

Green Manufacturing

A Green Power Practitioner

In addition to pursuing business growth and breakthroughs, TSMC aims to become a practitioner of green power to raise environmental and social value. We assimilate green management into business and implement continuous improvement projects in the areas of climate change, energy management, water management, waste management and air pollution control. TSMC's goal is to facilitate coexistence and mutual prosperity between our business and the environment.

5.1GWh

Effectively reduced power consumption by 510 GWh through 452 conservation projects

103.4 million metric tons

Total recycled water quantity was 103.4 million metric tons, about 3.2 times the capacity of Baoshan Reservoir II

95%

95% waste recycling rate, the 9th consecutive year greater than 90%

Material Issue

Climate Change and Energy Management

Strategies

TSMC 2020/2025 Goals

Achievements & Targets

Promoting Low-Carbon Manufacturing

Continue adopting best practice approaches to mitigate emissions with the goal of being the industry's Low-Carbon Manufacturing leader

- Reduce unit wafer GHG emission (Metric tons of CO₂ equivalent /8-inch wafer e mask-layer) to 18% below the year 2010 level 2020
- Reduce unit wafer PFC emission (Metric tons of CO₂ equivalent /8-inch wafer e mask-layer) to 60% below the year 2010 ; Reduce total PFC emission (Metric tons of CO₂ equivalent) to 20% below the year 2010 level 2020

Development of Renewable Energy

Continue to purchase green power and install solar power systems, increase green power usage

- Continuously purchase renewable energy ^{Note} 2025

Improving Energy Efficiency

Develop new energy-saving measures each year, actively implement energy-saving measures, and increase power usage effectiveness

- Reduce unit wafer power usage (kWh /8-inch wafer e mask-layer) to 12% below the year 2010 level 2020
- Conserve a total of 2,800GWh beginning from 2016 2025

Strengthening Climate Resilience

Build up prevention and emergency reaction plans for climate disaster and reduce the impact of climate disasters

- Zero days of manufacturing interruption caused by climate change disasters 2025

Note: The regulatory and market environment isn't mature in Taiwan. TSMC purchase renewable energy & set up long-term goal once the conditions are mature

Strategies & 2020/2025 Goals

2017 Achievements

2018 Targets


13%
Unit wafer layer GHG emissions were 13% less than 2010

Target: 13%

○ Reduce unit wafer layer GHG emission to 15% below the year 2010 level


55%
Unit wafer layer PFC emissions were 55% less than 2010

Target: 50%

○ Reduce unit wafer layer PFC emission to 55% below the year 2010 level


6%
Total PFC emissions were 6% less than 2010

Target: 4%

○ Reduce total PFC emissions to 10% below the year 2010 level


10.4%
Unit wafer layer power usage were 10.4% less than 2010

Target: 9%

○ Reduce unit wafer layer power usage to 11% below the year 2010 level


510 GWh/600 GWh
Annual power savings / Cumulative power savings

Target: Annual power-saving target of 280 GWh
Cumulative power-saving of 370 GWh

○ Annual power-saving of 200 GWh

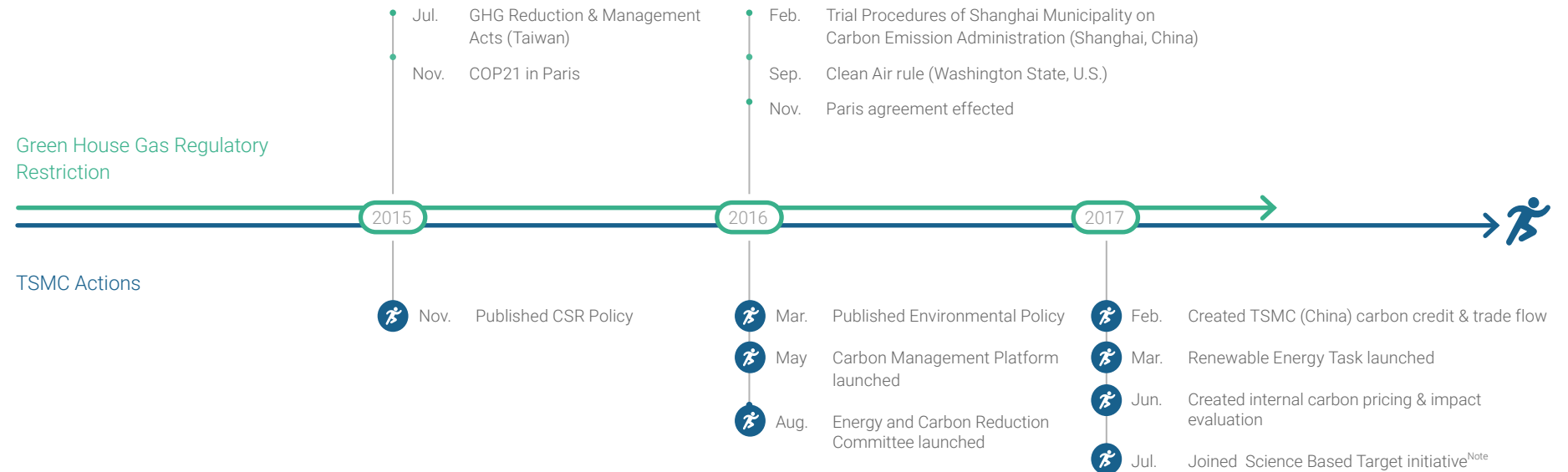
○ Cumulative power-saving of 800 GWh



Climate change has greatly impacted the global ecosystem and people's lives. After the signing of the Paris Agreement, nations from around the world have affirmed the threat of climate change. TSMC clearly states in its Corporate Social Responsibility Policy and Environmental Protection Policy that adapting to climate change is part of its responsibility to sustainable management. TSMC continues to monitor

