Focus 4

Green Manufacturing

A Practitioner of Green Power

TSMC’s goal is to facilitate coexistence and mutual prosperity between business and environment. Aiming to become a practitioner of green power, we assimilate green management into our business and implement continuous improvement projects in the areas of climate change, energy management, water management, waste management, and air pollution control. We hope to protect our environment while increasing the Company’s value.

1

Led the world to reach 93% reduction rate of fluorinated greenhouse gases (F-GHGs) and nitrous oxide processing equipment exhaust

133.7 Million Metric Tons

Recycled 133.7 million metric tons of water in total

> 300 Million (NT$)

Promoted the Circular Economy Project to create over NT$300 million of value through recycling and waste reduction
### Climate Change and Energy Management

<table>
<thead>
<tr>
<th>Strategies &amp; 2030 Goals</th>
<th>2019 Achievements</th>
<th>2020 Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drive Low-Carbon Manufacturing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continue to use best available technology to reduce emissions of greenhouse gases (GHG), becoming an industry leader in low-carbon manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Reduced greenhouse gas emissions per unit of production (metric ton of carbon dioxide equivalent (MTCO2e)/8-inch equivalent wafer mask layer) by 40% (Base year: 2010)</td>
<td>- Reduced greenhouse gas emissions per unit of production (metric ton of carbon dioxide equivalent (MTCO2e)/8-inch equivalent wafer mask layer) by 17%&lt;br&gt;Target: 16.5%&lt;br&gt;Exceeded</td>
<td>- Reduce greenhouse gas emissions per unit of production (metric ton of carbon dioxide equivalent (MTCO2e)/8-inch equivalent wafer mask layer) by 18%&lt;br&gt;Target: 16.5%&lt;br&gt;Exceeded</td>
</tr>
<tr>
<td>- Reduced fluorinated greenhouse gas (F-GHG) emissions per unit of production (MTCO2e/8-inch equivalent wafer mask layer) by 65%&lt;br&gt;Target: 60%&lt;br&gt;Exceeded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Total fluorinated greenhouse gases emissions decreased 15%&lt;br&gt;Target: 15%&lt;br&gt;Exceeded</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Use Renewable Energy** | | |
| Continue to purchase renewable energy and establish solar-energy power systems, increasing the use of renewable energy | | |
| - Renewable energy accounts for 20% of energy consumption of new fabs starting from 3nm, and the purchasing of renewable energy to increase annually to achieve 25% renewable energy for fabs and 100% renewable energy for non-fab facilities | - 910 GWh of Renewable Energy, Renewable Energy Certificates (REC), & Carbon Credit purchased, achieving 6.7% of TSMC’s power consumption<br>Target: All overseas sites use renewable energy<br>Exceeded | - Continue to purchase renewable energy until it makes up 7% of TSMC’s energy consumption, and overseas sites use 100% renewable energy<br>Target: Negotiating<br>Missed Target |
| - Taiwan sites continued to negotiate 700MW of additional long-term renewable energy purchases<br>Target: Negotiating | | |

Note: Reduction of greenhouse gas emissions includes reduction of fluorinated greenhouse gas emissions. This indicator will be used as of 2020 to manage the performance of various practices.

<table>
<thead>
<tr>
<th>Date: 2019</th>
<th>Corporate Social Responsibility Report</th>
<th>Our Business</th>
<th>Sustainable Governance</th>
<th>Our Focuses and Progress</th>
<th>Appendix</th>
</tr>
</thead>
</table>

Our Focuses and Progress

- Ethical Management
- Innovation and Service
- Responsible Supply Chain
- Green Manufacturing
- Inclusive Workplace
- Common Good

Our Business

- Sustainable Governance

Appendix

2019 Corporate Social Responsibility Report

Our Business Sustainable Governance Our Focuses and Progress

- Ethical Management
- Innovation and Service
- Responsible Supply Chain
- Green Manufacturing
- Inclusive Workplace
- Common Good

Appendix

(Continued on next page)
### Increase Energy Efficiency

**Plan for new energy-saving measures each year and actively implement energy-saving measures, increasing the efficiency of energy productivity**

- **Save 5,000 GWh cumulatively between 2016 and 2030 through implementation of new energy-saving measures**
- **Double energy efficiency after five years of mass production for each process technology**
  - Note 1: Energy efficiency of 16-nm and above process technologies in the fifth year of mass production improved 1.4 times on average; energy efficiency of 10-nm technology in the third year of mass production improved 0.7 times on average.
  - Target: NEW
  - Process energy efficiency of 10-nm process technology improves 0.8 times in fourth year of production
- **Energy consumption per unit of production increased 17.9% (Base year: 2010)**
  - Target: Reduction of 11.5%

### Strengthen Climate Resilience

**Establish climate change countermeasures and preemptive precautions, lowering the risks of climate disasters**

- **0 days of production interruption due to climate disasters**
  - Target: 0 days
  - Note: Exceeded
- **0 days of production interruption due to climate disasters**
  - Target: 0 days
  - Note: Achieved

---

**Strategies & 2030 Goals**

<table>
<thead>
<tr>
<th>2019 Achievements</th>
<th>2020 Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increase Energy Efficiency</strong></td>
<td><strong>Strengthen Climate Resilience</strong></td>
</tr>
<tr>
<td>- Save 5,000 GWh cumulatively between 2016 and 2030 through implementation of new energy-saving measures</td>
<td>- 0 days of production interruption due to climate disasters</td>
</tr>
<tr>
<td>- Double energy efficiency after five years of mass production for each process technology</td>
<td>- Energy saving goal of 400 GWh, and total energy savings of 1,600 GWh</td>
</tr>
<tr>
<td>- Energy efficiency of 16-nm and above process technologies in the fifth year of mass production improved 1.4 times on average; energy efficiency of 10-nm technology in the third year of mass production improved 0.7 times on average.</td>
<td>- Process energy efficiency of 10-nm process technology improves 0.8 times in fourth year of production</td>
</tr>
<tr>
<td>- Energy consumption per unit of production increased 17.9% (Base year: 2010)</td>
<td>- Target: Reduction of 11.5%</td>
</tr>
<tr>
<td>- Power consumption of 10-nm processes is double that of 16-nm technologies</td>
<td></td>
</tr>
</tbody>
</table>

---

**Note 1:** Energy efficiency is the product equivalent per each kWh of power (8-inch equivalent wafer-mask layer/kWh)

**Note 2:** The increased complexity of new process technologies and manufacturing processes results in increased power consumption in new process equipment, causing the power consumption of <10-nm processes to be double that of >16-nm technologies.
In 2019, the European Parliament declared a climate emergency in response to the frequent climate disasters around the world. TSMC effectively adapted to the potential impacts of climate disasters on business operations by strengthening climate-resilient designs for its facilities and reinforcing emergency response disaster plans. Furthermore, the Company purchased 910 GWh of renewable energy and improved its energy management, investing additional resources to the development of energy-saving designs for production equipment. Through a series of relentless efforts, carbon emissions per unit of production continued to decrease, effectively mitigating greenhouse gas emissions.

In 2019, TSMC reported steady decreases in carbon emissions per unit of production while it continued to expand production capacity and develop new technologies. As declared in the Corporate Social Responsibility Policy and Environmental Protection Policy, responding to climate change is the responsibility of sustainable business such as TSMC. Striving to become a world leader in green manufacturing is our mission. We believe that only through cooperation with business partners, industry, government, academia, and all of society can we work together to overcome the severe challenges of climate change.

With the continuous advancement of process technology, integrated circuits are growing increasingly complex and therefore, the power required to manufacture them continues to grow. Even though in 2019 TSMC invested considerable resources into the development of renewable energy and green tools, implemented 503 energy-saving measures, and introduced new energy-saving equipment, energy consumption per unit of production still did not reach the anticipated reduction goals. With a commitment to green manufacturing, TSMC will continue to purchase renewable energy and expand renewable energy power generation to increase the percentage of renewable energy in TSMC’s energy structure, reduce greenhouse gas emissions from production activities, and achieve the goals of greenhouse gas reduction.

TSMC established the Corporate Social Responsibility Executive Committee in 2019. Led by the Chairman, TSMC’s management team examines a variety of corporate sustainable development issues, and climate change received the greatest focus. In addition to biannual reviews, the CSR Executive Committee must report the company’s climate actions and outcomes to the Board of Directors every year. Extreme climate and global warming may lead to potential business crises, and therefore TSMC is focused on three main goals:

- Compliance with regulations, energy conservation and carbon reduction, and the management of carbon assets.
- In 2019, the Task Force on Climate-related Financial Disclosures (TCFD) framework proposed by the Financial Stability Board (FSB) was used to identify TSMC’s climate risks and opportunities. Based on the results, measures and goal management were established to effectively track response progress and outcomes, thereby lowering the financial impact of climate risks on business operation.

A History of Responses to Climate Change

TSMC Actions

<table>
<thead>
<tr>
<th>Year</th>
<th>Nov</th>
<th>Published CSR policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Green House Gas Regulatory Restriction

<table>
<thead>
<tr>
<th>Year</th>
<th>Jul</th>
<th>GHG Reduction &amp; Management Acts (Taiwan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Feb</th>
<th>Trial Procedures of Shanghai Municipality on Carbon Emission Administration (Shanghai, China)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Sep</th>
<th>Clean Air Rule (Washington State, U.S.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Nov</th>
<th>The Paris Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Mar</th>
<th>Published Environmental Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>May</th>
<th>Carbon Management Platform launched</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Aug</th>
<th>Energy and Carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Feb</th>
<th>Created TSMC (China) carbon credit &amp; trade flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Mar</th>
<th>Renewable Energy Task launched</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Jun</th>
<th>Created internal carbon pricing &amp; impact evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Jul</th>
<th>Joined Science Based Target Initiative^</th>
<th>Renewable Energy Task launched</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>May</th>
<th>Joined the Industrial Development Bureau Voluntary Carbon Reduction Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Jun</th>
<th>Launched the Green Tools Certification Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Oct</th>
<th>Launched TSM Energy-Saving Work Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Nov</th>
<th>Signed Power Purchase Agreement for REW2NW (megawatts) of renewable power in Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Dec</th>
<th>Overseas Locations Completed Purchases of Renewable Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Science Based Targets Initiative, SBTi is an initiative jointly established by the Carbon Disclosure Project (CDP), the “We Mean Business” Coalition, the UN Global Compact, and the World Wide Fund for Nature (WWF). It aims for companies to set reductions in line with the Paris Agreement.
TSMC Task Force on Climate-related Financial Disclosures (TCFD)

Corporate Management Strategies and Actions

- Board of Directors reviews climate change-related risks and opportunities.
- Corporate Social Responsibility Executive Committee: The Corporate Social Responsibility Executive Committee is chaired by the CEO. It is a top management organization in climate change management. The Committee reviews TSMC's climate change strategies and goals every six months and reports to the Board of Directors.
- Corporate Social Responsibility Committee: The Corporate Social Responsibility Committee is chaired by the Senior Vice President of Europe & Asia Sales. It includes the Energy Saving and Carbon Emission Reduction Committee, the Corporate Social Responsibility Executive Committee, and the CSR Executive Committee. Each quarter, the Committee formulates management plans, reviews implementation status, and discusses future plans.

2019 Implementation Status

- Composed of high-level managers from various departments, the CSR Executive Committee was established in December 2019, to set long-term targets and development directions for climate change and renewable energy by 2030. For more details, please refer to the section entitled "Climate Risk and Opportunity Matrix.”
- The CSR Executive Committee, in cooperation with the Senior Vice President of Fab Operations, presented a report on climate change-related risks for water resources, power supply, and natural disasters to the Board of Directors. Furthermore, the implementation of carbon reduction actions continued. The risk of Scope 2 indirect greenhouse gas emissions due to electricity consumption and the risk of Scope 3 due to supplier indirect emissions continue to increase. For more details, please refer to the section entitled "Climate Risk and Opportunity Matrix.”
- The TCFD workshop was hosted. Through cross-departmental discussions, climate-related risks/opportunities were identified and ranked, and their financial impact was evaluated.
- Based on the results of cross-departmental discussions on climate risks and opportunities, nine opportunities and seven risks have been identified in total. For more details, please refer to the section entitled "Climate Risk and Opportunity Matrix.”

- Completed the Climate Change Risks and Opportunity Evaluation Project, and used the Carbon Pricing mechanism to promote the promotion and development of energy conservation and carbon reduction activities.
- Used the 2°C global warming scenario of the Intergovernmental Panel on Climate Change (IPCC) to analyze climate risks during operation, and devised relevant mitigation measures that complied with the Adaptation policy framework for climate change and developed strategies for renewable energy purchasing to meet SBT.
- The TCFD workshop was hosted. Through cross-departmental discussions, climate-related risks/opportunities were identified and ranked, and their financial impact was evaluated.
- Reported climate-related risks/opportunity evaluation results and financial impact to the chair of the Corporate Social Responsibility Committee, and then carried out response plans.

- For more details, please refer to the section entitled "Climate Risk and Opportunity Matrix.”
- Researched and devised climate change performance indicators, including greenhouse gas emissions per unit of product, renewable energy purchasing, total energy saved, and days of production interruption due to climate disasters. For more details, please refer to the section entitled "Climate Change and Energy Management Strategies, Goals, and Outcomes.”
- In accordance with carbon inventory results, the risks of Scope 1 emissions were reduced effectively because of continuous implementation of carbon reduction actions. The risk of Scope 2 indirect greenhouse gas emissions due to electricity consumption and the risk of Scope 3 due to supplier indirect emissions continued to increase. For more details, please refer to the section entitled "Greenhouse Gas Emissions (GHG) Inventory.”
- Set climate change and energy management goals for 2030 in accordance with climate change performance indicators and top management performed reviews on implementation performance on a regular basis. For more details, please refer to the section entitled "Climate Change and Energy Management Strategies, Goals, and Outcomes.” and "GHG Reduction Standard Practices.”

