Sustainability in Manufacturing
The Technology Landscape
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Sustainability has become increasingly important as a key driver of growth, profitability, and value creation, for industries worldwide. Sustainability-led innovation enables organizations to differentiate their products and services in a crowded marketplace. To be successful, organizations should embrace the twin concepts of corporate social responsibility and environmental awareness, while building on the foundation of improving the bottom line and enhancing brand value.

The concept of sustainability has evolved over the last few decades. From being merely a regulatory necessity, it has gained strategic prominence today, especially in the manufacturing sector. Sustainable manufacturing requires simultaneous consideration of economic, environmental, and social implications; associated with the extraction, production, and delivery of goods. As a result, measuring and reporting sustainability parameters across the organization is becoming increasingly difficult.

This paper aims to study the sustainability strategies of manufacturing organizations and how they leverage the power of information technology to measure their sustainability performance. It throws light on the various approaches enterprises can use to address their sustainability agendas and explores a new approach that leverages the power of cloud computing to enable companies to implement their sustainability practices in an effective manner. Lastly, the paper highlights how this approach can drive competitive advantage for an organization and power it towards a more innovative, sustainable and green future.
Sustainability is Integral to the Manufacturing Industry

The classic definition of sustainability is, ‘meeting the needs of the present without compromising the ability of future generations to meet their own needs.’ Today, sustainability is a growing theme across organizations. Traditionally encompassing only environmental, economic and social issues, the scope of sustainability has expanded today. The recent inclusion of factors like supply chain de-risking, operating in resource stressed areas, reliable and cost-efficient energy supplies, product stewardship initiatives etc., have made sustainability even more strategically important than ever before. With increasing complexity, we believe that technology will play a key role in enabling companies to achieve and continuously improve their sustainability commitments.

Sustainability, if embedded within an organization, can deliver numerous benefits, some of which are listed below:

- Increase in revenue through the introduction of environment-friendly products and services
- Reduction in cost owing to energy efficient measures, and control and optimization of resources
- Enhancement in organizational brand value and reputation, attributed to the sustainability-conscious culture
- Efficient risk management due to better compliance with global and regional regulations

Sustainability is critical to manufacturing organizations, and is now being projected as a key differentiator across the industry. Fundamentally, sustainable manufacturing relies on descriptive metrics, advanced decision-making, and public policy for implementation, evaluation, and feedback. Manufacturing organizations are measuring key performance indicators for various parameters including emissions, energy consumption, water and waste usage, and safety, among others. This is carried out through the entire lifecycle, from material extraction to end of life and disposal. Figure 1 shows the high level sustainability indicators across the manufacturing lifecycle of a product.

![Figure 1: Sustainability indicators across the manufacturing lifecycle](image)

Manufacturing enterprises have been traditionally concerned with quality, cost, and productivity. The new dimension added to these is 'sustainability', which has now become a major trend. Enterprises face numerous challenges to meet their sustainability goals. While the benefits of sustainability are well known, sustainability as a subject is quite vast and complex. Many enterprises today claim to have their sustainability goals aligned to business goals, but measuring the degree to which they successfully engage in sustainable growth can be very difficult. In the age of innovation-led growth, sustainability-centric initiatives are being viewed with great interest by many organizations.

Some key factors that reinforce the importance of the sustainability concept in the manufacturing sector are:

1. **Climate change**: This is the most critical factor driving manufacturing organizations to rethink the way they conduct their operations. Organizations and policymakers need to take strong and early action to mitigate the impact on the climate and to put more stress on usage of renewable resources and innovative technologies.

2. **Energy and Fuel**: Fluctuation in global energy demands and prices has resulted in unpredictable and volatile markets. Thus, many companies are now heavily investing in R&D to achieve energy efficiency, devise renewable or alternate sources of power, enhance resource productivity, and ensure pollution control.

3. **Positive impact on society**: All organizations attempt to create a positive impact on society by carrying out CSR activities, such as participating in social and environmental awareness programs, creating jobs, building schools and hospitals, etc. They are increasingly sensitive towards the impact of their operations on the society at large. Thus, most manufacturing organizations are exploring ways to design products and processes that use limited natural resources, thereby minimizing the operational impact.

