a business outcome workshop, deeper solution session, private preview, or customer focus group—or develop a proof of concept or pilot to drive the right implementations and solutions for your business.

For more information on business solutions and case studies, please visit the Chemical & Agrochemical webpage.