- 503 energy-saving measures, divided into eight categories, have been planned and implemented, saving 300 GWh of electricity, and making TSMC the first semiconductor company in Taiwan to receive carbon credits under the TM002 Method. For more details, please refer to the section entitled "Increase Energy Efficiency.”

- The Corporate Social Responsibility Executive Committee, and then carried out response plans.
- The Energy Saving and Carbon Emission Reduction Committee serves as the Company’s top management organization for taking action on climate change risk and opportunity. It is chaired by the Senior Vice President of Fab Operations. Every quarter, this Committee formulates management plans, reviews implementation status, and discusses future plans.

- Engage in cross-departmental discussions, and identify short-term, mid-term, and long-term climate risks and opportunities.
- Major climate risks and opportunities are evaluated for the potential impact to Company operations and finance.
- Carry out scenario analyses and evaluate Science Based Targets (SBT).
- Use the TCFD framework to construct TSMC’s identification procedure for climate risks.
- Set appropriate response plans in accordance with climate risk identification and ranking results.
- Integrated climate risks identification and ranking in Enterprise Risk Management (ERM) process.
- Set management metrics related to climate change.
- Followed ISO 14064-1 to conduct regular inventory of greenhouse gas emissions to examine the impact on the company’s operations.
- Drew up climate change management targets and examine progress and actual performance towards reaching the targets.
Climate Risk Matrix

With the support of top management, TSMC has identified and ranked climate-related risks and opportunities by following the TCFD. The Company refers to international research reports on climate risks and opportunities and conducts cross-organizational evaluations of climate change risks and response measures to identify potential risks and possible opportunities in response to climate change. TSMC has set policies and solutions that encompass economic development, environmental protection, and sustainable development. The Company actively implements energy saving, carbon reduction, and water-saving plans; constructs green buildings, establishes CO2 assets, develops energy-saving products and services, strengthens climate resilience, and develops a culture of environmental sustainability.

Climate Change Risk and Opportunity Matrix

<table>
<thead>
<tr>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Participate in carbon trading/renewable energy market</td>
</tr>
<tr>
<td>2. Obtain government’s cooperation and reward</td>
</tr>
<tr>
<td>3. Construct green buildings</td>
</tr>
<tr>
<td>4. Increase efficiency of water consumption and water recycling</td>
</tr>
<tr>
<td>5. Develop low-carbon products and serve the market</td>
</tr>
<tr>
<td>6. Increase investors’ willingness for long-term investment</td>
</tr>
<tr>
<td>7. Strengthen resilience to natural disasters</td>
</tr>
<tr>
<td>8. Promote energy-saving and low-carbon production</td>
</tr>
<tr>
<td>9. Positive corporate image</td>
</tr>
</tbody>
</table>

Physical Risks

1. Typhoon, flooding
2. Drought
3. Rising Temperature

Transition Risks

1. Energy resources/greenhouse gas laws and regulations
2. Increase in Greenhouse gas emissions costs
3. Unstable energy supply
4. Impact on the Company’s image
## Financial Impact Analysis of Climate Change

<table>
<thead>
<tr>
<th>Climate Risks</th>
<th>Potential Financial Impact</th>
<th>Climate Opportunities</th>
<th>Potential Financial Impact</th>
<th>2019 Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG Restrictions and Carbon Trading System</td>
<td>Restriction on capacity expansion, increase in operation costs</td>
<td>Participation in renewable energy plans</td>
<td>Participate in carbon trading market</td>
<td>Continued to negotiate the purchasing of additional long-term renewable energy in Taiwan</td>
</tr>
<tr>
<td>Increase in Greenhouse gas emissions costs</td>
<td>Increased cost of installation and operation for carbon reduction facilities</td>
<td>Obtain government’s reward and cooperation</td>
<td>Accumulate carbon credits in preparation for future expansion of manufacturing capacity</td>
<td>Applied for fluorinated greenhouse gas and nitrous oxide reduction offset project to receive carbon credit</td>
</tr>
<tr>
<td>Unstable Utilities (Water, Electricity)</td>
<td>Impact on production, increase in operation costs</td>
<td>Construct green buildings</td>
<td>Lower utility costs</td>
<td>Acquired four green building certificates</td>
</tr>
<tr>
<td>Cost of Developing Low-Carbon Energy Saving Products</td>
<td>Increased cost of developing low-carbon energy saving products</td>
<td>Develop or increase energy-saving products or services</td>
<td>Satisfy customer demands for energy saving products, increase revenue</td>
<td>Invested in the development of energy-saving products</td>
</tr>
<tr>
<td>Impact on the Company’s Image</td>
<td>Unable to satisfy the expectations of stakeholders, impacting the Company’s reputation or image</td>
<td>Increase investors’ willingness for long-term investment</td>
<td>Stabilize stakeholder structure, lessen the risk of large stock fluctuations</td>
<td>Boosted green production</td>
</tr>
<tr>
<td>Typhoon, Flooding</td>
<td>Production is affected, causing financial losses and a decrease in revenue</td>
<td>Increase resilience against natural disasters</td>
<td>Strengthen climate resilience and lower the risk of operation interruption and potential losses</td>
<td>Raised the building base of Fab 18 Phase 2 two meters higher</td>
</tr>
<tr>
<td>Drought</td>
<td></td>
<td></td>
<td></td>
<td>Fab 18 Phase 2 committed to using and developing reclaimed water</td>
</tr>
<tr>
<td>Cost of Developing Low-Carbon Energy Saving Products</td>
<td>Increase in energy demand, cost, and carbon emissions</td>
<td>Driving low-carbon green manufacturing</td>
<td>Save energy and cut cost</td>
<td>Established a comprehensive water use monitoring system</td>
</tr>
</tbody>
</table>

### 2019 Actions

- Continued to negotiate the purchasing of additional long-term renewable energy in Taiwan
- 910 GWh of Renewable Energy, Renewable Energy Certificates (REC), and Carbon Credit purchased
- Applied for fluorinated greenhouse gas and nitrous oxide reduction offset project to receive carbon credit
- Acquired four green building certificates
- Invested in the development of energy-saving products
- Boosted green production
- Raised the building base of Fab 18 Phase 2 two meters higher
- Fab 18 Phase 2 committed to using and developing reclaimed water
- Established a comprehensive water use monitoring system
- Conserved 300 GWh of electricity through energy-saving projects
TSMC Standard Practices

Continue to Drive Low-Carbon Manufacturing

TSMC has long been committed to green manufacturing and aspires to be a world leader in low-carbon manufacturing. The Company performs yearly reviews of the overall effectiveness of carbon reduction based on third-party-verified GHG inventory results. Because fluorinated greenhouse gas emissions and the indirect emission of GHGs due to power consumption are the two main sources of GHG emissions, TSMC has for many years continued to establish industry best-practice measures for GHG reduction, replacing and installing roughly 1,600 point-of-use abatement equipment for fluorinated GHGs and nitrous oxide in 2019. At the same time, the Company has continued to build green factories and constructed two additional facilities, acquired four green building certificates, and implemented energy-saving projects on production tools and utility facilities, while taking progressive steps to increase the use of renewable energy to effectively reduce the emission of GHG per unit of production.

GHG Reduction Standard Practices

<table>
<thead>
<tr>
<th>TSMC Standard Practices</th>
<th>2019 Implementation Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 14064-1 inventory and third party verification</td>
<td>100% All fabs and subsidiaries underwent inventory and third party verification</td>
</tr>
<tr>
<td>Optimization of gas quantity used in production</td>
<td>100% 100% introduced GHG-optimized process parameters in accordance with the manufacturing specifications of the Intelligent Engineering Center</td>
</tr>
<tr>
<td>Substitute high global warming potential (GWP) fabrication gases</td>
<td>100% All 12-inch fabs are now using optimized carbon reduction technology – remote plasma dissociation of nitrogen trifluoride (NF3), while 6-inch and 8-inch fabs are using nitrogen trifluoride (NF3)/octafluorobutane (C4F8)</td>
</tr>
<tr>
<td>Install Point-Of-Use abatement equipment for fluorinated GHGs</td>
<td>100% Installed 1,500 POU abatement equipment on new process tools using F-GHGs in new and existing fabs (including subsidiaries)</td>
</tr>
<tr>
<td>Continue to develop on-site nitrous oxide removal technology</td>
<td>5 100% Continued to develop removal technology, and types of certified equipment increased from 3 to 5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TSMC Standard Practices</th>
<th>2019 Implementation Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 50001 energy management and third party verification</td>
<td>100% The Company underwent ISO 50001 inspection and third party verification; 100% of facilities in Taiwan completed third party verification in 2019</td>
</tr>
<tr>
<td>Construct green buildings</td>
<td>1 1 The Company leads the global semiconductor industry with the largest LEED-certified building area and constructed two more fabs, which received LEED certification and EEWH green architecture certification. In total to date, 32 buildings have received LEED certifications and 23 buildings received EEWH certifications</td>
</tr>
<tr>
<td>Energy efficiency standards</td>
<td>503 503 Energy efficiency of advanced-technology fab tools leads industry peers, with 503 energy-saving measures implemented and 300 GWh saved</td>
</tr>
<tr>
<td>Next-generation fab tools use energy-saving, carbon-reducing designs</td>
<td>1 1 Launched an energy conservation project for next-generation fab tools, and in 2019, implemented 110 energy saving projects for 54 process tools. Four vendors completed energy-saving certification for 27 process tools</td>
</tr>
<tr>
<td>Introduce renewable energy</td>
<td>910 GWh 910 GWh Leading semiconductor manufacturer in Taiwan, with 910 GWh of Renewable Energy, Renewable Energy Certificates (REC), &amp; Carbon Credit purchased</td>
</tr>
</tbody>
</table>

Note: Data comparison with industry peers refers to the World Semiconductor Association Report.
Greenhouse Gases (GHG) Inventory

In 2019, TSMC continued to implement the standard practices of the manufacturing process gases by optimizing the amount of use, minimizing the global warming potential (GWP), and maximizing the removal rate in exhaust, and comprehensively adopted the best available technology. By taking concrete actions, the Company has effectively reduced 320 metric tons CO2e of direct emissions (Scope 1), of which fluorinated greenhouse gases emissions per unit of production were reduced considerably by 65%, achieving the 2020 reduction goal ahead of schedule. Indirect emissions (Scope 2) due to energy consumption were also curbed as a result of increased use of renewable energy. Indirect emissions (Scope 3) of upstream and downstream value chains mainly involve raw material production and energy-related activities. Currently, TSMC has set energy conservation and carbon reduction goals with its suppliers to work together toward creating a sustainable supply chain. Because GHG emission reduction accounts for fluorinated greenhouse gases emissions, the term "GHG emission per unit of production" will be used as of 2020 to indicate future management performance.

<table>
<thead>
<tr>
<th>Year</th>
<th>GHG Emission of Taiwan Facilities</th>
<th>GHG Emission Intensity (CO2e / 8-inch equivalent wafer mask layer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1,566,662</td>
<td>0.0059</td>
</tr>
<tr>
<td>2016</td>
<td>1,648,268</td>
<td>0.0058</td>
</tr>
<tr>
<td>2017</td>
<td>1,638,051</td>
<td>0.0057</td>
</tr>
<tr>
<td>2018</td>
<td>1,678,753</td>
<td>0.0056</td>
</tr>
<tr>
<td>2019</td>
<td>1,638,051</td>
<td>0.0056</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>GHG Emission of Subsidiaries</th>
<th>GHG Emission Intensity (CO2e / 8-inch equivalent wafer mask layer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>460,983</td>
<td>0.0062</td>
</tr>
<tr>
<td>2016</td>
<td>387,242</td>
<td>0.0062</td>
</tr>
<tr>
<td>2017</td>
<td>435,396</td>
<td>0.0062</td>
</tr>
<tr>
<td>2018</td>
<td>419,979</td>
<td>0.0062</td>
</tr>
<tr>
<td>2019</td>
<td>392,989</td>
<td>0.0062</td>
</tr>
</tbody>
</table>

TSMC pays close attention to the various climate actions following the Paris Agreement, including the science-based targets (SBT) of holding the increase in the global temperature to well below 2°C and the 100% renewable energy (RE100) initiative. TSMC is well aware that using renewable energy is the necessary and primary approach for existing companies to achieve the SBT reduction goal. TSMC has continued to grow its production capability in recent years. Thus, its overall carbon emissions are still increasing, despite the Company’s global efforts to implement best practices for energy conservation and carbon reduction, and achieved the goal of reducing carbon emission per unit of production. Moreover, the renewable energy markets in TSMC’s major production bases are not equipped to supply as much renewable energy as other European and American countries. In addition to constantly strengthening various green innovations, TSMC also actively promotes regional renewable energy development to identify potential opportunities for carbon reduction.

Greenhouse Gas Emissions and Reduction Roadmap

- Energy conservation and carbon reduction measures
  - Use renewable energy
  - Carbon emissions pathway with reduction plans
  - Carbon emissions pathway without reduction
  - Science-based targets

Note: Greenhouse gas emissions including Scope 1&2 are normalized on 2017 as baseline. Note 1: Greenhouse gas emissions including Scope 1&2 are normalized on 2017 as baseline.
Increase Use of Renewable Energy

TSMC has been actively installing, using, and purchasing renewable energy in 2019. In addition to compliance with legal obligations, our aim is for 25% of power consumed by TSMC fabs to be supplied from renewable energy, and non-fab power consumption is 100% supplied from renewable energy by the end of 2030. Our long-term goal is to purchase renewable energy until it makes up 100% of TSMC’s power consumption. Through purchasing of renewable energy and supporting the government’s renewable energy policies, TSMC hopes to drive the application of renewable energy and development of related industries, and practice environmental sustainability.

Renewable Energy Purchasing

Starting in 2018, TSMC began to purchase renewable energy, RECs, and carbon credits in countries with comprehensive regulations and ample supply, aiming to completely offset the carbon dioxide emissions from the power used in locations around the world such as the United States, Canada, Europe, China, and Japan. In 2019, TSMC’s overseas sites have achieved the goal of zero carbon emissions from power consumption.