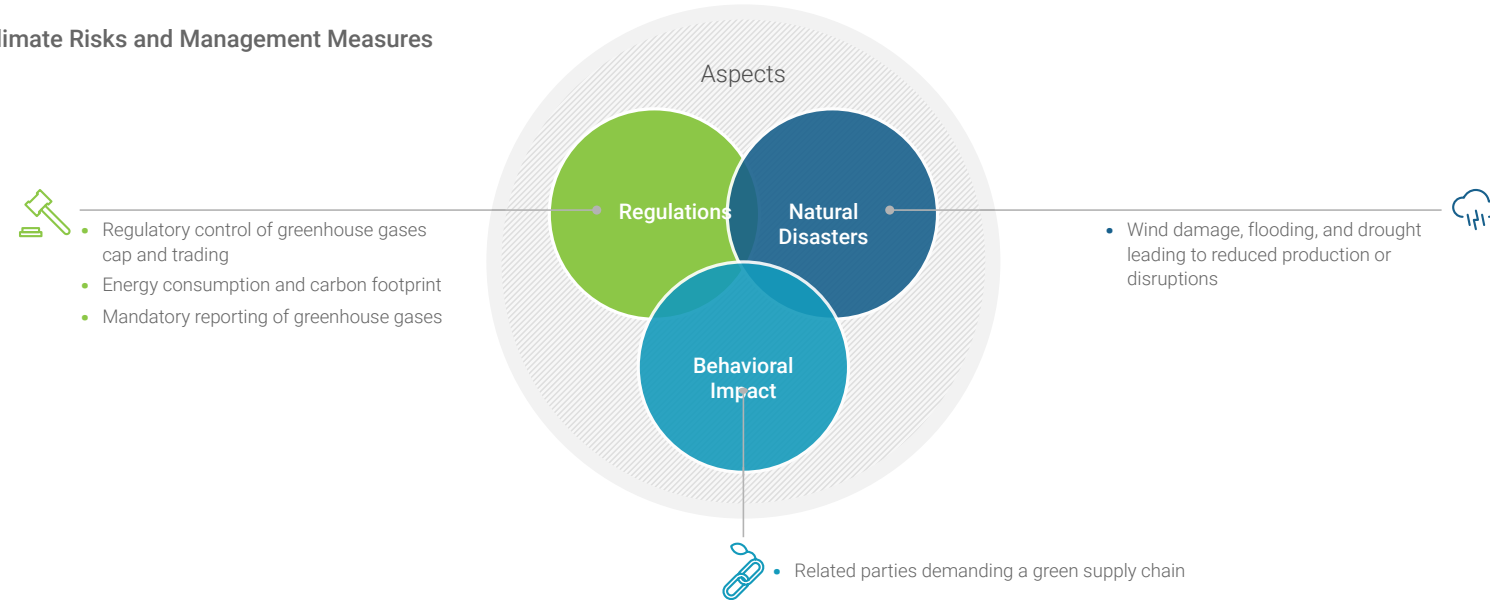
the status of global climate change as well as changes in international and domestic mitigation efforts, and identifies potential risks and opportunities of climate change by utilizing a risk matrix on the aspect of government regulations, natural disasters and behavioral impact. TSMC has made continuous long-term efforts to serve as an industry benchmark for energy conservation and carbon

reduction, and has been strengthening the requirements for its supply chain to do the same. TSMC collaborates with international industry associations and government agencies to promote carbon mitigation and identify the best available technologies to establish industry standards. TSMC aims to raise the supply chain's ability to respond to climate change and reduce climate risks in operations management.



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.

Types of Climate Risks and Management Measures



Aspects	Consideration	Measures	Achievements in 2017
Regulations	Mandatory reporting of greenhouse gases	Implement data inventory: investigate greenhouse gas emissions and energy usage	Greenhouse gas inventory 100% completed
	Regulatory control of greenhouse gases cap and trading	Implement carbon management: the Energy Conservation & Carbon Reduction Committee promotes energy saving and conducts quarterly review	Annual energy saving targets 100% completed Established procedures on carbon credits and trade in FAB 10
	Energy consumption and carbon footprint	Produce green products: raise product energy efficiency, produce low energy consumption products for customers, analyze key factors for carbon reduction and energy conservation	Energy efficiency of new generation production process raised
Natural Disasters	Wind damage, flooding, and drought leading to reduced production or disruptions	Enhance Resilience of business operations: establish crisis management procedures and emergency responses	Fab 15B designs followed climate resistance guidelines (all new fabs will follow)
Behavioral Impact	Related parties demanding a green supply chain	Strengthen collaboration with supply chain: calculate product footprint with suppliers to lower emissions and make purchasing decisions based on emissions. External promotion: support and promote climate change related programs and proposals	Strengthened requirements for supplier-side greenhouse gas monitoring and increased their proportion in audit Proposed semiconductor energy conservation and carbon reduction benchmarks



TSMC stands by its environmental promises, and continues to follow through on its many sustainability measures. Promoting energy conservation, carbon reduction, water saving, and circular economy are all important parts of our efforts to demonstrate the effectiveness of our environmental management and corporate social responsibility. TSMC will continue to share its green manufacturing experience, help the industry gain the competitive advantages of green enterprises, and contribute to the sustainable development of the earth.



J.K. Wang
Vice President, Operations/300mm Fabs

Total Risk Management of Climate Change – Carbon Management Platform

In response to global climate change and the Green House Gas Reduction and Management Act, TSMC established a cross-organizational platform for carbon management in 2016. The three main directives of the platform are: regulatory compliance, energy conservation and carbon reduction, and carbon asset management. TSMC planned and executed short, mid, and long-term reduction plans through the Energy Conservation and Carbon Reduction Committee, led by Vice Presidents of Operations with the support of the Corporate Environmental Safety Division in regulatory discussions around the country. Following the TSMC subsidiary in China, the American subsidiary WaferTech will also be required to lower greenhouse gas emissions in accordance with the Clean Air Act of Washington State in the United States. Faced with tightening rules and regulations regarding carbon emissions and trading, the Finance Department has decided to evaluate carbon asset risk, and devise mid to long-term plans based on energy conservation and carbon reduction goals, carbon credits, and renewable energy options.



