Designing Factories That Are Built for the Future

AUGUST 2023
Manufacturers face four main challenges that impact their business:

- **Productivity**: Optimizing production efficiency
- **Sustainability**: Increasing sustainability and meeting net zero targets
- **Flexibility**: Increasing flexibility of production and resilience
- **Talent**: Augmenting and supporting the workforce

*Source: BCG.*
Most manufacturers have begun their digitization efforts but with limited success

- **89%** of executives consider advanced manufacturing technologies such as AI as a must and aim to implement them.
- **68%** of manufacturers have already started their factory of the future (FoF) journey, with at least one fully implemented AI use case.
- **16%** of adopters have successfully achieved their FoF-related targets.

*Source: BCG Global Survey on AI in Industrial Operations 2023; n = 1,800.*
Successful factory of the future initiatives require a focus on three optimization dimensions and two foundations to realize their full potential.

Optimization dimensions:
- Digitization and automation
- Lean processes
- Effective structure

Foundations:
- People
- Technology

Source: BCG.
Three optimization dimensions must be considered together to create the factory of the future

**Digitization and automation**
Leverage advanced manufacturing technologies to digitize and automate across the entire plant.

**Lean processes**
Improve process stability through combination of Lean and Industry 4.0 opening new value potentials compared to conventional process improvement.

**Effective structure**
Define optimal plant structure, e.g., through use of digital twins to simulate different layout alternatives.

Source: BCG.
The foundational dimensions for factory of the future success directly align with the six key attributes that enable a future-built company

<table>
<thead>
<tr>
<th>People</th>
<th>Technology</th>
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<tbody>
<tr>
<td>1. Align <strong>leadership around a corporate purpose</strong>, particularly sustainable manufacturing.</td>
<td>6. Migrate to <strong>modernized tech platforms</strong>, including scalable infrastructure to leverage the power of manufacturing data and capitalize on advanced technologies such as AI.</td>
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<tr>
<td>2. Develop a clear <strong>people advantage</strong> by attracting, upskilling, and retaining top talent and building the capabilities to drive innovation, operational excellence, and exceptional customer satisfaction.</td>
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<td>3. Institute an operating model to enable <strong>agility and resilience</strong>, making supply chains more responsive and durable to efficiently deliver products.</td>
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<td>4. Establish an <strong>innovation-driven culture</strong> by empowering employees to explore emerging technologies, leverage analytics, and apply advanced solutions to improve operations.</td>
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<td>5. <strong>Embed AI</strong> in the organization to increase transparency, analyze performance, forecast more accurately, and optimize production.</td>
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Source: BCG Build for the Future Survey 2022; n = 724.
Most manufacturers have significant work ahead; only 16% are scaling their efforts to build for the future, and just 3% are fully future-built.

Source: BCG Build for the Future Survey 2022; n = 724.

Note: Advanced = future-built + scaling; lagging = stagnating + emerging.

1Manufacturing-oriented sectors: machine and automation, consumer products, oil and gas, medtech, transport and logistics, biopharma, auto and mobility, hardware and semiconductors, materials and process industries.
Advanced manufacturers excel in all key attributes by a wide margin compared to their peers, especially in embedding AI into their operations.

<table>
<thead>
<tr>
<th>People</th>
<th>Median score</th>
<th>% increase in advanced vs. lagging companies</th>
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<tr>
<td>Aligning leadership around a corporate purpose</td>
<td>6.4</td>
<td>7.9</td>
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<tr>
<td>Developing a clear people advantage</td>
<td>5.7</td>
<td>7.5</td>
</tr>
<tr>
<td>Instituting operating model to enable agility, resilience</td>
<td>5.9</td>
<td>7.5</td>
</tr>
<tr>
<td>Establishing innovation-driven culture</td>
<td>6.0</td>
<td>7.8</td>
</tr>
<tr>
<td>Embedding AI for value in the organization</td>
<td>4.3</td>
<td>6.7</td>
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<td>Migrating to modernized tech platforms</td>
<td>6.0</td>
<td>7.6</td>
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Source: BCG Build for the Future Survey 2022; n = 724.
Note: Manufacturing-oriented sectors: machine and automation, consumer products, oil and gas, medtech, transport and logistics, biopharma, auto and mobility, hardware and semiconductors, materials and process industries. Advanced = future-built + scaling; lagging = stagnating + emerging.
Advanced manufacturers are also prioritizing factory of the future investments to achieve strong digital operations capabilities

**Advanced companies are allocating more of their operational spending toward FoF …**

% OF TOTAL CURRENT OPERATION SPENDING ON FOF

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**… and achieving higher digital operations and manufacturing capability scores**

AVERAGE DIGITAL OPERATIONS AND MANUFACTURING CAPABILITY SCORE (OUT OF 5)

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Source: BCG Build for the Future Survey 2022; n = 724.