In 2019, TSMC developed strategies to increase the purchasing of renewable energy in Taiwan. Around 0.7 GWh of renewable energy is currently under negotiation, which will be supplied to TSMC in the coming years. Since Taiwan’s renewable energy development is still in its nascent phase, TSMC has set up a Renewable Energy Development Task Force through which it closely communicates with government through the Allied Association for Science Parks and the Taiwan Semiconductor Industry Association (TSIA) to provide constructive suggestions regarding renewable energy development. For example, TSMC has advised the government to expand offshore wind farms and increase the supply from renewable energy trading platforms. With the collaboration between the Ministry of Economic Affairs, Taipower, Green energy companies and TSMC, renewable energy development in Taiwan has reached a key milestone. 90MW of renewable energy was officially provided to TSMC in early May 2020, making TSMC one of the first companies in Taiwan to purchase transmitted renewable energy.

The highest governing body of TSMC—the Board of Directors—supports the UN SDGs of affordable and clean energy and climate action, pays attention to renewable energy purchasing issues, and requires the Corporate Social Responsibility Executive Committee to regularly provide reports on renewable energy purchase strategies and progress. TSMC believes that close communication with the government and cooperation with renewable energy providers will accelerate the growth of Taiwan’s renewable energy industry, which in turn increases the purchasing of renewable energy and reduces the environmental impact of power consumption.

Use of Renewable Energy and Percentage

<table>
<thead>
<tr>
<th>Year</th>
<th>Renewable Energy Purchased and Self-Generated Electricity (GWh)</th>
<th>Percentage of Renewable Energy Used (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1.2</td>
<td>10.0</td>
</tr>
<tr>
<td>2016</td>
<td>2.1</td>
<td>11.9</td>
</tr>
<tr>
<td>2017</td>
<td>0.9</td>
<td>16.5</td>
</tr>
<tr>
<td>2018</td>
<td>7.1</td>
<td>25.5</td>
</tr>
<tr>
<td>2019</td>
<td>6.8</td>
<td>25.7</td>
</tr>
<tr>
<td>2020</td>
<td>7</td>
<td>25.0</td>
</tr>
<tr>
<td>2021</td>
<td>25</td>
<td>25.0</td>
</tr>
</tbody>
</table>

TSMC Renewable Energy Development Timeline

- Purchased 200 GWh of renewable energy, holding the title of Taiwan’s largest renewable energy purchaser 2 years in a row
- Taiwan fabs signed a long-term contract to purchase 30 MW (Megawatts) of renewable energy
- 880 GWh in Renewable Energy, Renewable Energy Certificates (REC), & Carbon Credit purchased
- 910 GWh of Renewable Energy, Renewable Energy Certificates (REC), & Carbon Credit purchased
- Around 0.7 GWh of renewable energy is under negotiation
- In response to the Amendment to Electricity Act opening the electricity market, a renewable energy team was established to evaluate renewable energy purchases
- Joined the Taiwan Renewable Energy Certification Platform, and Fab 6 was among one of the first semiconductor fabs to receive renewable energy certificate
- Purchased 100 GWh of renewable energy, 3 consecutive years as Taiwan’s largest purchaser

Corporate Social Responsibility Report

Our Business Sustainable Governance Our Focuses and Progress

- Ethical Management
- Innovation and Service
- Responsible Supply Chain
- Green Manufacturing
- Inclusive Workplace
- Common Good

Appendix

2019
Installing a Renewable Energy Power System

Apart from purchasing renewable energy, TSMC has also installed solar panels at its sites, providing zero carbon emission renewable energy for fabs. In 2019, 1,720 kWp of solar panel capacity was installed, and has already provided 3.7 GWh, decreasing carbon emissions by 1,975 metric tons, or the annual carbon absorbed by 197,500 trees. In 2020, an additional 655 kWp in capacity of solar panels will be added, and this is expected to generate up to 5.27 GWh of power.

Increase Energy Efficiency

In light of the continuous growth of production capacity and the development of complex advanced manufacturing processes, improving the efficiency of production energy is a longstanding commitment for TSMC. In addition to setting energy-saving goals in 2019, TSMC also responded to the seventh SDG of the UN: Affordable and clean energy. To meet our goal of doubling energy efficiency by 2030, TSMC has developed the Process Energy Efficiency Enhancement Plan, which aims to manage energy usage, increase power efficiency, and maximize production process efficiency to ultimately double the energy efficiency of each process technology after its fifth year of mass production. In 2019, the energy efficiency of >16-nm process technology improved 1.4 times on average after five years of mass production, and the energy efficiency of 10-nm and 7-nm process technology also improved 0.7 times on average after three years of mass production, reaching their targets for the year.
Energy management is an ongoing responsibility for TSMC. The Company is committed to systematically managing each kWh of power. All fabs in Taiwan have obtained ISO50001 energy management certification in 2019. Insisting on transparent and fair inspection and inventory, TSMC identifies improvement opportunities from its status quo; therefore, as of 2019 following a comprehensive GHG inventory through ISO 14604 verification, TSMC requires all of its fabs to complete the ISO50001 energy management third party verification every year and follow the Plan-Do-Check-Act (PDCA) management model to strengthen their self-management mechanisms and continue to achieve energy conservation and carbon reduction targets.

In 2019, TSMC consumed a total of 14,327 GWh in energy; with electricity making up 94.8%, natural gas coming second at 5.2%, and diesel with less than 0.1%. Electricity is the main energy used to power TSMC’s manufacturing equipment and fab systems. Natural gas is used in exhaust processing facilities to decrease the direct emission of fluorinated greenhouse gases and volatile organic compounds. Diesel is not used directly in production, but to run power generators and fire pumps during emergencies, power outages, or during annual maintenance.

Total Energy Consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Energy Consumption (GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>8,360</td>
</tr>
<tr>
<td>2016</td>
<td>9,158</td>
</tr>
<tr>
<td>2017</td>
<td>11,288</td>
</tr>
<tr>
<td>2018</td>
<td>11,564</td>
</tr>
<tr>
<td>2019</td>
<td>12,662</td>
</tr>
</tbody>
</table>

Note 1: Data included TSMC’s facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing), and VisEra

Note 2: 1 cubic meter of natural gas=10.5 kWh of electricity; 1 kWh=3,600 kilojoules

Comprehensive Energy Inventory and ISO50001 Third-Party Verification

Focus of PDCA Implementation for Energy Management System

- **Energy Inventory and Action Plan**: Comprehensively conduct energy inventory, analyze energy consumption distribution of equipment, and formulate action plan for energy conservation and carbon reduction.

- **Implementation and Operation**: Follow action plan to implement energy conservation and carbon reduction actions, including personnel training, facility efficiency improvement, and equipment replacement.

- **Management Review and Continuous Advancement**: Improve deficiencies according to the gap between the current situation and targets, and carry out various improvement practices to achieve goals, while setting targets for the next phase.

- **Supervision and Measurement**: Supervise, measure, and analyze all implementation items, control energy management performance, and ensure energy conservation goals are achieved.

Greenhouse Gas Emission Distribution

- CO₂ + CH₄: 75%
- F-GHGs: 15%
- N₂O: 8%
- O₂: 2%

**Note**: Diesel fuel not shown in the distribution chart.
In 2019, increases in advanced process development and process complexity led to increased power consumption in new process equipment, raising the power consumption per unit of 10nm and 7nm production to double that of >16-nm process technologies. Consequently, the overall power consumption per unit of production in 2019 increased by 17.9% compared to the base year and therefore did not achieve the default reduction target of 11.5%. For this reason, TSMC has increased its use of renewable energy each year and also extended its technological innovation to sustainable equipment designs. In 2019, the Company invested resources and collaborated with more suppliers to introduce complete energy-saving plans in the development of next-generation process equipment, with the goal of saving 5,000 GWh of electricity by 2030.

Expanding Energy Saving Measures

At TSMC, the primary consumers of energy are production tools and fab facility systems. At the same time, the Company’s Operations and Facilities organizations are the main advocates of energy conservation. TSMC’s Energy Conservation and Carbon Reduction Committee has organized a comprehensive range of energy-saving activities in recent years, such as the cross-organizational Energy-Saving Idea Competition, which encourages employees to integrate energy-saving concepts in manufacturing facilities. In 2019, TSMC has carried out a total of 503 energy-saving measures spanning 8 different categories. These measures saved 300 GWh, which is equal to eliminating 160 thousand metric tons of carbon dioxide emissions, and saved NT$750 million in utility fees. By cutting down on carbon dioxide emissions, NT$240 million was saved in potential external carbon costs. To further promote green innovation in the supply chain, TSMC has continuously worked with equipment suppliers to develop next-generation energy saving equipment. In 2019, 110 energy-saving projects were introduced to 54 equipment models, with 45 models reaching average energy savings of 12%, surpassing annual energy targets.

Power Consumption per Unit of Production

| Unit: kWh/8-inch equivalent wafer mask layer |

<table>
<thead>
<tr>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.9</td>
<td>9.7</td>
<td>9.5</td>
<td>9.9</td>
<td>12.5</td>
</tr>
</tbody>
</table>

TSMC 15-year Energy-Saving Targets

<table>
<thead>
<tr>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>900</td>
<td>1,200</td>
<td>2,800</td>
<td>5,000</td>
</tr>
</tbody>
</table>

Note 1: Data included TSMC’s facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing), and VisEra
Note 2: Diesel and natural gas are excluded from calculations as they are not used for production

16 Million Trees

In 2019, TSMC conserved 300 GWh of energy, reducing carbon emissions by 160,000 metric tons, which is the yearly carbon sequestration rate of around 16 million trees.

5,000 GWh

Accumulated Energy Saved by 2030

In 2019, TSMC conserved 300 GWh of energy, reducing carbon emissions by 160,000 metric tons, which is the yearly carbon sequestration rate of around 16 million trees.

In 2019, TSMC conserved 300 GWh of energy, reducing carbon emissions by 160,000 metric tons, which is the yearly carbon sequestration rate of around 16 million trees.

In 2019, TSMC conserved 300 GWh of energy, reducing carbon emissions by 160,000 metric tons, which is the yearly carbon sequestration rate of around 16 million trees.

In 2019, TSMC conserved 300 GWh of energy, reducing carbon emissions by 160,000 metric tons, which is the yearly carbon sequestration rate of around 16 million trees.

In 2019, TSMC conserved 300 GWh of energy, reducing carbon emissions by 160,000 metric tons, which is the yearly carbon sequestration rate of around 16 million trees.

In 2019, TSMC conserved 300 GWh of energy, reducing carbon emissions by 160,000 metric tons, which is the yearly carbon sequestration rate of around 16 million trees.

In 2019, TSMC conserved 300 GWh of energy, reducing carbon emissions by 160,000 metric tons, which is the yearly carbon sequestration rate of around 16 million trees.
TSMC Energy Conservation Measures

Note: Carbon dioxide emission is 0.533 kg CO₂e/kWh; 1 kWh=3,600 kilojoules
Strengthen Climate Resilience

Resilience to climate disasters is an integral part of corporate operations in an increasingly extreme climate environment. Using 2°C-global warming and worst-case disaster scenarios, TSMC identifies key factors from climate change and extreme weather each year that could affect operations such as droughts, high temperatures, power shortages, floods, and wind damage, and establishes standard guidelines for all fabs to strengthen operational resilience. The Company successfully achieved its target of undisrupted production in 2019, and successfully protected against possible natural disasters and business losses brought on by climate change.

By constructing fabs in compliance with international and domestic green building certifications, TSMC can not only reduce the consumption of water, electricity, and other resources during the construction and operation processes but also increase the climate resilience of buildings. Meanwhile, ecological operation features were incorporated in architectural designs to promote the co-existence of industrial production and ecological sustainability.

As of 2019, 32 fabs have received LEED gold international certifications and 23 fabs received EEWH certifications. TSMC is also leads the global semiconductor industry with the largest LEED-certified architectural area, and number one in Taiwan for largest green building-certified areas and certified green fabs.

For more details, please refer to the article titled Bring Back the Environment - TSMC Ecological Sustainability Park that Technology and Ecology Co-exist on the TSMC Corporate Social Responsibility website.
Setting an Example to Lead Industry Learning

TSMC’s active energy-saving and carbon-reducing performance has been registered on the Voluntary Greenhouse Gases Emissions Reduction Platform of the Bureau of Industrial Development. Through the government’s yearly verification, TSMC has been recognized as an Outstanding Manufacturer for Voluntary Greenhouse Gases Emissions Reduction by the Bureau of Industrial Development. TSMC has comprehensively adopted the industrial best practice measures of reducing fluorinated greenhouse gases used in production. This approach was verified by a third party in 2019, making TSMC the first semiconductor company in Taiwan to receive carbon credits under the TM002 Method. In the future, the Company will fulfill its commitment to green manufacturing by using the carbon credits obtained from this reduction method to reduce greenhouse gas emissions from TSMC’s manufacturing processes.

TSMC has spent years adjusting its operations to mitigate the impacts of climate change and is more than happy to share its environmental knowledge, experience, and optimization measures through public associations so that industry standards can be improved. These measures include six dimensions of eight energy-saving measures, such as the three energy-saving steps of intelligent chilled water system and energy-saving measures for uninterrupted power systems and wafer cleaning hot water recycling systems. In 2019, the TSMC-led Taiwan Semiconductor Industry Association (TSIA) Energy Committee established an energy-saving task force. The task force regularly engages with members of 13 associations to share energy-saving experience and management practices, enabling an additional 200 GWh of electricity to be saved on top of the 300 GWh electricity saved by TSMC. Also in 2019, TSMC joined forces with flat panel display manufacturers and packaging/testing industries to host the High-Tech Energy Conservation and Carbon Reduction Forum. Together, they promised to create a sustainable industry by achieving the following energy management goals by 2025: Adopt ISO50001 in 80% of manufacturing facilities and reduce GHG emissions by 85%.