Three Aspects of Carbon Management



Achievements in 2017


Regulatory
compliance

Energy Saving
& Carbon
Reduction

Carbon Assets
and Credits

Adhere to greenhouse gas regulations	Participate in public hearings for regulations	✓ Participated in establishing regulations for Phased Regulatory Goals and greenhouse gas emission rewards
	Member of the Industrial Development Bureau response team	✓ Participated in the analysis of industry emission controls and quota for the Phased Regulatory Goals and Greenhouse Gas Emissions Rules.
Support the carbon management commitments of the global semiconductor industry	Member of the World Semiconductor Council greenhouse gas response team and convener of the energy conservation team	✓ Continued participation and followed the WSC PFC reduction best practice.
Establish greenhouse gas database (ISO14064/ISO14067)	Acquire greenhouse gas inventory certification -ISO14064-1	✓ All fabs completed third-party greenhouse gas inventory verification
	Acquire carbon & water footprint certification -ISO14067	✓ Not required in 2017 (every 3-5 years)
	Establish e-platform	✓ Energy Conservation & Carbon Reduction e-platform Enhancement Project
Directly reduce greenhouse gas	Use low greenhouse warming potential gasses	✓ C ₂ F ₆ & C ₃ F ₈ (cleaning process) replaced by C ₄ F ₈
Establish and implement best available practice for greenhouse gas abatement	Install best available greenhouse abatement equipment	✓ Fully installed new equipment in Fab 15B and replaced 62 tools in other fabs
	Develop and implement new greenhouse gas abatement technologies	✓ Installed nitrous oxide abatement equipment in Fab 15B
Implement energy management system (ISO 50001)	Acquire energy management system certification -ISO 50001	✓ Fab 12 phase 7 received certification
Initiate equipment energy-saving projects	Identify the energy saving potential of production tools, propose energy-saving measures, and include energy-saving features in tool purchasing decisions	✓ Included energy-saving features in new equipment purchase guidelines
Construct green fabs	Raise performance of fab systems	✓ Enhanced chiller unit performance by 9%
	Acquire green building certification	✓ Fab 12 phase 7 received U.S. LEED certification ✓ All 12-inch fabs received green building certification
Low carbon investments	Study Renewable Energy Certificate, REC	✓ Fab 6 solar-powered system is the first semiconductor foundry in Taiwan to receive T-REC (received 275 RECs)
Carbon trading platforms	Study carbon credits and trading systems	✓ TSMC (China) purchased 280 thousand metric tons of carbon credits with carbon emissions in 2016
Energy saving and carbon reduction incentives	Programmatic CDM - Clean Development Mechanism for certified emission reduction credits	✓ Fab 2/5, Fab 5, Fab3, Fab 14B, and Fab 15A applied for Clean Dry Air system (CDA) CDM
	Greenhouse gas emission reduction rewards	✓ Applied for greenhouse gas emission reduction rewards in 2018
	Continue to work on voluntary carbon reduction	✓ Joined Industrial Development Bureau voluntary reduction project
Renewable energy usage	Study the Electricity Act	✓ Formed a corresponding task force
	Continue to purchase renewable energy	✓ Purchased 100 GWh of green electricity from Taiwan Power Company

Promoting Low-Carbon Manufacturing

Aiming to Be the Leading Global Benchmark

In response to the global mission of the Paris Agreement, TSMC continues to participate in the Carbon Disclosure Project (CDP^{Note}) and joined Commit to Action, a voluntary enterprise carbon reduction initiative in 2017. The most important step in the initiative is to set reduction targets to keep the global temperature rise below 2 degrees. TSMC is the first semiconductor company in Taiwan to join the Science Based Targets Initiative, SBTi. Under the 2 degrees scenario, the semiconductor industry aims to lower greenhouse emissions intensity to 87% below 2010 levels before 2050.

TSMC successfully reached its targets by reducing gas used in the production process as well as exhaust gas. Due to these efforts, the greenhouse gas emission per product unit decreased 3% in 2017 over the previous year, and dropped 13% compared with 2010. In recent years, the increasing complexity of new generations of products has pushed TSMC to find more innovative methods in meeting government and company renewable energy policies to conserve energy and reduce carbon dioxide emissions.

Note: Established in 2003, the Carbon Disclosure Project (CDP) is an independent, London-based, non-profit organization which supports companies to disclose environmental impact through the collection of carbon emission surveys.

Greenhouse Gas Inventory for Upstream and Downstream Supply Chain

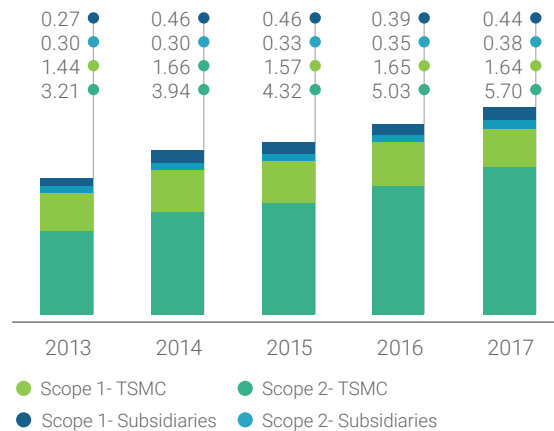
TSMC has required all its fabs around the world to establish greenhouse gas inventory and disclosure by the greenhouse gas protocol since 2005. New fabs must begin inventorying greenhouse gases within 1.5 years after initial production. Each year, every TSMC fab must complete scope 1 and scope 2 greenhouse gas inventories for the previous year and pass the external audit of a third-party organization with ISO 14064-1 verification. TSMC began the scope 3 emission

inventory and verified by a third-party since 2017. In 2017, TSMC and subsidiaries ramped up production and acquired VisEra. As a result, total greenhouse emissions increased 11% over the previous year. TSMC fabs in Taiwan accounted for 90% of the total carbon dioxide emissions of 8.15 million metric tons. Due to the development of advanced processes and the related power demand, the scope 2 greenhouse gas emission ratio is three times larger than scope 1. In

addition to monitoring its own greenhouse gas emissions, TSMC is also concerned with the carbon footprint of final products and looks into the emissions of its upstream and downstream supply chain. The Company requests suppliers to have the ability to conduct their own greenhouse emission inventory. The largest emission in scope 3 emission data is generated by raw materials, followed by fuel and energy related activities and waste disposal.