Note: Advanced = Future-built + scaling; lagging = stagnating + emerging. Manufacturing-oriented sectors: machine and automation, consumer products, oil and gas, medtech, transport and logistics, biopharma, auto and mobility, hardware and semiconductors, materials and process industries.

Industry 4.0-related investment questions in BCG Build for the Future Survey 2022.
Elements of the factory of the future people foundation

**Capabilities**
Includes roles such as data scientists and engineers, software developers, and machine-learning engineers to develop and implement new technologies.

**Governance**
The right organizational structure, clear roles and responsibilities, processes, and dedicated KPIs and incentives.

**Change management and communication**
Includes leadership buy-in and engagement at all levels to ensure transformation success.

**Legal compliance**
Comprehensive policies to mitigate risk from technologies such as generative AI.

Source: BCG.
Elements of the factory of the future technology foundation

**Data sourcing**
Systems to capture required data (such as from sensors) and route it to advanced manufacturing solutions

**Data processing**
Includes the ingestion, pre-processing, storage, distribution, and deletion of data

**Data application**
Developing, validating, deploying, and serving AI-based algorithms, along with the user interface

**Computing**
Sufficient computing power, including the determination of on-premise versus cloud computing

**Connectivity**
Link plants and other assets to share data

**Cybersecurity**
Identity and access management, detection and response, risk analysis and management, and recovery planning

Source: BCG.
Digitization and automation technologies can dramatically increase efficiency in manufacturing plants

Before
Operators manually handle parts, which are transported from injection molding machines to the next workstation using forklifts.

After
Autonomous mobile robots (AMRs) can pull parts directly from injection molding machines and transport them. Humans supervise the process and focus more on value-creating work.

Impact
Significant reduction in direct logistics labor costs. Investment pays for itself in 18 months.

Source: BCG.
Automated quality control systems can reduce costs and increase manufacturing quality

**Before**
Operators need to visually inspect parts and components for quality issues. Process is manual, costly, and prone to risk that defects are not identified due to human error.

**After**
Automated cameras equipped with AI can automatically spot defects. AI algorithms that power the automated inspection process are trained with synthetic data, improving accuracy from day one. Humans can focus on identifying root causes of product defects and potential new quality issues.

**Impact**
30% reduction in quality inspection costs and decreased risk of delivering defective products to customers.

Source: BCG.
Generative AI can make repairs to plant equipment more proactive, consistent, and cost-effective

Before
Factory equipment repairs require an in-person diagnostic by a technician (or remote support), with uneven repair quality based on the technician’s experience level.

After
Machine-learning analytics can identify potential issues with equipment. Generative AI uses the ML insights to automatically provide repair instructions and recommendations for required parts, leading to more reliable repairs. Humans focus more on preventing breakdowns, and repair processes are more efficient.

Impact
Reduction in equipment downtime and maintenance costs, along with an increase in plant productivity.

Source: BCG.
One company built a factory of the future as a pilot initiative at a single factory, with plans to scale that model across the enterprise.

**Digital journey**

- **Phase 1**
  - 2 months
  - Activate the leadership team and define targets

- **Phase 2**
  - 8 months
  - Implement 30 digital use cases in a pilot initiative

- **Phase 3**
  - 18+ months
  - Deploy digital initiatives in other markets
    - End-to-end automation
    - Autonomous mobile robots (AMRs)
    - Advanced data and analytics
    - Energy monitoring

8% Profit gross margin impact achieved

~$200 million Total yearly saving impact

Source: BCG.
Five key steps in the process to building the factory of the future

1. **Diagnose**
   - Analyze status quo and identify gaps and opportunities.

2. **Design**
   - Design target picture, strategy, and roadmap.

3. **Engineer**
   - Engineer solutions and develop measures to close gaps.

4. **Implement**
   - Implement solution pilots and measures and validate impact.

5. **Scale**
   - Roll out proven solutions and measures.

*Source: BCG.*