Mark Liu, the Chairman of TSMC, is the Chairman of the Taiwan Semiconductor Industry Association (TSIA). Chairman Liu and other semiconductor, panel display, and packaging/testing manufacturers, jointly declare their commitment to energy conservation and carbon reduction at the High-Tech Energy Conservation and Carbon Reduction Forum.
Case Study

Taking the Lead in Joining Forces with Suppliers to Develop World-class Semiconductor Green Tools

As the world’s largest dedicated IC foundry company, TSMC is committed to creating a sustainable semiconductor supply chain. Because the power consumption of process equipment accounts for more than 50% of the company’s energy use, and the number of advanced process equipment is increasing every year, TSMC has collaborated with equipment suppliers since 2016 to develop green tools for semiconductor manufacturing. Before these new tools were introduced, TSMC completed energy-saving design verification, installed energy-saving components, and expanded the energy-saving effects of advanced process equipment.

TSMC is the first semiconductor company in the world to ask its equipment suppliers to introduce energy-saving measures. Based on the assessments of the Energy and Carbon Reduction Committee, in 2018‒2019 TSMC invited seven semiconductor manufacturers and suppliers around the world to host hundreds of discussion forums and extensively analyze the energy consumption parameters of all advanced fab tools, subsequently leading to the launch of the Energy Conservation Action Project for Next-Generation Fab Tools. From energy-saving ideas, planning, simulation testing to product verification, this process is continuously repeated, and energy-saving specifications are incorporated into new fab tool procurement standards, demonstrating TSMC’s commitment to saving energy. TSMC expects that energy savings will be achieved to 20% by 2030 to drive the positive cycle of the industry and supply chain.

Thanks to the relentless efforts of more than 300 TSMC employees, 250 energy saving action plans were proposed in 2019, of which 110 plans were approved, verified, and applied to 54 types of 5-nm advanced process tools. High-efficiency parts and energy saving designs have been incorporated into 11 types of energy-intensive components. TSMC expects that 200 GWh of electricity will be saved in 2020 due to the use of 5-nm energy-saving fab tools. In addition, the Company developed the "green tools certification system" in 2019, and completed the green certification of 27 types of fab tools for four equipment suppliers.

Milestones for Next-Generation Energy Saving Equipment

<table>
<thead>
<tr>
<th>Initiate</th>
<th>Plan</th>
<th>Verify</th>
<th>Expand</th>
<th>Introduce</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>2017</td>
<td>2018</td>
<td>2019</td>
<td>2020</td>
</tr>
</tbody>
</table>

- Set goal to save 20% of energy in new process equipment
- Work with top 5 suppliers of energy-intensive equipment to initiate energy saving equipment design
- Top 5 suppliers propose energy conservation plans and engage in regular discussion and review with TSMC
- Complete the verification of 37 energy conservation measures
- Apply to 20 equipment models to save 10% of energy on average
- Expand to include top 7 suppliers of energy-intensive equipment
- Complete the verification of 110 energy conservation measures
- Apply to 45 equipment models to save 12% of energy on average
- Develop a "green tools certification system"

Suppliers, Domain, and Scope of New Equipment Energy Conservation Cooperation

- Top 7 Partnering Suppliers
- Top 10 Equipment Domains
- Scope of 11 Energy-Intensive Components
- 110 Energy saving action plans were verified
- 54 Types of tools were applied
- 27 Types of green tools were certified
# Water Management

## Strategies & 2030 Goals

### Risk Management of Water Resources

- Enforce climate change mitigation policies, implement water conservation and water shortage adaptation measures

<table>
<thead>
<tr>
<th>2019 Achievements</th>
<th>2020 Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Reduce unit water consumption (liter/8-inch equivalent wafer mask layer) by 30% (Base year: 2010)</em></td>
<td><em>Reduce unit water consumption (liter/8-inch equivalent wafer mask layer) to 10% (Base year: 2010)</em></td>
</tr>
</tbody>
</table>
| Reduced water consumption per unit product by 5.2% *(Base year: 2010)*<sup>4</sup>  
Target: 27%  
*Saved an additional 3,280,000 metric tons of water through newly-adopted water conservation measures*  
Target: 1.14 million metric tons  
*Discharge less than 6 ppm of tetramethylammonium hydroxide (TMAH)*  
Water pollution composite indicator reduction rate of 20% | Discharge less than 6 ppm of tetramethylammonium hydroxide (TMAH)  
Water pollution composite indicator reduction rate of 20% |

### Develop Diverse Water Sources

- Integrate internal and external company resources to develop regenerated water technology; implement water conservation and the use of regenerated water in the manufacturing process

- *Increase the replacement rate of regenerated water by more than 30%*<sup>1</sup>  
*Commence the TSMC Tainan Science Park Reclaimed Water Plant tender project and start supplying water in 2021*

### Develop Preventive Measures

- Improve the efficiency of water pollution prevention and removal of water pollutants<sup>2</sup>

- **Water pollution composite indicator 30% above effluent standards**<sup>3</sup>  
**Average concentration of tetramethylammonium hydroxide (TMAH) in wastewater discharge was 7.86 ppm**  
**Average concentration of copper ions in wastewater discharge was 0.09 ppm**  
Target: Tetramethylammonium hydroxide (TMAH) < 8 ppm; copper ion (Cu<sup>2+</sup>) < 0.15 ppm  
*Exceeded*  
*Achieved*  
*Missed Target*  
*Note 1: Replacement rate of reclaimed water includes cumulative total of conserved water*  
*Note 2: The scope of water pollution projects and data includes Taiwan facilities and VisEra*  
*Note 3: Water pollution composite indicator is an integration of TSMC’s pollutants as compared to the average reduction rate of effluent standards: Including chemical oxygen demand (COD), villaumite, suspended solids, ammonia nitrogen, nitrate nitrogen, arsenic, boron, copper, NMP, and cobalt*  
*Note 4: Due to test production in new fabs, water consumption per unit product did not meet standards. TSMC continues to commit to the development of water reclamation techniques. Its industrial water reclamation plant is expected to commence operation and supply water by 2021*
Semiconductor processes have become complex as they advance from 2D structures to a 3D FinFET architecture, which in turn increases the types and quantity of the chemical materials used. Water is vital to cleaning wafers and maintaining a clean environment. TSMC has established various water recycling applications through water resource risk management, expansion of diverse water sources, and the development of pollution prevention techniques in order to maximize the efficiency water use throughout the water cycle in its facilities. In 2019, the Company took further steps to regulate the water management framework of its facilities to ensure the reasonable allocation of facility water resources in response to seasonal temperature changes.

TSMC Water Consumption Rate at Three Science Parks

<table>
<thead>
<tr>
<th>Science Park</th>
<th>Daily Supply</th>
<th>TSMC Water Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hsinchu Science Park</td>
<td>55.3</td>
<td>5.7 (10.3%)</td>
</tr>
<tr>
<td>Reservoirs: Baoshan Reservoir, Second Baoshan Reservoir</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central Taiwan Science Park</td>
<td>146.1</td>
<td>4.9 (3.3%)</td>
</tr>
<tr>
<td>Reservoirs: Liyutan Reservoir, Deji Reservoir</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern Taiwan Science Park</td>
<td>94.3</td>
<td>5.0 (5.3%)</td>
</tr>
<tr>
<td>Reservoirs: Nanhua Reservoir, Zengwen Reservoir</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Public information from the website of the Water Resources Agency, Ministry of Economic Affairs; Reservoir capacity of Central Taiwan Science Park includes the capacity of Taichung and Miaoli.
Main Water Cell and On-site Recycling System

**Water Supply Diversity**
- Diverse water resource supply outside of facilities
- Water Reclamation Plants in Yongkang and Anping, Tainan

**Water Efficiency Management**
- Domestic water consumption
- Air scrubbing in cleanrooms
- Reclaiming air-scrubbing water from cleanrooms
- Ultrapure water system
- Tool production
- Liquid waste distribution
- Wastewater treatment system
- Wastewater treatment plants

**Wastewater Resource Recycling**
- TSMC Water Reclamation Plant in Southern Taiwan Science Park
- Advanced oxidation process system

**Waste Resource Recycling**
- Final Discharge

**Water Reclaim System**
- Improvement and Balance in Facilities
- City water replenishment during peak periods
- Reclaiming AC condensate water
- Reclaiming exhaust scrubbing water
- Smart water pumping model to regulate peak water consumption

**City water**
- AC condensate water
- AC recycled water
- Rainwater recycling system

**Tool production**
- Liquid waste distribution
- Wastewater treatment system

**Wastewater treatment plants**
- TSMC Water Reclamation Plant in Southern Taiwan Science Park
- Advanced oxidation process system

**Cooling tower**
- Seasonal factors influence evapotranspiration, causing imbalance in facility recycled water

**Exhaust scrubber system**
- Reclaiming exhaust scrubbing water

**City water replenishment during peak periods**
- Replace city water with excess recycled water by increased refining in winter

**Water Reclamation Plants in Yongkang and Anping, Tainan**
- Introduce in 2021

**AC recycled water**
- Reclaiming AC condensate water

**Ethical Management**
- Responsible Supply Chain
- Green Manufacturing

**Innovation and Service**
- Responsible Supply Chain
- Green Manufacturing

**Our Focuses and Progress**
- Common Good

**Sustainable Governance**
- Our Business
In 2019, TSMC has continuously increased the depth of its four water conservation measures: reduce water consumption by facility systems, increase wastewater recycling in facility systems, improve system water production rates, and decrease water discharge loss from the system. In addition to continuously enhancing the effectiveness and expanding the scale of the eight existing water-saving measures, TSMC also introduced wastewater recycling machines and took comprehensive measures in five of its facilities to “purify recycled water into industrial water”, effectively saving 1,286,000 tons of water. The annual additional water conserved reached 3,280,000 metric tons in total.

Many newly-built TSMC fabs (Fab 15 Phase 7 and Fabs 19 Phases 1 and 2) began operating in 2019. Due to increased demand for process cleanliness and optimization of operating systems, unit water consumption was 59.3 (L/8-inch equivalent wafer mask layer) in 2019, a reduction of 5.2% as compared to the base year, which means the annual target was not achieved.

### Water Conservation Measures and Results in 2019

<table>
<thead>
<tr>
<th>Measure</th>
<th>Recycled/Conserved</th>
<th>Metric Tons</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease Water Discharge Loss from the System</td>
<td>Recycled</td>
<td>436,000</td>
<td>13.31%</td>
</tr>
<tr>
<td></td>
<td>Conserved</td>
<td>2,000</td>
<td>0.06%</td>
</tr>
<tr>
<td>Reduce Facility System Water Consumption</td>
<td>Reduced cooling tower and sand filter backwash water</td>
<td>1,000</td>
<td>0.04%</td>
</tr>
<tr>
<td></td>
<td>Conserved kitchen cleaning water in office buildings</td>
<td>2,000</td>
<td>0.06%</td>
</tr>
<tr>
<td>Increase Wastewater Recycling of Machines</td>
<td>Recycled hydrofluoric acid wastewater</td>
<td>285,000</td>
<td>8.67%</td>
</tr>
<tr>
<td></td>
<td>Reclaimed water produced from TMAH system</td>
<td>574,000</td>
<td>17.48%</td>
</tr>
<tr>
<td></td>
<td>Purified recycled water into industrial water</td>
<td>1,286,000</td>
<td>39.24%</td>
</tr>
<tr>
<td>Improve Water Production Rate of the System</td>
<td>Increased RO recycling systems by</td>
<td>132,000</td>
<td>8.67%</td>
</tr>
<tr>
<td></td>
<td>Improved usage efficiency by allocating</td>
<td>302,000</td>
<td>17.45%</td>
</tr>
</tbody>
</table>

### Annual Additional Water Conserved

3,280,000 Metric tons
Annual Water Conservation

<table>
<thead>
<tr>
<th>Year</th>
<th>Unit: ten thousand metric tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>141</td>
</tr>
<tr>
<td>2017</td>
<td>338</td>
</tr>
<tr>
<td>2018</td>
<td>465</td>
</tr>
<tr>
<td>2019</td>
<td>793</td>
</tr>
</tbody>
</table>

Water Recycling and Usage Efficiency

<table>
<thead>
<tr>
<th>Year</th>
<th>Total amount of water recycling (million metric tons)</th>
<th>Average process water recycling rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>85.6</td>
<td>87.3</td>
</tr>
<tr>
<td>2016</td>
<td>94.3</td>
<td>87.4</td>
</tr>
<tr>
<td>2017</td>
<td>103.4</td>
<td>87.5</td>
</tr>
<tr>
<td>2018</td>
<td>129.0</td>
<td>86.7</td>
</tr>
<tr>
<td>2019</td>
<td>133.6</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Total amount of water recycling includes numbers from manufacturing process water treatment and recycling as well as manufacturing process water recycling in scrubber towers.

Note 2: Total volume of water recycled and average recycling rate of water for manufacturing processes are calculated with data from TSMC’s facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing) and VisEra.