Scope 1 and Scope 2 Greenhouse Gas Emissions

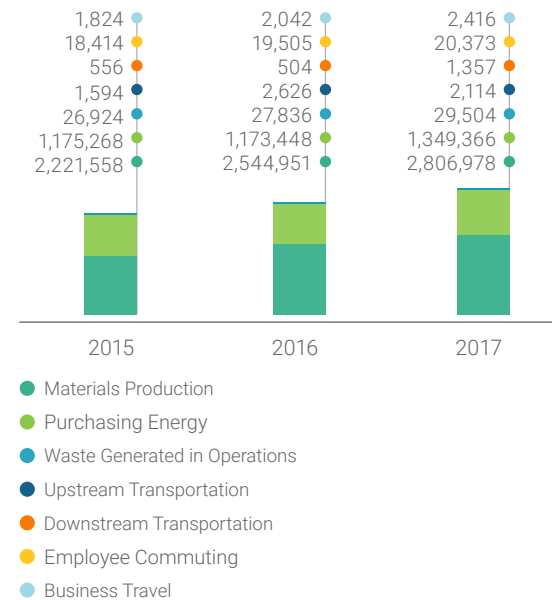
Unit: Million metric ton CO₂e



Note: TSMC total annual greenhouse gas emission data includes emissions from all TSMC fabs (as well as advanced backend facilities) in Taiwan and its subsidiaries WaferTech, TSMC China, VisEra.

Scope 3 Greenhouse Gas Emissions

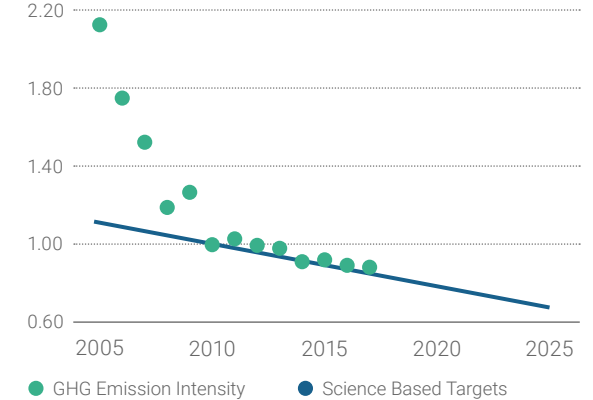
Unit: Metric ton CO₂e



Note 1: Scope 3 emissions include only data from TSMC fabs in Taiwan
 Note 2: According to the announcement of Energy bureau that 1 kWh emits 0.529 kg of CO₂ equivalent and 1kWh = 3,600 Kilojoules.

Greenhouse Gas Emission Intensity

Unit: Metric ton CO₂e/8-inch e wafer-layer



Note 1: TSMC total annual greenhouse gas emission intensity data includes emissions from all wafer fabs belonging to TSMC and its subsidiaries.
 Note 2: Reduction targets are based on SBTi - Sectoral Decarbonization Approach (SDA)
 Note 3: Emission intensity normalized by the baseline data in 2010.

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Best mitigation results in the industry

Best Mitigation Results in the Industry

F-GHG is the main source of greenhouse gas emissions in the semiconductor manufacturing process, it accounts for over 80% of emissions. TSMC aims to lower direct emissions by optimizing gas usage and substituting F-GHG with low greenhouse warming potential gases and installing exhaust gas abatement equipment. In 2017, TSMC reduced 2.35 million metric tons of carbon dioxide on F-GHG emission reduction. Nitrous oxide (N₂O) is the second-largest source of direct emissions which TSMC is striving to reduce. Since 2016, TSMC and

equipment vendors have been collaborating to develop high-performance N₂O abatement and tail gas reduction equipment, and have completed verification on certain models. TSMC leads the industry by being the first to incorporate N₂O gas abatement equipment into its new equipment standard. In 2017 TSMC's F-GHG emissions lowered significantly; emissions per unit decreased 6% over the previous year, not only reaching TSMC's own targets but is far outperforming targets set by the World Semiconductor Council's voluntary PFC agreement.

Scope	TSMC Best Practice Approach	Achievements in 2017
Scope 1 Greenhouse Gas Direct Emissions	ISO 14064-1 inventory and 3rd-party verification annual	✔ Includes all annual inventory and third-party verification for TSMC fabs and subsidiaries
	Gas usage optimization	✔ New fabs must adhere to best practices outlined in technical committee guidelines
	Replace high greenhouse warming potential (GWP) gases (current best available technology: remote plasma NF ₃ / NF ₃ / C ₄ F ₈)	✔ All 12-inch fabs use remote plasma NF ₃ ; 6-inch and 8-inch fabs use C ₄ F ₈ / NF ₃ ✔ Subsidiaries to gradually replace C ₄ F ₈ / NF ₃
	Install point of use (POU) abatement equipment for F-GHG processes	✔ New and existing fabs (including subsidiaries) must install POU abatement during new tools move-in ✔ Existing fabs abatement installation rate is up to 88% ; subsidiaries to gradually replace abatement equipment ✔ Existing fabs replaced 62 tools in 2017; 95 tools will be replaced in 2018 ✔ Lowest F-GHG emission per product unit in the world for semiconductor foundries
	Other greenhouse gases abatement technologies	✔ Continue to develop on-site nitrous oxide abatement technologies ✔ Completed nitrous oxide abatement equipment verification on combustive treatment equipment and listed it as standard equipment (first in the world for semiconductor foundries)
Scope 2 Greenhouse Gas Indirect Emissions	ISO 50001 Energy management 3rd-party verification	✔ All 12-inch fabs completed ISO 50001 inventory and 3rd-party verification; some 6-inch and 8-inch fabs completed ISO 50001 inventory and 3rd-party verification
	Top-level management	✔ Vice Presidents of Operations lead the Energy Conservation & Carbon Reduction Committee as well as set and regularly review company targets
	New generation process tool development with energy-saving design	✔ Initiated energy conservation projects for new generation process tools (first in the global semiconductor industry)
	Utilize renewable energy	✔ Purchased 100 GWh of green electricity from Taiwan Power Company in 2017; largest purchaser of green power from Taiwan Power Company for 3 consecutive years
	Energy efficiency enhancement	✔ Highest energy efficiency in the industry ✔ 10-year target of 2,800 GWh of electricity saved; 510 GWh of electricity saved with 452 energy-saving measures in 2017