4. **Risk and regulatory compliance**: Manufacturing is a resource-intensive industry that uses significant raw materials, water and energy resources, resulting in an immense amount of solid waste, effluents, and emissions. The industry as a whole is subject to numerous global and local regulations, and plant level geography compliance. To comply with these stringent regulations, companies need to adopt sustainability as a practice and use various methodologies to cater to these requirements.

5. **Sustainable value chain**: Manufacturing organizations are under immense pressure to become greener and to reduce the environmental impact of their products across the supply chain. This has resulted in organizations carrying out product lifecycle assessments and devising processes to ensure a sustainable and eco-friendly supply chain. In the automotive industry, for instance, large Original Equipment Manufacturers (OEMs) at the top of the supply chain are moving toward sustainable manufacturing and voluntary reporting, thus creating even more pressure on Tier I and II suppliers to begin implementing sustainability initiatives.

6. **Brand image and reputation**: With the environment becoming a global concern, investors, customers and suppliers are increasingly considering 'environmental practices' as a key factor in making choices about their relationship with manufacturers. Enterprises can now highlight their sustainability goals, achievements, and investments to strengthen their brand value and reputation. On the other hand, failing to resonate with what major stakeholders feel important will impact their brands and ultimately the business, adversely.
How Sustainability has Evolved as a Concept

Manufacturing organizations are gradually moving beyond the first wave of sustainability concept that focused on awareness and was primarily compliance driven. Optimizing resource consumption, bringing about process efficiencies, building sustainable operations, and utilizing green products, have been the prime goals of the sustainability drive ever since its inception. These are still important, but we see manufacturers going a step forward now. As we see it, manufacturing firms are investing thought, time, and money, into sustainability-led innovations, and are attempting to bring about transformations throughout the value chain and beyond.

One prime example is General Electric. In 2005, GE launched an ‘Ecomagination’ initiative which reflected its commitment to invest in sustainable products and services positioned to meet current environmental challenges. By the end of 2012, Ecomagination has reduced GE’s green-house gas emissions by 32% percent from the base year, and has yielded US $ 24 billion in revenue from these products. The investment has been constantly increasing.

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**Figure 2: Why sustainability is becoming increasingly important in the manufacturing industry**

<table>
<thead>
<tr>
<th>Major Drivers for Sustainable Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climate Change</strong></td>
</tr>
<tr>
<td>It’s the single most critical force driving manufacturing organizations towards conservation and optimal use of all its resources extracted from nature</td>
</tr>
<tr>
<td><strong>Brand Image &amp; Reputation</strong></td>
</tr>
<tr>
<td>Businesses are looking to build brand image, trust and reputation by implementing green initiatives.</td>
</tr>
<tr>
<td><strong>Energy &amp; Fuel</strong></td>
</tr>
<tr>
<td>Global energy demand is the driving force for volatile and unpredictable markets. This leads to rising input costs for firms.</td>
</tr>
<tr>
<td><strong>Sustainable Value Chain</strong></td>
</tr>
<tr>
<td>Enterprises are looking to create technological innovations by creating breakthrough green products and supply chains</td>
</tr>
<tr>
<td><strong>Impact on Society</strong></td>
</tr>
<tr>
<td>Manufacturing organizations are increasingly becoming sensitive to the impact of their operations on society and the population at large.</td>
</tr>
<tr>
<td><strong>Risk &amp; Regulatory Compliance</strong></td>
</tr>
<tr>
<td>Stringent and ever-evolving regulatory framework is forcing manufacturers to ensure compliance with the requirements of waste disposal, air emissions and water effluents.</td>
</tr>
</tbody>
</table>

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This clearly highlights that going green is a strategic priority on the corporate agenda. Organizations see this as a potential differentiator that will enable them to stand apart in the marketplace and ensure future growth and profitability.

Ford PSI (Product Sustainability Index) was the first of its kind in the automotive industry, and represented how sustainability can be integrated into mainstream product development.\textsuperscript{3}

In the chemical industry, Dow Chemical's SCI (Sustainability Chemistry Index) is a similar breakthrough initiative. It includes the ‘cradle-to-cradle’ concept that encourages efficient resource usage to provide customer value as well as enhance the quality of life for current and future generations.\textsuperscript{4}

Sustainability reporting is increasingly becoming an area of focus for organizations across the globe. Manufacturing organizations are exploring newer and effective ways to measure the sustainability performance of their products and processes. They look to achieve this in the following ways:

1. **Sustainability Reporting:** This is done through measuring resource utilization, waste and water generation, air and carbon emissions from all manufacturing processes, and evaluating and documenting the data.