City Water Consumption and Water Consumption per Wafer-Layer

<table>
<thead>
<tr>
<th>Year</th>
<th>Total city water consumption of Taiwan facilities (million ton)</th>
<th>Total city water consumption of subsidiaries (million metric tons)</th>
<th>Water consumption per wafer-layer (Liter / 8-inch equivalent wafer mask layer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>3.5</td>
<td>3.4</td>
<td>38.6</td>
</tr>
<tr>
<td>2016</td>
<td>3.4</td>
<td>3.8</td>
<td>45.2</td>
</tr>
<tr>
<td>2017</td>
<td>3.8</td>
<td>5.7</td>
<td>51.0</td>
</tr>
<tr>
<td>2018</td>
<td>5.7</td>
<td>6.3</td>
<td>58.0</td>
</tr>
<tr>
<td>2019</td>
<td>6.3</td>
<td>7.0</td>
<td>64.0</td>
</tr>
</tbody>
</table>

Wastewater Discharge per Product Unit

<table>
<thead>
<tr>
<th>Year</th>
<th>Wastewater discharge of Taiwan facilities (million metric tons)</th>
<th>Wastewater discharge of subsidiaries (million metric tons)</th>
<th>Discharge per product unit (Liter / 8-inch equivalent wafer mask layer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>2.79</td>
<td>31.0</td>
<td>31.0</td>
</tr>
<tr>
<td>2016</td>
<td>2.75</td>
<td>31.4</td>
<td>31.4</td>
</tr>
<tr>
<td>2017</td>
<td>2.86</td>
<td>31.1</td>
<td>31.1</td>
</tr>
<tr>
<td>2018</td>
<td>4.12</td>
<td>31.6</td>
<td>31.6</td>
</tr>
<tr>
<td>2019</td>
<td>4.44</td>
<td>39.8</td>
<td>39.8</td>
</tr>
</tbody>
</table>

Wastewater discharge is closely related to city water consumption and recycled water. Unit wastewater discharge in 2019 was 39.8 (L/8-inch equivalent wafer mask layer), an increase of 22.1% as compared to last year. TSMC actively conducts inventory of various water saving measures. By optimizing the water efficiency of advanced processes and introducing water reclamation techniques, the Company aims to improve the process water recycling rate, recycling volume, and use of reclaimed water and to reduce wastewater discharge.

Water Recycling and Usage Efficiency

- **187%**: Saved an additional 3,280,000 metric tons of water through newly-adopted water conservation measures, surpassing annual water saving targets by 187%.

- **6 Years**: Cu²⁺ and NH₄-N concentration of effluent water achieved 2025 goals six years ahead of schedule.

Wastewater discharge is closely related to city water consumption and recycled water. Unit wastewater discharge in 2019 was 39.8 (L/8-inch equivalent wafer mask layer), an increase of 22.1% as compared to last year. TSMC actively conducts inventory of various water saving measures. By optimizing the water efficiency of advanced processes and introducing water reclamation techniques, the Company aims to improve the process water recycling rate, recycling volume, and use of reclaimed water and to reduce wastewater discharge.

1. **Annual Cumulative Water Conserved**
2. **Annual Additional Water Conserved**

**Note 1**: Total amount of water recycling includes numbers from manufacturing process water treatment and recycling as well as manufacturing process water recycling in scrubber towers.

**Note 2**: Total volume of water recycled and average recycling rate of water for manufacturing processes are calculated with data from TSMC’s facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing) and VisEra.
Develop Diverse Water Sources

Adopting Domestic & Industrial Reclaimed Water to Reduce City Water Consumption

As a leading global semiconductor company, TSMC began developing water reclamation techniques in 2015 by coordinating with government departments to plan the construction of industrial recycled water facilities and use of recycled domestic water. In line with the reclaimed water pipeline configurations in science parks, bidding for TSMC’s Tainan Science Park Reclaimed Water Plant was successfully launched in 2019. This operation represents a concrete action by TSMC to expand water resource diversity.

Timeline of Highlights for Regenerated Water

Technology and R&D
- Biological treatment, advanced oxidation technology, and Membrane filtration module
- 48% reduction in the unit cost of water production
- Fab 14 (P5) established “Wastewater Effluent Recycling Pilot Plant
- Reached production line standards for regenerated water quality
- Began the development of water reclamation techniques
- Open tender for collaboration to build the TSMC Tainan Science Park Reclaimed Water Plant

Procurement of Tenders and Project Collaboration
- Collaborated with Southern Taiwan Science Park Management Department to build the TSMC Tainan Science Park Reclaimed Water Plant
- Commenced construction of water reclamation plant in Yongkang, Tainan
- Construction contract signed for TSMC Tainan Science Park Reclaimed Water Plant
- Supply TSMC with 10,000 tons/day of water from the water reclamation plant in Yongkang, Tainan
- Increase water supply for TSMC from the water reclamation plant in Yongkang, Tainan to 9500 tons/day

Construct Water Reclamation Plant and Supply Water
- Construct domestic water reclamation plant and supply water
- Construct industrial water reclamation plant and supply water
- Supply TSMC with 5000 tons/day of water from the water reclamation plant in Yongkang, Tainan
- Supply 5000 tons/day of water from the water reclamation plant in TSMC Tainan Science Park Reclaimed Water Plant
- Increase water supply to 20,000 tons/day
- Increase water supply for TSMC from the water reclamation plant in Yongkang, Tainan to 9500 tons/day
- Supply TSMC with 37,500 tons/day of water from the water reclamation plant in Anping, Tainan

Note: Water supply schedule and water supply volume for 2021 and thereafter are calculated from reclaimed water consumption contracts between TSMC and government departments (Southern Taiwan Science Park Administration and Tainan City Government).

Please refer to TSMC Fulfills Green Manufacturing by Supporting the Establishment of First Private-owned Reclaimed Water Plant in Taiwan on the TSMC Corporate Social Responsibility website for more details.
Develop Preventive Measures

Effective Source Distribution Management and Treatment Facilities

A total of 38 distribution systems have been established based on the composition and concentration of wastewater from manufacturing processes. TSMC has built a comprehensive wastewater classification and resourcing system integrated with treatment equipment to effectively decompose pollutants. Following this, wastewater is condensed and reclaimed through the recycling system to further reduce the concentration of pollutants in line with the dual goals of pollutant reduction and reuse. In 2019, TSMC installed a new distribution and treatment system for wastewater containing high concentrations of cobalt and cobalt-containing CMP wastewater. Additionally, a cobalt-containing wastewater electroplating system was established to recycle cobalt-containing wastewater for making cobalt bars. In 2019, 150 kg of cobalt bars were produced.

Wastewater Quality Improvement

All TSMC fabs have installed equipment to continuously monitor water quality and quantity at effluent spouts of wastewater treatment facilities. By closely monitoring and recording changes in water quality and quantity, TSMC can respond appropriately when abnormalities occur.

TSMC actively assesses manufacturing raw materials by referencing domestic and international studies on aquatic toxicity, placing focus on pollutants in the semiconductor industry, such as TMAH (strong base), copper ions (heavy metal) and ammonia nitrogen, as well as suspended solids and chemical oxygen demands that strongly impact marine life, setting these as five key targets to be improved in the first phase. The Company has carried out various improvement measures, and established the second-phase goal of reducing the water pollution composite indicator of 10 substances by 30% by 2030, to demonstrate TSMC’s determination to reduce the environmental impact of wastewater discharge. In 2019, TSMC enhanced distribution of copper-containing liquid waste and chemical dosage improvement, effectively reducing copper ions in discharged water by 0.09 ppm, which is far below the 1 ppm drinking water standard. The Company has reached the 2025 target ahead of schedule. The efficiency of ammonia nitrogen wastewater treatment was improved, as indicated by the reduction of discharge concentration to 17.31 ppm, which is better than the effluent standards.

Preventive Techniques on Key Pollutants of Wastewater Quality and Improvement Achievements

<table>
<thead>
<tr>
<th>Item</th>
<th>Status in 2019</th>
<th>Standards Set by Science Park Administration</th>
<th>Targets in 2025</th>
<th>2019 Improvement Outcome (2014 as Baseline)</th>
<th>Preventive Techniques</th>
</tr>
</thead>
</table>
| TMAH                  | 7.86           | HSP: 30 CTSP: 20 STSP: 60                     | 1.0             | Reduced by 74% from the previous year                                                         | • Recycle low-concentration liquid waste  
  • Establish anion exchange resin towers                                                   |
| Copper ion            | 0.09           | HSP: 1 CTSP: 0.8 STSP: 1.5                    | 0.1             | Reduced by 76% from the previous year                                                         | • Distribute copper-containing liquid waste and electroplating                        |
| NH₄-N                 | 17.31          | HSP: 30 CTSP: 20 STSP: 60                     | 20              | Reduced by 89% from the previous year                                                         | • Expand ammonia treatment systems  
  • Upgrade treatment facilities and improve treatment efficiency                           |
| Chemical oxygen demand| 185.5          | HSP: 500 CTSP: 500 STSP: 450                  | 100             | Reduced by 54% from the previous year                                                         | • Implement combustion treatment in strippers (Under assessment and planning)  
  • Establish biological treatment systems (bioprocess) (Under assessment and planning)   |

Note: Hsinchu Science Park (HSP), Central Taiwan Science Park (CTSP), Southern Taiwan Science Park (STSP)
Note 2: Suspended solids reduction achieved 2025 goals ahead of schedule in 2018

Ammonia Analyzer
Wastewater Classification and Recycling System

**Tap water** → **Processing equipment** → **Discharge to on-site wastewater treatment plants** → **Rivers and the environment**

**38 Different Types of Liquid Classified**
- **Hydrofluoric (HF) Acid Wastewater**
  - HF acid wastewater (2 types)
  - Ozone-containing HF acid wastewater
  - Manufacturing process scrubbing water
- **Acidic, Caustic, and Organic Wastewater**
  - Deionized water
  - Ozone-containing deionized water
  - Acidic wastewater (2 types)
  - Ozone-containing acidic wastewater
  - Caustic wastewater
  - Ozone-containing Caustic wastewater
  - TMAH wastewater
  - Organic wastewater (2 types)
- **CMP Wastewate**
  - Electroplating wastewater
  - CMP wastewater (2 types)
  - Copper-containing CMP wastewater
  - Cobalt-containing CMP wastewater
- **High-Concentration Liquid Waste**
  - Waste sulfuric acid
  - Waste copper sulfate
  - Cobalt-containing liquid
  - Other wastewater (16 types)

**9 Recycling Systems**
- Hydrofluoric (HF) acid wastewater
- Local scrubber wastewater recycling

**13 Types of Wastewater Treatment**
- Chemical coagulation treatment of HF acid wastewater
- Acidic wastewater recycling
- Ozone-containing acidic wastewater recycling
- Caustic wastewater recycling
- Organic wastewater recycling
- CMP wastewate treatment
- Copper-containing CMP wastewater treatment
- Cobalt-containing CMP wastewater treatment
- CMP wastewater recycling
- Copper-containing CMP wastewater recycling
- Cobalt-containing CMP wastewater recycling
- Waste-H2SO4 reclaim
- Copper-containing electroplating wastewater recycling
- Cobalt-containing electroplating wastewater recycling

**9 Products Recycled**
- Calcium fluoride
- Fluorite
- Ammonium sulfate
- Ammonia water
- Gypsum
- TMAH
- Sulfuric acid
- Copper bar
- Cobalt bar

Note 1: TMAH stands for tetramethylammonium hydroxide
Note 2: Among all recycled products, sulfuric acid and electronic grade coating copper are reused in TSMC sites, while the rest are reused externally by other industries
Note 3: Cobalt-containing electroplating wastewater recycling was introduced in 2019
First Semiconductor Company to Receive Platinum Certification from the Alliance for Water Stewardship with the Highest Rating in History

To mitigate climate change, implement green manufacturing, and continue to improve water efficiency, TSMC has introduced the world’s only AWS Standard in 2019, using Fab 6 and Fab 14 Phases 5/6/7 as the initial demonstration site. In December of the same year, TSMC was officially certified by AWS, becoming the world’s first semiconductor company to receive AWS certification. TSMC’s evaluation score of 114 points not only surpasses the Platinum-level threshold (80 points) but it is also the highest score on record.

TSMC is committed to managing its water resources in an effort to fulfill the sixth UN Sustainable Development Goal—Clean Water and Sanitation—and to be the first in the industry to comply with AWS standards. TSMC has established a comprehensive and systematic sustainable water management organization. The AWS team that came to inspect the entire catchment in the certification process has recognized and praised TSMC for implementing the industry-leading copper extraction from waste copper sulfate program, creating a high-tech green factory with firefly habitat restoration, planning the recycling and reuse of general wastewater in the site, and working with external units to create green energy smart water control gates that help improve efficiency in domestic irrigation.

In 2019, the AWS Task Force summarized their experiences with a demonstration site in the AWS Blue Book. The Blue Book serves as a guideline for promoting Fab matching, and Fab 15 is expected to complete certification in 2020, in hopes that the company’s operations can co-exist and prosper with the environment.

Laws & Regulations
Operating Management Strategies
Green Innovation

- Excellent Management System
  - Comprehensive and continuous employee training mechanisms
  - Comprehensive processing procedures (risk assessment, system setup, operations, and emergency response standard operating procedures)
- Healthy Water Environment
  - Continuous monitoring and improvement of the environmental impact of sites on the water catchments
  - Conservation and rebuilding of biodiversity in catchment environment
- Sustainable Water Balance
  - Well-structured information platform
  - Open and measurable water operations standards
- Good Water Quality
  - The quality of discharged water is higher than the regulatory requirements, and is continuously improving
  - Creation of a sustainable cycle system to reduce the impact of operations on the water catchments
- Safe Drinking Water and Sanitation Environment
  - Provide employees in the areas near sites with safe and healthy environments and drinking water
  - Implementation of the commitment on drinking water and sanitation indicators for sites and catchments

Our Business Sustainable Governance Our Focuses and Progress
Ethical Management Innovation and Service Responsible Supply Chain Green Manufacturing Inclusive Workplace Common Good
Appendix
Case Study

First Company to Recover Fireflies On-site

Dedicated to fulfilling our mission to strengthen environmental protection, we have adopted biodiversity conservation management and are the first business in Taiwan to successfully recover fireflies in our fab sites (For more detail, please go to “Successful Recovery of Fireflies in TSMC’s Tainan Fab”). After four years of unremitting efforts, as of April, 2019, over 200 fireflies have been spotted in our Tainan Fab. The firefly habitat experience is now being replicated in our Hsinchu and Taichung fabs.

Establishment of the Best Habitat Building Process

To ensure that the fireflies are breeding steadily, in 2019, we placed more focus on managing water quality and vegetation cover. We also monitored the quantity and growth of snail prey so that Aquatica fucta larvae, which feed on snails, are able to enter the pupal stage. Moreover, we have always maintained our firefly habitats with minimal interference. Apart from simulating their natural habitat, we took further measures such as installing shorter street lights and LED 590nm firefly lamps to reduce light pollution and habitat disturbance.