1

The first semiconductor manufacturer in Taiwan received renewable energy certificates

5.29 million trees

Purchased a total of 100 GWh of green power in 2017. This reduced carbon emissions by about 52.9 million kilograms, equivalent to the carbon absorbed by 5.29 million trees in one year

Development of Renewable Energy

Owing to its corporate responsibility to protect the environment, TSMC continues to track developments in climate change. In addition to lowering power consumption, TSMC also takes concrete action by adopting renewable energy. TSMC fully supports the government's policy, and commits to directly purchasing renewable energy once the regulatory and market environment is mature in the future. This move will effectively reduce greenhouse gas emissions and proactively supports the United Nations' sustainable development goals.

Purchasing Green Power

In response to the government's renewable energy policy, TSMC has purchased green power as a way of supporting the development of renewable energy. The Company purchased a total of 100 GWh of green power in 2017. This reduced carbon emissions by about 52.9 million kilograms, which are equivalent to the carbon absorbed by 5.29 million trees in one year. Since 2015, TSMC has been the biggest green power purchaser by cumulatively subscribing for 400 GWh of green energy for the last three years, accounting for 64.4% of the total green power sold in Taiwan.

Installing Renewable Energy Power Generation Equipment

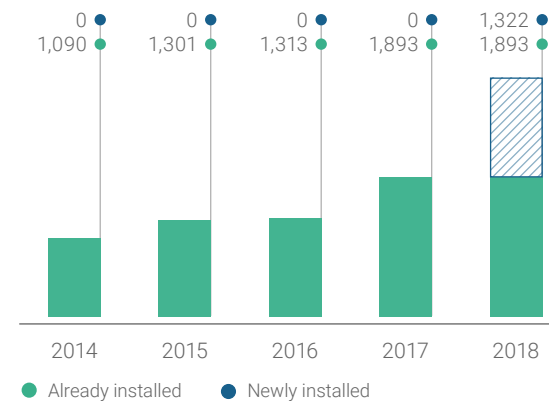
TSMC has also installed solar panels inside its science parks to generate renewable energy for its facilities. In 2017, the Company's total solar panel capacity expanded by 550 kW and combined with the 30 kW used by its subsidiary, VisEra Technology, total solar panel capacity reached 1,893 kW, generating 1.5 GWh. This reduced carbon emissions by 770 metric tons, equivalent to the carbon absorbed by 77,000 trees in one year. TSMC will continue to expand its solar panel capacity by 1,322 kW in 2018. In 2017, the

newly installed Fab 6 solar power plant was certified by the National Renewable Energy Certificate Center. TSMC also obtained 275 renewable energy certificates for the entire year, making it the first semiconductor manufacturer in Taiwan to receive renewable energy certificates. All these pro-active measures highlight TSMC's commitment towards the development of Taiwan's renewable energy.

TSMC will monitor local renewable energy development aggressively, purchase renewable energy and continue to install renewable energy generation equipment to fulfill our responsibility of global citizenship and support government strategy. We want to support renewable energy through concrete measures to make an impact on the mitigation of climate change.

Installed Capacity of Renewable Energy

Unit: kW



Note: Total Installed Capacity of Renewable Energy Power Generation Equipment include TSMC (all fabs and packaging and testing facilities located in Taiwan)) as well as its overseas subsidiaries (WaferTech, TSMC (China), VisEra Technology)

Improving Energy Efficiency

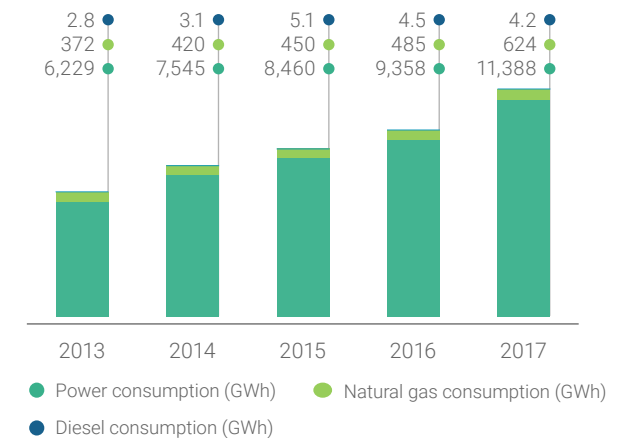
Comprehensive energy inventory

TSMC's total energy consumption in 2017 was 12,016 GWh, of which power usage accounted for about 94.8% of total energy consumption. This was followed by natural gas, which accounted for about 5.2% of total energy consumption. Diesel consumption is less than 0.03% of total energy consumption.

TSMC's electric power is mainly used in manufacturing by process equipment and facility systems. The Company uses ISO 50001 for energy management and cross-fab energy efficiency comparisons to find the best operating model and make company-wide adjustments to obtain

Total Energy Consumption

Unit: GWh



Note 1: The total energy consumption includes TSMC (all fabs and packaging and testing facilities located in Taiwan) as well as its overseas subsidiaries (WaferTech, TSMC (China), VisEra Technology)

Note 2: The conversion unit is 1 cubic meter of natural gas = 10.4 kWh, 1kWh = 3,600 Kilojoules

maximum efficiency from each kWh consumed. TSMC's unit power consumption was 9.5 (kWh/8-inch e wafer-layer) in 2017, 10.4% lower than 10.6 (kWh/8-inch e wafer-layer) in 2010. Additionally, this was 1.4% lower than the Company's optimum performance of 9% in 2017. Natural gas is mainly used for boilers, Volatile Organic Compound (VOC) treatment systems and burn-type Point-of-Use Waste Gas Treatment systems to reduce direct fluoride gas emission and greenhouse gas emission. In 2017, TSMC consumed 0.055 cubic meters of natural gas per 8-inch wafer per mask layer. Diesel is primarily used in emergency power generators and fire pumps, which are only engaged

during power supply disruptions, scheduled maintenance and emergencies, and is not a direct energy source for production. The Company consumed approximately 409 kiloliters in 2017.