2. **Impact Analysis:** This analysis assesses the impact of manufacturing the product on social well-being, on the environment and on the economy. It also measures its lifecycle impact from resource extraction to the end of use, and includes evaluation against industry benchmarks for well-defined sustainability performance metrics.

\textsuperscript{3} Ford, Product Sustainability Index, Jul 2007.

The purpose of sustainability reporting is to show how organizations are helping to improve environmental, social and other conditions over the long term. Reports should reflect the significant impact of the business on the environment and enable stakeholders to assess its performance in the reporting period. Some organizations are trying to implement sustainability-related initiatives not only within the organization, but outside as well, by including suppliers and consumers in the bigger scheme of things. Organizations are thus evaluating their current IT systems and processes to help address these emerging needs. Such initiatives raise a pertinent question: How can organizations meet this growing demand of a sustainable future and at the same time, address the business growth in an effective manner?

Figure 4 lists some major facets that organizations need to track and report to measure their sustainability performance.

| Resource Consumption | High resource intensity processes - energy, water etc.  
|                      | Enhancing efficiency of operations - production, logistics and materials |
| Water and Biodiversity Management | Water measurement, analysis and reporting  
|                                    | Water usage and recycling, impact on biodiversity while operating or expanding |
| Waste Management | Waste stream disposal and treatment  
|                  | Hazardous waste handling during manufacturing leading to product compliance |
| Reporting and Compliance | High degree of statutory and voluntary reporting  
|                        | Tracking and updating the data conversion factors |
| Supply Chain Sustainability | Lean and green supply chain adoption  
|                         | End-of life management: Reverse Supply Chain |
| Sustainable Products and consumption | Improve and add products that enable customers to reduce its environmental footprint  
|                                      | Eco-product innovation and Green Products |

Figure 4: Facets of Sustainability Reporting

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The Role of Technology in Implementing Sustainability Solutions

Dedicated sustainability software can play a pivotal role in addressing the sustainability services mentioned in Figure 4. Such software can either be commercial off-the-shelf (COTS), or a build solution. Making a choice between these two options is based on the needs and the maturity of the organization. Smaller organizations, with only a few facilities spanning a single geography, may find spreadsheets a feasible alternative to specialized software in the short term. However, there are risks in managing voluminous data manually by means of spreadsheets. Hence, a robust system is important to ensure fool-proof compliance for legislative purposes, which may vary across geographies. For example, Norway, Sweden, and the United Kingdom require environmental reporting, while France and Germany require environmental and social reporting. Thus, the solutions should include the following key features:

- **Data collection:** To ensure data quality and accuracy, comprehensive data checks should be built into the solution. The solution should also have alerts and/or reminders to enable periodic data collection. Updates to key performance indicators (KPIs) and data points, along with documentation storage are some other features the solution must offer, along with KPI trending and hotspots by country, company and business units to improve visibility across the organization.

- **Measurement and reporting:** Technology can play a key role in tracking, monitoring, measuring, and analyzing sustainability indicators on a regular basis, thus helping the organization meet its sustainability goals/targets. It allows data management and reporting across multiple dimensions, and makes it convenient to report ratios, trends and performance indicators across the organization.

- **Stakeholder participation:** Technology can play a crucial role in employee engagement by enhancing communication and sharing of knowledge within the organization.

Sustainability Services Solutions Landscape

Broadly, sustainability-related solutions cater to different reporting and analytical requirements in the areas of resource management, enterprise operations, value chain (sustainability related) and assurance related services. Manufacturing organizations are beginning to integrate and request for sustainability information across the value chain. There are several niche players in the market whose solutions meet some of the requirements in isolation. However, a holistic approach is needed in this area. Figure 5 highlights some of the major sustainability services currently provided by vendors in the sustainability space.
Different Approaches

In general, sustainability reporting software can be classified into two types:

a) Individual packages (focusing on a dedicated solution for sustainability reporting or supply chain)

b) Packages that are a part or a module of a larger ERP system (focusing on an integrated solution including sustainability).