A Larger Fireflies Habitat to Light up TSMC Fabs

Seeking to set up an eco-friendly fab, we collaborated with ecologists to select potential locations for firefly habitats in September 2019. In the future, we will be recovering three species on three newly-selected sites according to the respective environment, and gradually build up a habitat for the fireflies. With each step we take, TSMC is becoming greener, and one step closer to reaching a balance between technology and ecology.
Waste Management

Strategies & 2030 Goals

Source Reduction
Promote waste reduction by waste source separation and require suppliers to provide low chemical consumption equipment

- Outsourced unit waste disposal per wafer (kilogram/8-inch equivalent wafer mask layer) \( \leq 0.22 \)
- Outourced unit waste disposal per wafer (kilogram/8-inch equivalent wafer mask layer) \( 0.40 \) \( \text{Note 1} \)
  \( \text{Target: } \leq 0.34 \)
- Outsourced unit waste disposal per wafer (kilogram / 8-inch equivalent wafer mask layer) \( \leq 0.39 \)

Circular Economy
Collaborate with business partners to develop new waste recycling technology in order to increase the amount of waste recycled and reused

- Develop multiple types of electronics-grade chemicals for TSMC’s resource circulation
  - Recycling rate of 96%. Percentage of waste sent to landfills \( \leq 0.25\% \)
    \( \text{Target: Recycling rate } \geq 15\%; \text{ Percentage of waste sent to landfills } \leq 1\% \)
  - In-house reuse rate of resources \( 22\% \) \( \text{Note 2} \)
    \( \text{Target: } \geq 30\% \)
  - Completed establishment of electronic-grade sulfuric acid recycling pilot plant
    \( \text{Target: } \text{NEW} \)
- In-house reuse rate of resources \( \geq 23\% \)

Audit and Guidance
Conduct joint evaluation and supervision based on standards of waste management firms in the high-tech industry

- All waste treatment vendors acquire ISO14001 or other international EHS Management certifications \( \text{Note 3} \)
- Waste treatment vendors are 100% audited and given guidance
  \( \text{Target: } 100\% \)
- 70% of waste treatment vendors have acquired ISO14001 or other international EHS Management certifications
  \( \text{Target: } 70\% \)
  - Exceeded
  - Achieved
  - Missed Target
- 75% of waste treatment vendors have acquired ISO14001 or other international EHS Management certifications

Note 1: Please see section on "Source Reduction" for reasons why target was not achieved.
Note 2: Please see section on "Circular Economy" for reasons why target was not achieved.
Note 3: TSMC requires waste treatment vendors to at least acquire ISO14001 or ISO45001 certifications as the basis for standardized management. Vendors who are exempted from online reporting or are government-owned enterprises are excluded from the aforementioned vendors, including waste treatment and recycling vendors.
TSMC’s waste management strategies are primarily focused on source reduction. TSMC continuously minimizes resource consumption at the source, adjusts raw material usage parameters and technical solutions for process improvements, and collaborates with suppliers to achieve material optimization and minimization. After raw materials are used in production processes, on-site recycling is prioritized so that resources are sufficiently reused to delay the disposal of materials as waste.

TSMC has been implementing the concept of a circular economy to manage waste resources. First, waste resources are made into products through the use of facility resource renewal equipment. These products are then provided for use in facilities or sold to other industries for use. For non-reusable resources that cannot be converted through resource renewal technology or reused, TSMC prioritizes recycling and recovery by sending them to certified waste disposal vendors. When all options have been exhausted, TSMC’s final option is to dispose of waste by incineration and landfill. In 2019, the recycling rate was 96% and has been 95% or above for five years in a row. The percentage of waste sent to landfills has been less than 1% for ten years in a row.

In addition to actively implementing the concept of a circular economy, TSMC has also established a “waste treatment vendor management procedure”, the “waste treatment vendor sustainability enhancement project”, audited and guided waste treatment vendors, and provided vendors with relevant management experience in environmental protection, safety and health. Through a comprehensive inspection of environmental, safety, and health systems, TSMC continues to improve the effectiveness of environmental treatment facilities, organize and setup indoor waste storage areas, and conduct emergency response drills to improve capabilities to respond to abnormalities. Meanwhile, vendors are guided to acquire ISO14001 or other international EHS Management certifications, and operation management is strengthened through process documentation and standardization. Waste treatment vendors are encouraged to keep pace with TSMC in co-creating a path to environmental sustainability.

Life Cycle and Management of Sustainable Resources in TSMC

Note: Data include Taiwan Facilities.

<table>
<thead>
<tr>
<th>Raw Materials</th>
<th>Product Sales</th>
<th>Production Process</th>
<th>Reuse in the Fab</th>
<th>Waste Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Source Management |            | Safety management and facility availability | Safety management and facility availability | }
| Reuse Processes | 19%          | 78%                |                  |
| In the Fab    |              |                    |                  |
| Waste Resource Management | TSMC Satellite Management Tracking System; Tracking of GPS Anomalies |
| Incineration /Burial | 4%           |                    |                  |
| Recycled Energy | 1%           |                    |                  |
| Recycled Products | 73%        |                    |                  |
| Recycled Products |              |                    |                  |
| Other Industries Reuse | > 30 Products |
| Raw Materials for Other Industries |                  |
| Including Optoelectronic Semiconductor and Chemical Engineering |

Follow-up on reused products:
- Monthly sales of reused products
- Evaluation of the industry, clients, and usage
- Inspection of invoices and shipping records

Transport of Reused Products:
- Transport of reused products

On-site Audits:
- Safety management and facility availability
- Inspection on input and output

Outsourced Waste Treatment:
- Outsourced waste treatment

Vendors:
- TSMC Satellite Management Tracking System; Tracking of GPS Anomalies
- Incineration /Burial
- Recycled Energy
- Recycled Products

TSMC Output of Used Resources:
- Raw Materials
- Product Sales
- For other industries

Corporate Social Responsibility Report
Our Business Sustainable Governance Our Focuses and Progress
Ethical Management Innovation and Service Responsible Supply Chain Green Manufacturing Inclusive Workplace Common Good
Appendix

122
**Waste Quantity and Treatment Status Statistics**

**Waste from Outsourced Businesses**

<table>
<thead>
<tr>
<th>Year</th>
<th>General Industrial Waste</th>
<th>Hazardous Industrial Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>265,787</td>
<td>132,427</td>
</tr>
<tr>
<td>2016</td>
<td>291,984</td>
<td>158,899</td>
</tr>
<tr>
<td>2017</td>
<td>361,968</td>
<td>196,077</td>
</tr>
<tr>
<td>2018</td>
<td>377,767</td>
<td>208,340</td>
</tr>
<tr>
<td>2019</td>
<td>395,480</td>
<td>212,465</td>
</tr>
</tbody>
</table>

**Reused Resources**

<table>
<thead>
<tr>
<th>Year</th>
<th>Reused Resources (Unit: metric tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>18,804</td>
</tr>
<tr>
<td>2016</td>
<td>46,889</td>
</tr>
<tr>
<td>2017</td>
<td>63,658</td>
</tr>
<tr>
<td>2018</td>
<td>95,989</td>
</tr>
<tr>
<td>2019</td>
<td>112,829</td>
</tr>
</tbody>
</table>

**Percentage of Recycled Waste**

<table>
<thead>
<tr>
<th>Year</th>
<th>Taiwan facilities</th>
<th>Subsidiaries</th>
<th>Total Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>95</td>
<td>79</td>
<td>95</td>
</tr>
<tr>
<td>2016</td>
<td>95</td>
<td>79</td>
<td>95</td>
</tr>
<tr>
<td>2017</td>
<td>95</td>
<td>80</td>
<td>95</td>
</tr>
<tr>
<td>2018</td>
<td>95</td>
<td>83</td>
<td>95</td>
</tr>
<tr>
<td>2019</td>
<td>96</td>
<td>74</td>
<td>96</td>
</tr>
</tbody>
</table>

**Rate of Landfill**

<table>
<thead>
<tr>
<th>Year</th>
<th>Taiwan facilities</th>
<th>Subsidiaries</th>
<th>Rate of Landfill</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>0.2</td>
<td>15.8</td>
<td>0.2</td>
</tr>
<tr>
<td>2016</td>
<td>0.1</td>
<td>16.1</td>
<td>0.1</td>
</tr>
<tr>
<td>2017</td>
<td>0.2</td>
<td>15.9</td>
<td>0.2</td>
</tr>
<tr>
<td>2018</td>
<td>0.2</td>
<td>12.6</td>
<td>0.2</td>
</tr>
<tr>
<td>2019</td>
<td>0.3</td>
<td>11.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

**Note 1:** Data included TSMC's facilities in Taiwan (wafer fabs, testing and assembly plants), and subsidiaries (WaferTech, TSMC (China), TSMC (Nanjing), and VisEra).

**Note 2:** The definition of waste from hazardous businesses is determined by local regulations.

**Note 3:** Data for hazardous Industrial Waste in 2015 and 2016 has been corrected and recalculated.
In addition, TSMC has built a real-time management system to track the amount of waste produced per unit in the production process. In addition to examining effectiveness on a monthly basis and eliminating abnormalities, fab managers can monitor the output of waste in real time and compare outputs with other fabs to identify opportunities for waste reduction. In 2019, through 247 new source reduction and resource reuse plans, TSMC reduced the amount of waste per wafer by 274,348 tons over the whole year. However, new production processes are difficult to develop, initial operating systems have not yet been optimized, and the operating processes of in-house resource renewal equipment still need to be improved. Therefore, the reuse rate of resources was only 22%, and outsourced unit waste disposal per wafer was 0.4 kg in 2019, indicating a failure to achieve the original goals. In 2020, TSMC will continue to implement various reduction plans for newly-constructed facilities and further increase the reuse rate of resources to meet the goal of achieving 0.39 kg per wafer equivalent of outsourced waste disposal.

Source Reduction

TSMC continues to expand the production capacity of advanced manufacturing processes. Consequently, demand for raw materials has increased correspondingly, increasing waste generation. To effectively inhibit waste generation and reduce environmental impact, TSMC established a “Waste Management Task Force”, which integrates TSMC’s Material Supply Chain Waste Resource Management Section, Facility Division, and Process Division. Within the committee, the Vice President of Operations designates inter-fab coordinators to set waste reduction plans with fab managers at the beginning of each year. Goals for 2019 include improving strategies for simplifying the manufacturing process, extending the life cycle of chemicals, recycling and reusing resources, exploring alternative chemical replacements, extending the life cycle of chemicals, recycling and reusing waste production from all aspects.

Unit Waste Output Trendchart

 WVW/8-Inch Equivalent Wafers Unit: kg/8-inch Equivalent Wafer Mask Layer

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual amount of waste per wafer</th>
<th>Estimated amount of waste per wafer (if no proactive measures are taken)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0.23</td>
<td>0.34</td>
</tr>
<tr>
<td>2013</td>
<td>0.28</td>
<td>0.40</td>
</tr>
<tr>
<td>2014</td>
<td>0.34</td>
<td>0.49</td>
</tr>
<tr>
<td>2015</td>
<td>0.36</td>
<td>0.59</td>
</tr>
<tr>
<td>2016</td>
<td>0.35</td>
<td>0.61</td>
</tr>
<tr>
<td>2017</td>
<td>0.35</td>
<td>0.70</td>
</tr>
<tr>
<td>2018</td>
<td>0.34</td>
<td>0.40</td>
</tr>
<tr>
<td>2019</td>
<td>0.32</td>
<td>0.43%</td>
</tr>
<tr>
<td>2020</td>
<td>0.34</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Note 1: Outsourced waste per wafer increased because of increased wafer production.
Note 2: TSMC lists the nitrogen in wastewater as waste in order to comply with new wastewater regulation beginning in 2015.
Note 3: Data include Taiwan Facilities.

Case Study

Minor Alterations Create Major Waste Reductions in IPA

TSMC capitalizes on its Waste Management Task Force and unit waste output management system to control its waste output and fulfill its commitment to source reduction. In 2019, TSMC identified a gradual increase in the output of IPA liquid waste from advanced manufacturing processes. An analysis of this liquid waste revealed a low concentration of IPA waste from advanced processes, and that the high water content was attributed to an increase in IPA waste output. Further inspection of 45 machines that produce IPA waste showed that IPA vapor easily adheres to pipeline walls, causing wafer surface defects. Advanced process wafer-cleaning machines were incorporated with a new design that uses deionized water to remove residual IPA, resulting in increased water content in IPA liquid waste and a dramatic increase in waste output. For this reason, TSMC immediately carried out an IPA waste reduction project and discussed improvement methods with equipment vendors. Water volume control valves were installed in wafer cleaning machines for advanced processes, and experimental designs were adopted to reduce water volume by 87%. This approach not only meets the quality requirements of advanced processes but also successfully reduced low-concentration IPA waste by 9,720 metric tons per year.
Circular Economy

In addition to source reduction, TSMC is also taking actions to respond to the call for circular economy. To increase the feasibility of waste recycling, TSMC has reviewed the use of each chemical and classified the ultimate flows of chemicals inside the facilities. 38 types of liquid waste were distributed using a comprehensive plan and remade into 30 types of recycled products for circular use in other industries. To strengthen product flow control and reduce the mishandling risks of outsourced vendors, TSMC has implemented the “Action Plans to Turn Waste into High-Value Products”, which includes recycling waste sulfuric acid for internal use, electroplating copper-containing and cobalt-containing liquid waste into recycled products, and freeze-drying ammonium sulfate waste into recycled products. In 2019, TSMC recycled more than 110,000 tons of waste and reclaimed 360 tons of products for sale, bringing in more than NT$300 million of economic value in recycled resources.