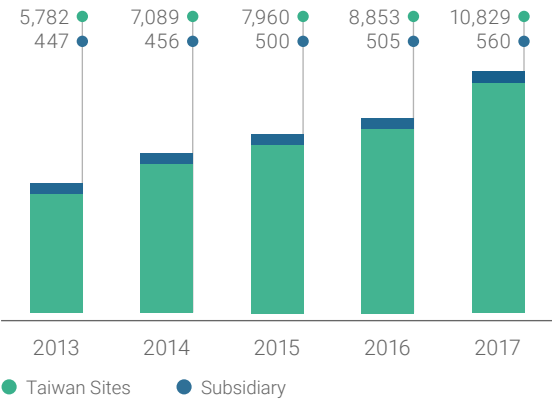
Enhancing Power Usage Effectiveness

Due to the expansion and increasing complexity of advanced manufacturing process, TSMC expects power consumption will continue to increase. To maximize energy efficiency, and in response to the government's energy-saving targets, TSMC has invested heavily in energy-saving measures and had laid out an implementation plan from 2016 to 2025 that

targets an average annual energy-saving rate of greater than 1%. By 2025, new energy-saving measures are expected to reduce energy consumption by 2,800 GWh as well as reduce carbon emissions by 1.48 billion kilograms, which is equivalent to the carbon absorbed by 148 million trees in one year. Compared to the absence of energy-saving measures, total power consumption has fallen by 13%.

Total Power Consumption

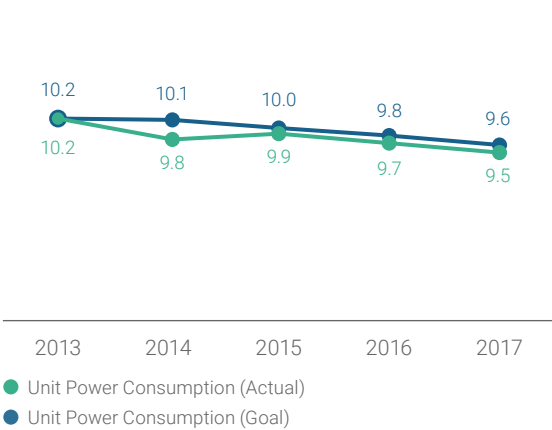
Unit: GWh



Note 1: The total power consumption includes TSMC (all fabs and packaging and testing facilities located in Taiwan) as well as its overseas subsidiaries WaferTech, TSMC (China), VisEra Technology

Unit Power Consumption and Goal Completion

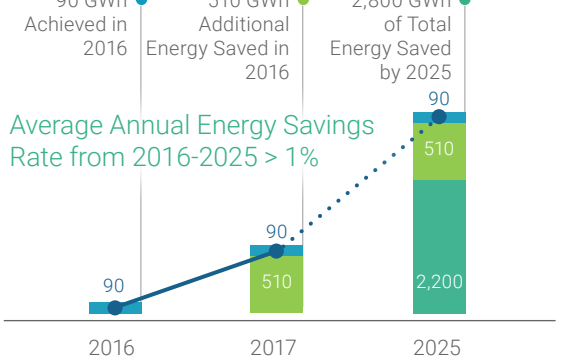
Unit: kWh/8-inch e wafer-layer



Note 1: The indicator for power consumption per wafer-layer includes all wafer fabs of TSMC and subsidiaries.
Note 2: This calculation does not include diesel and natural gas, as these are not used for production.

TSMC 10-year Energy-Saving Targets

Unit: GWh



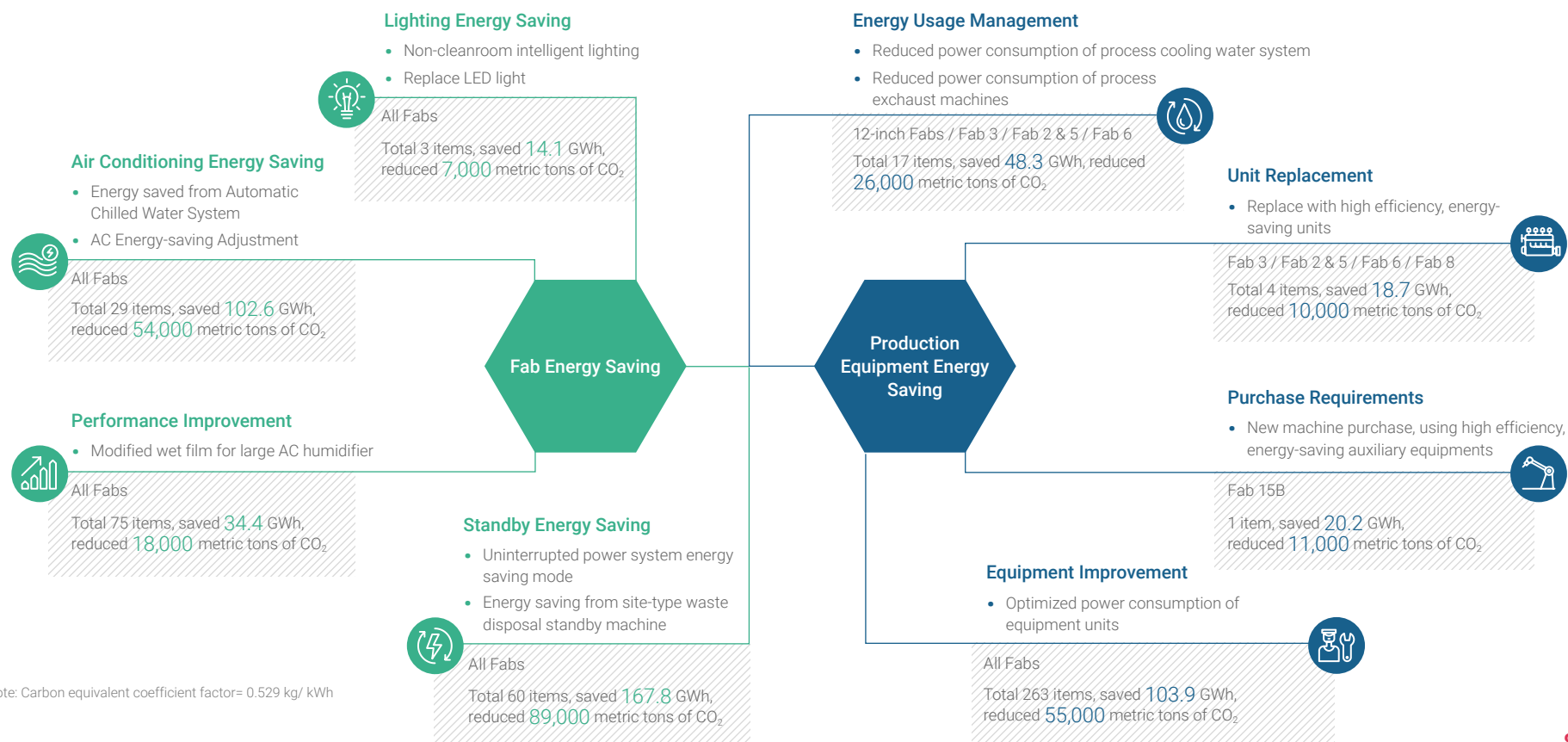
Average Annual Energy Savings Rate from 2016-2025 > 1%