Over time, we expect that the need for integrated reporting will drive organizations towards adopting integrated solutions.

While most vendors offer web interfaces on their software, very few solutions are entirely on the ‘cloud’. However, new players in the market are focusing on this emerging cloud trend, which also has added benefits in terms of cost and payment structure to the client.

Three key approaches followed by sustainability solution providers are outlined below:

**Applications deployed on built platform:** Enterprise applications are built and deployed on platforms owned, installed, run and supported by the in-house IT vendor. The server software is deployed on a company-owned or outsourced data center, and the client software is installed on the individual machines of the users who have
access rights within the system. This requires dedicated time for the in-house IT team to install, test and provide support to. It thus means higher installation, running and implementation costs as dedicated infrastructure is required. The major benefits in this case include data security and customized reporting with drill down abilities to the desired level.

**Applications hosted on the web**: In this deployment model, the application is hosted at the vendor’s premises and the users access software functionalities like task scheduling, reporting etc., via a secure web user interface. The key advantage of this model is the lower price point. However, the integration with the organization’s existing legacy systems and ERP applications could pose a challenge and there is a potential risk in leaving the data security aspects to the vendor.

**Software as a Service (SaaS)**: This methodology of deployment is a recent introduction to the world of sustainability solutions. The application is centrally controlled, instead of being deployed at the individual user’s systems. In this model, there is a one-time configuration of the software, and payment is made on a monthly subscription basis for the features and functionalities of the system that are accessed via a web interface. The benefits of this model include the lower upfront implementation cost in terms of license fees, the short time needed to deploy due to reliance on the service provider and the fact that in-house IT teams are not required. Quick sharing of new features and functionalities across the entire customer base at the same time, and the ease of expanding access to additional user groups without the need to install software on individual machines are also significant benefits. However, like the earlier option, data security is a concern. Also, SaaS deployments can get tricky when integrating with existing systems, and significant customization of SaaS offerings is not possible.

All three options have their set of pros and cons, and organizations must carefully evaluate their business requirements and the commercial viability of the chosen solution before arriving at a decision.

### Cloud: An Opportunity?

Cloud computing is a scalable means to receive technology on-demand, but its benefits are still undervalued in the industry. Cloud providers are responsible for updating and upgrading their software in real-time, which ensures that the users are always using up-to-date technology. Maintenance and updates occur seamlessly and automatically. Cloud-based services can be utilized in the following three ways:

- **Software as a service**: Software applications hosted in the cloud and provided on a subscription basis
- **Platform as a service**: Virtualized application development and run-time platform
- **Infrastructure as a service**: Raw infrastructure (CPU, memory, storage, network) available on an as-needed basis

We believe that an enterprise can gain significant benefits by reporting its sustainability information through cloud enabled software. It gives them a model which is scalable, dynamic and low cost, while reducing complexity and achieving a granular level of visibility of its sustainability information. The flexible, on-demand nature of this solution enables companies to achieve improved performance, generate more efficient reports, and achieve greater return on investment.
Solution features

Implementing a successful sustainability improvement program requires the seamless integration of past, present, forecasted and targeted data, as well as analytics to provide the insights and intelligence needed to drive action. We believe that an integrated solution can address the need for sustainability reporting in the most effective manner. The sustainability solution on cloud must encompass the following features to ensure an efficient sustainability information management system:

**Comprehensive system for data management, analysis and reporting:** The solution would enable monitoring, reporting and management of energy, carbon emissions, environmental factors, along with supply chain and corporate responsibility indicators. This addresses the key requirement of having a centralized data base for various data sources used for environmental reporting. It will also enable customized analytics and automated production of Global Reporting Initiative (GRI) and other state or federal level reports.

Another important aspect of centralization is that the organization will be presented with a common and consistent user interface. This helps in streamlining the training, reporting, and other support needs as there is no requirement for a distinct platform or interface.

**Proactive sustainability performance management:** A sustainability reporting and analytics tool makes a lot of business sense. It contributes towards a significant reduction in carbon and energy emissions by providing enhanced visibility at a granular level. It is a low cost and high impact way to engage within the organization thus achieving measurable results and driving improvements.