Reuse of facility resources is key to promoting the circular economy in TSMC. To improve the quality of ammonium sulfate treatment in line with the highest specification requirements in the industry, TSMC suspended its ammonium sulfate waste crystallization system in 2019 and engaged in a series of system modifications and process optimizations, in hopes of identifying the optimal operating process with maximum efficiency. Consequently, the company’s production capacity based on in-house resource reuse rates did not achieve the original goal for 2019. Operation at full capacity will be restored in 2020, with the expectation of achieving a 23% in-house resource reuse rate. Furthermore, to purify waste sulfuric acid, which is outsourced for treatment, into raw materials for reuse in semiconductor manufacturing processes, TSMC has completed establishing the first electronic-grade sulfuric acid recycling pilot plant in 2019. TSMC is transforming from a waste producer to an advocate for the circular economy and lessening environmental impact by reusing materials.

Flow control and reduce the mishandling risks of outsourced vendors, TSMC has implemented the “Action Plans to Turn Waste into High-Value Products”, which includes recycling waste sulfuric acid for internal use, electroplating copper-containing and cobalt-containing liquid waste into recycled products, and freeze-drying ammonium sulfate waste into recycled products. In 2019, TSMC recycled more than 110,000 tons of waste and reclaimed 360 tons of products for sale, bringing in more than NT$300 million of economic value in recycled resources.

Reuse of facility resources is key to promoting the circular economy in TSMC. To improve the quality of ammonium sulfate treatment in line with the highest specification requirements in the industry, TSMC suspended its ammonium sulfate waste crystallization system in 2019 and engaged in a series of system modifications and process optimizations, in hopes of identifying the optimal operating process with maximum efficiency. Consequently, the company’s production capacity based on in-house resource reuse rates did not achieve the original goal for 2019. Operation at full capacity will be restored in 2020, with the expectation of achieving a 23% in-house resource reuse rate. Furthermore, to purify waste sulfuric acid, which is outsourced for treatment, into raw materials for reuse in semiconductor manufacturing processes, TSMC has completed establishing the first electronic-grade sulfuric acid recycling pilot plant in 2019. TSMC is transforming from a waste producer to an advocate for the circular economy and lessening environmental impact by reusing materials.

309,000 Thousand (NT$) Cost saving from waste reduction
394,600 Thousand (NT$) Income from waste recycling

Note: Statistics of economic value include Taiwan Facilities

TSMC Aspires to be a Practitioner of Circular Economy

Case Study

Successful Implementation of the Circular Economy "Three-Zero" Project

With the expansion of production capacity, TSMC has expanded its circular economy actions to avoid the environmental burden caused by the corresponding increase in waste output. Concurrently, the Company has amended its Articles of Incorporation and introduced 4 additional business items, including chemical materials, to increase opportunities for recycling resources. TSMC’s green manufacturing team in Facility Division constantly studies and evaluates the feasibility, operational safety, and economic benefits of various resource renewal technologies. In 2019, the "three-zero" project was successfully implemented, subsequently achieving the "three-zero" goals: zero outsourcing treatment of cobalt-containing liquid waste, zero outsourcing treatment of copper-containing liquid waste, and zero purchase of industrial-grade sulfuric acid.

Successful Implementation of the Circular Economy "Three-Zero" Project

Zero Copper-Containing Liquid Waste Outsourced

Since 2016, TSMC has actively developed copper-containing liquid waste electroplating recycling systems and continued to extract copper from waste copper sulfate to directly convert copper-containing liquid waste into recycled copper tubes onsite in the facilities. In 2017, TSMC subsequently cooperated with raw material suppliers to research and develop purification procedures that remake pure reclaimed copper tubes into electronics-grade copper anodes. As of 2018, the Company began extending this recycling process to TSMC’s manufacturing processes and succeeded in establishing a reclamation model for electronic-grade copper materials. In 2019, TSMC realized the goal of zero outsourcing treatment of copper-containing liquid waste in its mass-production facilities and recovered a total of 15,654 metric tons of copper-containing liquid waste, reclaiming 167 tons of recycled copper tubes and creating an annual benefit of over NT$100 million from recycling and waste reduction.

Zero Cobalt-Containing Liquid Waste Outsourced

The development of semiconductor advanced manufacturing processes has resulted in the widespread use of cobalt as a conductive material. However, for this rare metal, there are no cobalt-containing liquid waste recovery technologies and treatment vendors in the market. Therefore, tapping into its successful experience with copper extraction systems, TSMC has installed in-house electroplating systems to completely recover cobalt-containing liquid waste and remake them into pure cobalt products. In addition to achieving zero outsourcing treatment of cobalt-containing liquid waste in its mass-production fabs, TSMC has also produced pure cobalt products that can be reused in the battery and catalyst industries. In 2019, TSMC reduced a total of 277 tons of cobalt-containing liquid waste, which were originally treated by outsourced vendors, and generated roughly 180 kg of pure cobalt products, creating an annual benefit of over NT$10 million from recycling and waste reduction.

(Continued on next page)
Zero Purchase of Industrial-Grade Sulfuric Acid

Adhering to the principle of "Minimizing Waste and Maximizing Resources," TSMC changed its traditional waste treatment approach in 2015 and successfully introduced a waste sulfuric acid recycling system that enables waste sulfuric acid from semiconductor manufacturing processes to be reused as additives for wastewater systems. In 2019, TSMC continued to hone its green innovation capability, effectively improve the production capacity and quality of reclaimed sulfuric acid, and achieved cross-fab recycling of reclaimed sulfuric acid, exempting the company from purchasing 50% industrial sulfuric acid. In total, TSMC recycled 96,081 metric tons of waste sulfuric acid, creating an annual benefit of over NT$200 million from recycling and waste reduction.

Timeline of Sulfuric Acid Reuse in TSMC

<table>
<thead>
<tr>
<th>Traditional Mode</th>
<th>Reclamation Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material exploitation</td>
<td>Raw material exploitation</td>
</tr>
<tr>
<td>Sulfuric acid factory</td>
<td>Sulfuric acid factory</td>
</tr>
<tr>
<td>Industrial sulfuric acid</td>
<td>Industrial sulfuric acid</td>
</tr>
<tr>
<td>Wastewater treatment system</td>
<td>Wastewater treatment system</td>
</tr>
</tbody>
</table>

waste sulfuric acid produced from the semiconductor manufacturing process is entirely outsourced for reuse. Meanwhile, industrial-grade sulfuric acid must be purchased for use as a wastewater additive.

Waste Sulfuric Acid Recycling System
Audit and Guidance

TSMC is committed to implementing its waste disposal vendor sustainability enhancement project in an effort to verify the disposal of facility waste, strengthen the effectiveness of vendor inspection, and take responsibility for the outsourced cleaning and management of its waste. TSMC has a thorough procedure for choosing and introducing new business partners. A documentary review that includes business scale, risk assessment, and related certifications of its business partners is first conducted by a team of interdisciplinary experts from the company’s Material Supply Chain Procurement and Waste Resource Management Section and Corporate Environmental Safety & Health Division. Next, TSMC conducts an onsite audit and carefully chooses outstanding vendors to work with.

Qualified vendors must be subject to weekly and monthly documentary reviews and quarterly and annual onsite inspections. A standard audit system encompassing eight dimensions and 166 inspection items is established in accordance with the “Waste Treatment Vendors Audit Plan.” The audit form is revised on a yearly basis according to regulatory amendments to facilitate annual auditing and guidance counseling. In 2019, TSMC found that vendors were unaware of the need to stay up-to-date on laws and regulations. Subsequently, the risks of regulatory violations were redefined, and management of 113 provisions was strengthened to reduce the risks of vendor violation. TSMC conducted onsite inspections and audits on 54 vendors in 2019, completing improvements to 198 deficiencies.

At the same time, TSMC’s Material Supply Chain Procurement and Waste Resource Management Section, Corporate Environmental Safety & Health Division, and Legal Division use the three dimensions of the Annual Evaluation for Waste Treatment Vendors as the basis for vendor replacement. The percentage of vendors evaluated as “excellent” and “good” in the 2019 evaluation increased from 36% in 2015 to 74%. In addition, since 2016, TSMC has been pushing for vendors to gain ISO14001 certifications from third-party organizations recognized by TSMC. In 2019, the number of ISO-certified vendors increased from 23 to 38, accounting for 70% of all vendors.

In addition to working with vendors to control the quality of waste management, TSMC also acts as the representative of the Taiwan Semiconductor Industry Association (TSIA) in collaborating with the Environmental Protection Administration, Industrial Development Bureau, MOEA, and Ministry of Science and Technology to establish the “High-Tech Industry Waste Treatment Platform.” The objective of this cooperation between the government and corporations is to promote the circular economy, simplify waste reporting and reuse application procedures, and establish a more efficient and effective management system for the flow of waste and recycled resources. In 2019, TSMC cooperated with the Environmental Protection Administration through this platform to develop Taiwan’s first highly efficient process for issuance of manifests for waste disposal and transportation. The original approach, which was time consuming because each item had to be entered manually, was optimized into a system batch upload mode. This new process not only increased data accuracy and convenience of waste reporting, but also created an excellent environment for waste management.

2019 Waste Treatment Vendors Audit and Guidance Outcomes

- Acquired ISO14001 or other international EHS management certifications
  - 2 vendor Solid waste
  - 1 vendor Liquid waste
  - 1 vendor Sludge waste
- Recipient of environmental protection awards from government or credible media/institutions
  - 1 vendor Sludge waste

- Established/improved waste storage area inspection systems
  - 3 vendor Solvent waste
  - 2 vendor Solid waste
  - 1 vendor Sludge waste
- Established indoor waste storage area
  - 1 vendor Liquid waste
- Amended waste disposal contract to comply with regulatory requirements
  - 6 vendor Liquid waste
  - Established waste disposal company audit regulations
  - 5 vendor Liquid waste
  - 1 vendor Solid waste

- Improved onsite chemical GHS labeling and compliance with SDS
  - 4 vendor Liquid waste
  - 3 vendor Solid waste
  - 1 vendor Sludge waste

- Improved onsite leak prevention facilities
  - 3 vendor Liquid waste
  - 1 vendor Sludge waste

- Improved equipment standard checkpoint procedures
  - 3 vendor Liquid waste

- Established air pollution control equipment standard checkpoint procedures
  - 5 vendor Sludge waste

- Established emergency response procedures and regulations for environmental system abnormalities
  - 4 vendor Liquid waste
Waste Cleanup and Disposal Vendor Management Process

Vendor Selection
6 Main Aspects
- Corporate Scale and Reputation
- Safety / Health Management
- License
- Violation Assessments
- On-site Facilities
- Waste Control

Vendor Inspection
8 Main Aspects
- Corporate Scale and Reputation
- On-site Facilities
- Vendor Selection
- Safety / Health Management
- License
- Violation Assessments
- On-site Facilities
- Waste Control

Vendor Inspection
8 Main Aspects
- Corporate Scale and Reputation
- On-site Facilities
- Vendor Selection
- Safety / Health Management
- License
- Violation Assessments
- On-site Facilities
- Waste Control

An annual evaluation of the vendors is conducted to assess their performance in various aspects. The evaluation results are based on a total score of 100, with the following criteria:

- ≧ 90: Excellent
- < 90: Good
- ≧ 80: Average
- ≧ 70: Passed
- < 60: Disqualified vendor

The chart shows the evaluation results for 2017, 2018, and 2019, with the percentage of vendors in each category.

ISO-Certified Waste Treatment Vendors

The chart displays the number of ISO-Certified Waste Treatment Vendors for 2017, 2018, 2019, and 2020, with the percentage of certified vendors for each year.

Note: Total score 100: ≧ 90 Excellent, ≧ 80: Average, ≧ 70: Passed, ≧ 60: Disqualified vendor.
## Air Pollution Control

### Strategies & 2030 Goals

<table>
<thead>
<tr>
<th>Use Best Available Technology</th>
<th>2019 Achievements</th>
<th>2020 Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapt best available technology to deal with pollution caused by operations and mitigate environmental impact</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Reduce air pollutant emissions per unit of production by 45% (Base year: 2015)\textsuperscript{new} | Reduced air pollutant emissions per unit of production by 30.3%  
Target: 27% | Reduce air pollutant emissions per unit of production by 32% |
| Reduction rate of volatile organic gases > 98% | Reduction rate of volatile organic gases was 97.8%  
Target: >90% | Reduction rate of volatile organic gases > 95% |

### Strengthen Monitoring of Prevention Facilities

Leverage backup systems and dual-track management, along with pollutant monitors, to ensure that equipment functions as intended and prevent abnormal occurrences.

- Reported <1 case of abnormal occurrences to supervising authorities
  - Reported 0 cases of abnormal occurrences to supervising authorities  
  - Target: <1
  - Exceeded  
  - Achieved  
  - Missed Target

- Report <1 case of abnormal occurrences to supervising authorities
  - Target: <1

\textsuperscript{new} Air pollutant emissions data encompasses the total emissions of eight gases: hydrocarbons, sulfuric acid, hydrochloric acid, nitric acid, hydrofluoric acid, phosphoric acid, chlorine, and ammonia.
TSMC is committed to reducing air pollution. In addition to compliance with the "Air Pollution Control and Emissions Standards for the Semiconductor Industry" and "Stationary Pollution Source Air Pollutant Emissions Standards" in Taiwan, TSMC's air pollution prevention practices include the adoption of best available technology, such as source categorization and multi-station treatment, as well as continuous collaboration with industry experts to improve the effectiveness of terminal prevention facilities so that concentrations of pollutants emitted to the atmosphere can be equal to or less than governmental standards. With the concerted efforts of all facilities in 2019, TSMC reported 30.3% lower air pollutant emissions per unit of production compared to the base year of 2015, achieving the 2025 target of 30% ahead of schedule. Subsequently, TSMC aims to set its 2030 reduction target to 45% as testament to our determination to reduce air pollution and continuously strive toward the goals of pollution reduction.