TSMC's energy management is based on ISO 50001. It develops energy-saving management platforms, implements energy audits, and strives for the most efficient use of each kWh. In 2017, TSMC's Facilities Department became the first to apply Big Data in the analysis of air-conditioning energy-saving parameters. In the process, it was able to develop an optimal control program, which can automatically adjust chilled water system and its auxiliary equipment to the best energy-saving point, effectively improving the efficiency of the chilled water system by 9%. TSMC also held classes on energy saving and carbon reduction to share its knowledge with the industry. The Process Equipment Department has focused on replacing

inefficient components and optimizing equipment energy consumption. TSMC's annual energy-saving plan included 452 energy-saving measures across eight categories, reducing consumption by 510 GWh, eliminating 270,000 metric tons of carbon dioxide emission and saving NT\$1.28 billion in electricity costs. In addition, reducing carbon emissions also saved NT\$400 million in potential external carbon costs^{Note}. The energy-saving measures of TSMC's subsidiary companies, such as WaferTech, TSMC (China), VisEra Technology, were mainly focused on using LED lighting, as well as replacing old and worn equipment. In 2017, a total of 4.5 GWh of energy was conserved.

Note: Computed using a NT\$1,500 fine per metric ton for direct and indirect carbon emissions (metric tons) levied by the Taiwan government

Additional Energy-Saving Performance 2017





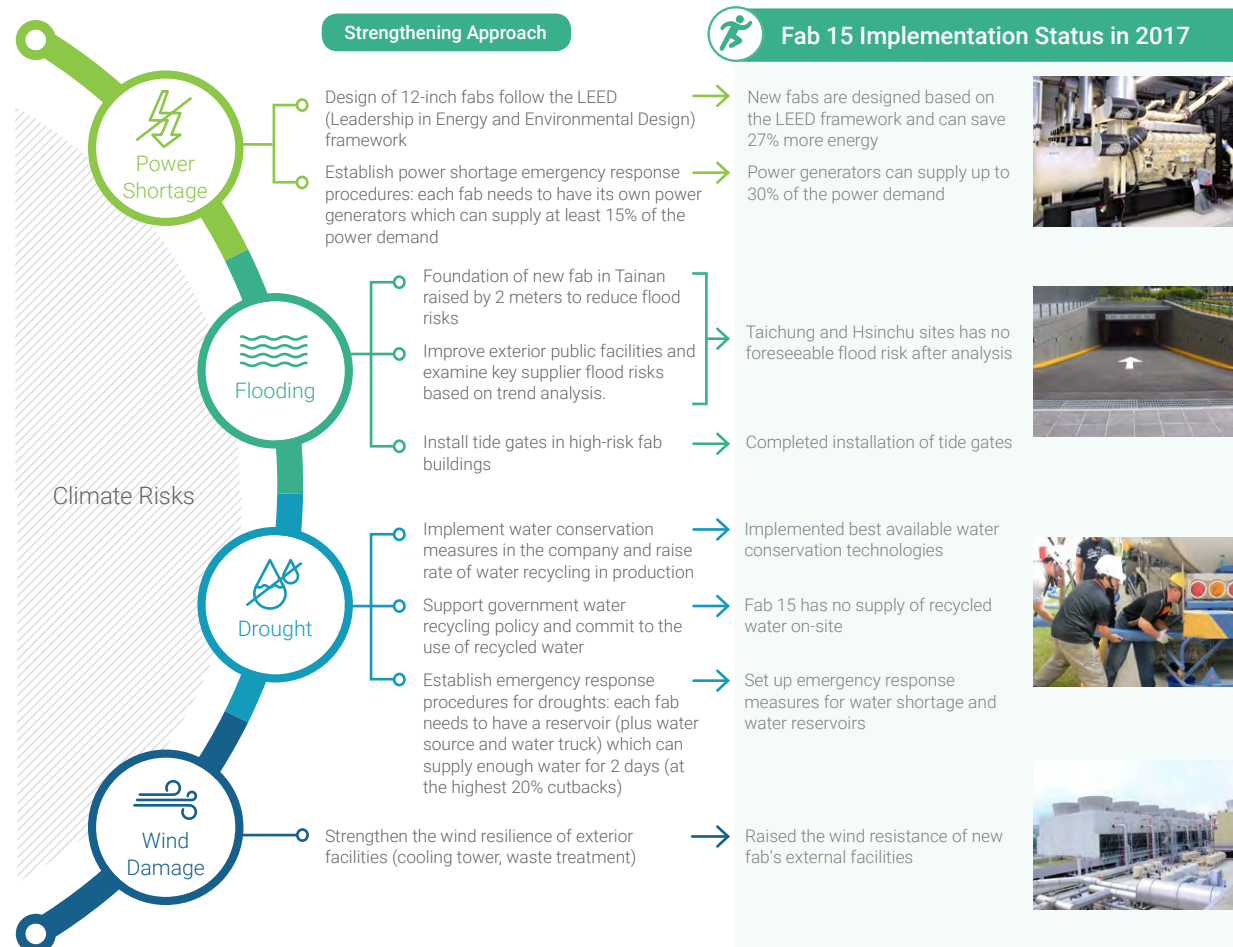
TSMC promotes industry benchmarking by inviting government agencies and academia to attend Energy and Carbon Reduction Committee meetings