**Sustainability database:** Dedicated sustainability software provides a ‘single source of the truth’ for all the sustainability data. However, this requires that the sustainability software be integrated with external IT systems, such as ERP and legacy systems, where the data resides, along with good synchronization between the various IT systems and the sustainability software to avoid discrepancies in the information.

**Use of analytics to turn data into actionable information:** The solution should enable organizations to gain greater understanding of the data and glean relevant insights from it. This can also be achieved through benchmarking at various levels (plant level, business unit level, corporate and industry level). For example, it should enable peer to peer comparisons, and provide the ability to create a comprehensive sustainability index for a specific market segment or industry, thereby enabling the culture of constant improvement. Some enterprises also undertake a benchmarking exercise to understand the best practices of competitors in order to compare and determine how stakeholders might perceive any discrepancies.

**Organization-wide sustainability performance management view:** Stakeholders responsible for meeting corporate sustainability goals should be able to share ownership of these goals with the wider workforce. This enables them to forecast accurately, allowing for the management of their overall ‘sustainability-performance’ in real-time.
**Sustainability across the value chain:** The solution can create an impact beyond a company’s own internal sustainability performance and allow a company to assess the sustainability performance of those it does business with, such as suppliers, partners, contractors and outsourcers by integrating information across the value chain. This functionality helps the organization reinforce its commitment to sustainability efforts across the value chain.

**Management of product compliance:** Environmental regulations like Registration, Evaluation, Authorization and Restriction of Chemical Substances (REACH) and Restriction of Hazardous Substances (ROHS) require that companies know exactly what chemical substances are in the raw materials, components and products that they purchase from suppliers. Also, because regulations change frequently, the solution must have an in-built capability to upgrade the data sets as and when regulations get updated.

**Workflow management:** The solution should allow analysis to be performed over the internet by various stakeholders, including technical and managerial teams, from within their own work environment and in real-time. This allows them to collaborate virtually with others, thereby streamlining their work process and identifying opportunities in advance.

**High level solution architecture:** The key factors in a successful solution delivery involve the use of applications that help clients identify the problem, and select the appropriate data acquisition and aggregation capabilities to share the right data across the enterprise. The solution must create a reporting layer on top of the data warehouse that can provide visibility to the end users and management and suggest the areas of improvements and how efficiently their sustainability goals are met. This will help organizations deliver accurate sustainability information to the key stakeholders at the right time across geographies and business units. Information must be organized around the major aspects of sustainability performance management like energy, water, waste and safety.

Figure 6 describes a high level data flow for an enterprise, indicating the possible data sources, the major aspects or parameters of reporting and various levels leading to an integrated sustainability report at the corporate level. Customized user dashboards are provided at each reporting layer to deliver the intuitive graphical visualization, KPIs and benchmarking needed to bring visibility to key issues. The scalability and flexibility of such a solution will allow users to review the architecture on a timely basis and suggest changes to enhance the solution.
Implementation model

The implementation model for such a solution is highlighted in Figure 7. The organization-wide implementation of this solution starts by establishing sustainability goals at all levels. It requires the active participation and commitment of all internal and external stakeholders. It needs an in-depth understanding of the current state, identification of the gaps and inputs for selecting the best suitable technology. This should be logically followed by a pilot implementation across selected sites and then a global roll out. Once the solution is implemented the parameters must be tracked, analyzed and monitored on a regular basis.
Benefits of the cloud-based approach

A cloud-based sustainability solution that delivers software-as-a-service has great business value for organizations. There are major benefits in implementing software on a cloud platform. Customers can save time and money, focus on competitive advantage rather than infrastructure, and gain immediate access to the latest innovations. The pay-as-you-go nature of cloud-based infrastructure encourages users to only consume what they need and nothing more.