Use Best Available Technology

Best available technology (BAT) controls air pollution at the source. TSMC divides its prevention strategy into two phases: "effective reduction of emission from sources" and "strengthened management of terminal prevention facilities". In the first phase of source classification, manufacturing process air pollutants are classified according to their properties, and newly-installed high-efficiency local scrubbers will treat specific toxic gases, corrosive gases, flammable gases, and perfluorocarbon greenhouse gases, while the remaining manufacturing process waste gases are also treated effectively through special facilities such as thermal-wet scrubbers, combustion-wet scrubbers, and plasma-wet scrubbers. Then in the second phase, waste gases containing low concentrations of inorganic acids or bases will be sent to the central scrubber for second-stage water rinsing and neutralization treatment. With complete multi-phase processing through effective classification and a two-phase treatment process, TSMC has significantly increased the treatment efficiency of air pollution emissions.

Air Pollution Prevention Treatment Procedures

- **Source of Pollutants**
  - Dry Process
  - Chemical Storage Tank
  - Wet Process
  - Organic Process

- **Local Scrubbers**
  - Burn+Wet
  - Plasma+Wet
  - Thermal+Wet
  - Wet (Facility Site)
  - Wet (Process Site)
  - Condensation

- **Central Scrubbers**
  - Acid and Alkaline Gases
  - Exhaust
  - Organic Gases
  - Dual-stag
  - Burn+Wet Scrubber
  - Central Scrubber Connecting High-Efficiency Washing Tower
  - Dual Zeolite Rotor and Incineration

- **Dual-track Emission Monitoring**
  - Emission by Stack
  - Monitor Operating Conditions
  - Monitor Fluorine Gas Online
  - Monitor Reduction Rates of Emission
  - Monitor IPA Online
  - Emission by Stack
TSMC continues to develop advanced manufacturing processes and expand its production capacity, and works to prevent the possibility of air pollution emissions derived from new chemicals. When new chemicals are used, the “New Tool and New Chemical Review Committee”, made up of the Company’s industrial safety, environmental protection, facilities, equipment, and waste treatment organizations, must review and evaluate the safety and environmental impact of the new chemical before deciding whether to approve its use. The treatment effectiveness of local scrubbers is one of the key items to be reviewed.

Based on the different properties of pollutants in high-concentration waste gases emitted from fab equipment, TSMC performs preliminary treatments through seven types of local scrubbers: thermal, combustion, plasma, wet type in facility site, adsorption, and condensation. For every special gas or chemical used in fab equipment, the efficiency of each special gas treatment is certified by third-party institutions to ensure that the reduction rate of the target pollutant is 95% or more.

For effective removal of nitrous oxide (N₂O), in 2019 TSMC introduced high-temperature thermal wet scrubbers that can operate at 1000°C or more. These scrubbers can reduce not only nitrous oxide by 90% or more but also fluorinated greenhouse gas (F-GHG) and ammonia NH₃ by 99% or higher. Presently, for dry fab equipment that use N₂O, TSMC requires the comprehensive use of high-temperature thermal-wet scrubbers to improve the results of pollutant source reduction, thereby reducing the load of the central scrubber to effectively minimize the total emissions of air pollutants.

### Effective Reduction of Emission from Sources—Local Scrubbers

<table>
<thead>
<tr>
<th>Process Type</th>
<th>Semiconductor Manufacturing Process</th>
<th>Target Pollutants</th>
<th>Technology</th>
<th>Equipment Pictures</th>
<th>Reduction Rates</th>
<th>Real-time Monitoring Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Etching</td>
<td>Epitaxial Dry Etching</td>
<td>Corrosive Gases PFCs</td>
<td>Burn-Wet</td>
<td></td>
<td>&gt;99%</td>
<td>• Natural Gas Flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Oxygen Flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Circulating Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Inlet Pressure</td>
</tr>
<tr>
<td>Dry Etching</td>
<td>Dry Etching</td>
<td>Corrosive Gases Combustible Gases</td>
<td>Plasma-Wet</td>
<td></td>
<td>&gt;95%</td>
<td>• Current Amperage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Circulating Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Inlet Pressure</td>
</tr>
<tr>
<td>Thin Film Diffusion</td>
<td>Thin Film Diffusion Sputtering</td>
<td>Corrosive Gases PFCs</td>
<td>Thermal-Wet</td>
<td></td>
<td>&gt;95%</td>
<td>• Reactor Temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Combustible Gases</td>
<td></td>
<td></td>
<td></td>
<td>• Circulating Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• PH Value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Inlet Pressure</td>
</tr>
<tr>
<td>Ion Implantation</td>
<td>Ion Implantation Sputtering Epitaxy</td>
<td>Toxic Gases</td>
<td>Adsorption</td>
<td></td>
<td>&gt;95%</td>
<td>• Pressure Difference In Scrubber</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Inlet Pressure</td>
</tr>
<tr>
<td>Thin Film Diffusion</td>
<td>Thin Film</td>
<td>Nitrous Oxide (N₂O)</td>
<td>High-Temperature</td>
<td></td>
<td>&gt;90%</td>
<td>• Reactor Temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thermal + Wet</td>
<td></td>
<td></td>
<td>• Circulating Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• PH Value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Inlet Pressure</td>
</tr>
<tr>
<td>Wet Etching</td>
<td>Wet Etching</td>
<td>Corrosive Gases Organics Gases</td>
<td>Wet (Process Site)</td>
<td></td>
<td>&gt;95%</td>
<td>• Pressure Difference In Scrubber</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Circulating Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• PH Value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Inlet Pressure</td>
</tr>
<tr>
<td>PR Stripping</td>
<td>PR Stripping</td>
<td>High Boiling Point Organics</td>
<td>Condensation</td>
<td></td>
<td>&gt;95%</td>
<td>• Pressure Difference In Scrubber</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Circulating Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• PH Value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Inlet Pressure</td>
</tr>
<tr>
<td>Storage Tank</td>
<td>Chemical Storage</td>
<td>Corrosive Gases</td>
<td>Wet (Facility Site)</td>
<td></td>
<td>&gt;95%</td>
<td>• Pressure Difference In Scrubber</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Circulating Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• PH Value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Inlet Pressure</td>
</tr>
</tbody>
</table>

Dual Zeolite Rotor Concentrators
Strengthen Management of Terminal Prevention Facilities—High-Efficiency Central Scrubbers

After first-phase treatment, the processed waste gases containing low-concentration inorganic acids or bases are delivered to high-efficiency central scrubbers for acid-base neutralization, while waste gases containing volatile organic components are delivered to zeolite rotor concentrators in terminal prevention facilities and exhaust to the atmosphere after condensation and combustion. In 2019, new plants (plants built after Fab 15 Phase 7) have introduced an independent central scrubber connecting washing towers for wet process equipment, which emits a large amount of acidic and caustic gas. The washing tower uses clean recycled water sources to increase the absorption of acidic and caustic gases. Measurements show that the reduction rate of hydrofluoric acid and nitric acid pollutants can be as high as 94%. Existing facilities are not only continuously installing local scrubbers but also treat acidic pollutants by installing hydro-membranes as needed, in order to improve the acid and alkali removal performance of the central scrubber. With the robust efforts of all facilities in Taiwan, the emission of acidic and caustic pollutants by facilities in Taiwan in 2019 was reduced by 9% overall, compared to 2018. TSMC will continue to improve the removal performance of its central scrubbers.

TSMC not only adopts the most cutting edge and industry-suited pollution reduction technology but also continuously improves the treatment results of existing prevention facilities. Regarding volatile organic gas prevention technologies, TSMC uses high-efficiency zeolite rotor concentrators to first concentrate volatile organic gases, burns them in thermal oxidizer, then merge with the clean gases after adsorption, before finally emitted into the atmosphere. After processing by the zeolite rotor concentrators, the reduction rate of organic waste gases can reach 95%, which exceeds the regulatory requirement of 90%. In 2019, parameter optimization of zeolite rotor concentrators was introduced, and zeolite rotor concentrators for facilities whose reduction rate was lower than 95% were replaced, thus effectively improving the reduction rate to 97% or higher. Newly-built facilities (plants built after Fab 15 Phase 7) adopted dual zeolite rotor concentrators, which can achieve a 99.5% reduction rate of volatile organic gases. TSMC’s average reduction rate of organic waste gas emissions has surpassed 95% for five consecutive years since 2015. Due to the continuous increase in prevention efficiency, the total emission of volatile organic gases did not increase with new fabs coming into production.

Through continuous improvements in acidic, caustic, and organic gases, TSMC’s air pollution emission per unit of production in 2019 was 0.28 (grams/8-inch equivalent wafer mask layer), compared to the 0.4 in base year of 2015 (grams/8-inch equivalent wafer mask layer), representing a decrease of 30.3%, achieving the 2025 goal of 30% ahead of schedule.

Analysis and Air Pollutants Emissions per Unit of Production

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Hydrocarbon</th>
<th>Ammonia</th>
<th>Chlorine Gas</th>
<th>Hydrofluoric Acid</th>
<th>Nitric Acid</th>
<th>Hydrochloric Acid</th>
<th>Sulfuric Acid</th>
<th>Phosphoric Acid</th>
<th>Emission of Air Pollutants Per Unit of Production (g / 8-inch equivalent wafer mask layer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>245.3</td>
<td>0.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>300.2</td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>295.2</td>
<td>0.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>309.3</td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>298.4</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** TSMC’s air pollutant emissions were reported in accordance with local laws and regulations.

**Note 2:** Air pollutant emissions include the total emissions of eight gases: hydrocarbons (THC), sulfuric acid (H2SO4), hydrofluoric acid (HF), nitric acid (HNO3), hydrochloric acid (HCl), phosphoric acid (H3PO4), chlorine (Cl2), and ammonia (NH3).
Continuous Improvement of Prevention Technology

In order to improve the capabilities of air pollution prevention facilities, TSMC continuously strives to develop reduction technology, evaluates feasibility from factors such as fab space, technical safety, and economic interests, and considers the reduction effectiveness of prevention technology to make multi-faceted, comprehensive assessments on whether to introduce such prevention technology. In 2019, three new technologies, namely, independent central scrubbers connecting washing towers, dual zeolite rotor concentrators, and parameter optimization of zeolite rotor concentrators, were incorporated in overall assessment.

Strengthen Monitoring of Prevention Facilities

TSMC actively strengthens the capacity of its pollution prevention facilities and relevant monitoring and backup systems. The capacity of related prevention facilities in overseas subsidiaries complies with not only Taiwanese regulations, but also local regulatory standards. To guarantee stable and optimal operating conditions all day and year round, and to ensure that all colleagues gain first-hand information on the operating parameters of prevention facilities and are aware of the reduction rate and pollutant emission situations, all prevention facilities are equipped with N+1 backup systems and real-time monitoring systems in order to ensure that prevention facilities can immediately switch to backup systems if any abnormalities occur, and are protected by an uninterrupted power supply system to reach the management goal of zero facility failures.

An air pollution prevention equipment operation status platform was established in 2019 to ensure immediate emergency response in the event of monitoring equipment failure. Furthermore, the Facilities Division and industrial Safety and Environmental Protection Department are able to submit online queries on the operation status and maintenance status of air pollution prevention facilities and keep apprised of whether relevant operation parameters match the facility’s optimal values. Combined with the original abnormality reporting system, relevant monitoring results can be reported to the facility monitor control center and the industrial safety emergency response center. Thus, the dual-track independent monitoring system more comprehensively ensures that the gas emitted from stacks are in compliance with regulations. With the protection of an early warning system and real-time responses, no abnormal occurrences were reported to supervising authorities in 2019.
Zeolite Rotor Concentrators Designed with Dual Rotors Achieve 99.5% Annual Reduction Rate of Volatile Organic Gas Emissions

TSMC utilizes zeolite rotor concentrators and thermal oxidizer to deal with the emission of volatile organic gases, and the removal rate can reach 95–97%, which exceeds than the 90% required by the “Air Pollution Control and Emissions Standards for the Semiconductor Industry”. In particular, the volatile organic emissions make up the largest proportion of air pollutants. In an effort to achieve environmental sustainability, TSMC continues to employ new technologies to improve the effectiveness of central prevention facilities.

The zeolite rotor designs for volatile organic gases emitted by TSMC facilities feature single rotors. To continuously improve the reduction rate of zeolite rotors and reduce the emission of VOCs, TSMC has introduced dual zeolite rotor concentrators to the new Fab 15 Phase 7 facility in 2019. The rotor substrate adopts a new zeolite with wet-impregnation method, which can reduce rotor pressure drop by roughly 10% and enhance adsorption performance. At the same time, due to lower thermal capacity, the concentration factor can be increased from 15 times to 20 times or more, effectively reducing energy consumed during operation. Dual rotors treat waste gas by transferring high-concentration process waste gas (60–120 ppm) from the first rotor adsorption process to the thermal oxidizer for combustion. Subsequently, the low-concentration waste gas (2–5 ppm), which was originally emitted, is concentrated in the second rotor and transferred back to the first rotor for repeated processing. Finally, the clean air (0.5–1.5 ppm) treated in the second rotor is emitted through the exhaust stacks.

Following the dual adsorption treatment of the dual rotor, the reduction rate of volatile organic gases was increased significantly to 99.5%, demonstrating an effective reduction of volatile organic gas emissions. In 2019, TSMC successfully adopted clean-gas-desorbing zeolite rotor concentrators in its existing facilities, and simultaneously introduced parameter optimization of zeolite rotor concentrators to ensure that the total emission of volatile organic gases in 2019 was unaffected by facility expansion, actively working to realize the corporate mission of green manufacturing.

The evolution of zeolite rotor concentrator performance:

- Introduced clean-gas-desorbing zeolite rotor concentrators to existing facilities
- Introduced dual zeolite rotor concentrators to new facilities
- Introduced parameter optimization of zeolite rotor concentrators to existing facilities
- Introduced replacement program for inefficient zeolite rotors to existing facilities
- Introduced application of AI parameters in zeolite rotor concentrators to existing facilities
- Introduced clean-gas-desorbing zeolite rotor concentrators to new facilities
- Introduced parameter optimization of zeolite rotor concentrators to existing facilities

2017
2018
2019
2020

Dual Zeolite Rotor Concentrators

- High-concentration process waste gas (60-120 ppm)
- Low-concentration process waste gas (2-5 ppm)
- Clean & Fresh Air (0.5-1.5 ppm)