Cloud computing offers many operational benefits to organizations of all sizes, while at the same time providing them with a more sustainable, eco-friendly alternative to a traditional model. Deployment of sustainability services on a cloud platform will provide an organization with the following important benefits:

- Automated capture of sustainability data to support GRI and Carbon Disclosure Project (CDP) reporting as well as other state and federal level reporting across the globe, such as Toxic Release Inventory (TRI), Superfund Amendments and Reauthorization Act (SARA), etc.
- Reducing the time and cost of managing corporate environmental information by automating the process of capturing and tracking energy, water and other environmental data from utilities and third party suppliers.
- Providing up-to-date, auditable business and compliance reports via dashboards that summarize energy, emissions and other environmental data. This allows for cost reduction through operational efficiency gains and employee engagement.
- Sustainability solutions on cloud can leverage the flexibility and power of a hybrid cloud to collaborate, collect, analyze and distribute the product information from disparate sources.
- Moving to the cloud will provide business users at the corporate level with the benefit of aggregate IT efficiency advantages in one stroke, instead of investing in gradual improvements in case of other approaches.
Besides the reporting benefits, the solution can help reduce carbon emissions significantly by reducing the need for on-premises hardware infrastructure for the organization.

It allows for collaboration across the value chain that is needed to measure, monitor and manage the environmental and social footprint.

Sustainability software on cloud makes a company’s sustainability business practices truly integrated, and enables comparability across companies for similar benchmarking purposes.

It enables cost-saving decisions by providing a wide range of environmental performance analytics with features such as benchmarking and forecasting at various levels.

The solution eliminates risks related to non-disclosure of information through automated disclosure reporting.

The low cost and incremental economics of the solution make it possible for even the smallest companies or divisions to practice integrated reporting.

It helps the company meet the stakeholders’ demand for transparency and business improvements.

Organizations are able to focus on strategic execution as fewer personnel are required to maintain and operate the application.

Cloud computing also enables the exchange of information between communities, thereby enabling community building. Sharing non-competitive information (through public cloud) between companies can yield significant benefits when trying to assess the risks of energy efficient or low carbon projects.

Risks

**Data Security:** Sustainability solutions on the cloud are risky as there is lack of control over the infrastructure. As with most cloud environments, the solution could fall victim to malicious attacks. It is therefore very important to have a robust data loss prevention plan in place for the organization.

**Centralization of a vendor application:** Vendor dependency could ensue because organizations typically outsource their data and application services to a centralized provider. If the provider is unable to deliver services or goes out of business, then all clients are affected, making it an expensive proposition for the organization.
Conclusion

Sustainability is one of the most significant strategic programs that organizations will undertake in the coming decades. All entities in the manufacturing value chain, from raw material producers to consumers, have a critical role to play in ensuring sustainability. A sound sustainability strategy drives innovation, enhances the organization’s reputation, satisfies customers, and attracts and retains top talent. These enable a company to carve a niche for itself in the cluttered marketplace, leading to sustained growth and high profitability. Though manufacturing organizations are under immense pressure to weave sustainability into their very fabric, potential rewards are also significant.

To achieve substantial results, companies will need to develop new capabilities, tools and skills to meet the challenges and grab the opportunity of green businesses. The role of technology is vital as it creates visibility of environmental and sustainability related data, so that manufacturing enterprises can use the information to transform products, processes and related practices, and integrate sustainability into every aspect of their business operations. Cloud computing is one of the ways forward and it is rightly positioned to meet the changing needs of an organization’s sustainability initiatives. It provides cost savings, improved data management and performance improvement. When one looks at the concept holistically, benefits certainly outweigh the risks. If implemented with the right vendor who has strong expertise in the sustainability domain and adequate technical knowhow, an organization can derive tremendous results for its sustainability drive. Such a partnership provides the organization with a strategic path to implement its sustainability strategy in a cost-effective yet efficient manner.
About the Manufacturing Solutions Unit

Global manufacturers are trying to reduce operational expenditure, invest in process improvement, utilize existing capacity optimally and increase efficiencies, while maintaining product quality and meeting safety and regulatory norms.

TCS’ Manufacturing Solutions provide you the bandwidth to innovate on business models, leveraging contemporary technology solutions.

We believe in leveraging learning from across the segments in driving business solutions. Be it in applying the concepts of lean new product introduction from discrete industries to a chemical manufacturer, or leveraging the aerospace industry experience in service management for the automotive sector, our dedicated Manufacturing Centers of Excellence (CoEs) under these focus vertical industries are continuously looking at breakthrough solutions. Clients can benefit from our rich experience in both the discrete (automotive, industrial machinery and equipment, aerospace) and process industries (chemicals, cement, glass and paper).

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