Strengthening Climate Resilience

TSMC assesses climate related risks annually to protect its operations against climate change and extreme weather. The Company's standardized guidelines focus on weather-related factors which could disrupt daily operations such as drought, power shortages, flooding, and wind damage. All fabs are required to carry out assessments to prevent all potential damage from natural disasters and avoid any disruption to production. The newly-completed Fab 15B was designed specifically with climate resistance guidelines in mind, and other fabs have also made changes according to these guidelines.

Leading the Industry in Facing Climate Changes

TSMC understands the challenges of climate change. It is a difficult mission which requires the cooperation of the entire industry, from upstream to downstream vendors, and adherence to government policies to complete this task. TSMC fully supports the planning and implementation of government policies and acts as industry and trade association representative and committee member of the Energy White Paper and Greenhouse Gas Expert Advisory Committee, offering feasible benchmark solutions and advice. TSMC is also the ESH Committee Chairman of the Taiwan Semiconductor Council and World Semiconductor Council. In addition to hosting regular conferences and forums to discuss best approaches in energy conservation and carbon reduction, TSMC also actively pursues the best feasible benchmarks, including F-GHG Reduction Best Available Approach Guidelines and F-GHG and N₂O Abatement Approaches. TSMC possesses a strong resolve to lead the global semiconductor industry through its actions.



Case Study

Using Big Data Analysis to Develop Intelligent Chilled Water System

In 2017, TSMC analyzed the energy consumption of its plants and discovered that its chilled water system accounted for as much as 20% of its total power consumption. The issue of enhancing its plants' operational efficiency, therefore, became an important concern. Through a study of Big Data and after examining close to 500,000 operational data, TSMC was able to successfully develop "an optimal energy-saving control program" for its chilled water system. While the conventional method focuses only on enhancing the energy efficiency of a single piece

of equipment or device, this new model - the first in the industry - takes things a step further by taking into consideration the entire chilled water system, dynamically adjusting the temperatures of the chilled and cooling water. Furthermore, it automatically adjusts the system to its "optimal energy-saving point" based on varying external air conditions and on-site loads, and in the process, increases operational efficiency by as much as 9%.

In addition to its innovative energy-saving measures, TSMC has always been strict and

rigorous in conducting risk assessments. Prior to the full implementation of the "optimal energy-saving control program" for its chilled water system, the Company first tested the program on its Fab 12B plant for six months and monitored 260,000 air-conditioning parameters. After ensuring that no abnormalities were seen in 100% of the parameters, the program was officially incorporated into its production system in the third quarter of 2017. The system is currently part of TSMC's advanced manufacturing process and has helped the

Company conserve 58 GWh of electricity in 2017, an estimated 11% of the Company's annual energy savings. The smart energy-saving chilled water system is considered a major breakthrough in the industry for energy conservation.



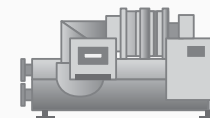
For more details, please refer to our website: ["TSMC Successfully Developed Industry's First Chilled Water System Optimization, Energy-Saving Control Program"](#)

Traditional Control Point Manual Adjustment

Single equipment energy saving:
Cooling Tower



Does not consider for power consuming of
other equipment: Chiller



Optimal Control Point Automatic Control

Considering the correlation of power consumption between each equipment

Chiller



Chilled Water Pump



Cooling Water Pumps



Cooling Tower



58 GWh

2017 Saving Contribution

9%

Increased efficiency

Case Study

TSMC Generously Shares its Energy-Saving and Waste Reduction Methods

TSMC is fully committed to environmentally friendly actions and integrates green management and development strategies into its corporate culture. Internally, the Company holds competitions for energy-saving proposals, inviting colleagues to brainstorm and share their ideas, with the aim of developing

more efficient and more innovative energy-saving projects. Externally, the Company shares its energy-saving and waste reduction experiences with the public through education and training courses. As a continuation of the Company's successful educational model in the past, TSMC again launched two free

classes on "Energy Conservation Practices and Energy Management Strategies" and "Resource Regeneration" in Hsinchu, Taichung and Tainan in 2017. These classes, as well as actual plant visits, were personally handled by highly qualified TSMC employees, who shared their experiences in corporate benchmarking

practices. Originally only six classes were scheduled but this was increased to nine due to the number of registered attendees. These talks attracted 357 participants from the manufacturing sector, the medical and healthcare field, as well as college professors and students.



2017 Energy-saving and Waste Reduction Course Plan

Energy-Saving



- Energy Monitoring and Management System
- Air Conditioning System Operational Optimization Strategy
- Sharing of AC Energy-saving Practices
- Sharing of TSMC's Energy-saving Measures

Waste Reduction



- Recycling and Regulatory Practices
- Industrial Water Treatment Technology Enhancement
- Wastewater Classification and Recycling Evolution
- Waste Recycling and Recovery

Feedback from Participants

72%

72% of participants, who joined this activity, changed their opinion and concept concerning energy-saving and carbon reduction

48%

48% of participants who joined this activity, claimed that it helped them identify areas where they can conserve energy

“

TSMC would love to not only share our green management knowledge but also arrange a site tour visit. The various kinds of facility systems are categorized by different colors or shapes clearly indicating on/off. This method is for reducing miss operation, it could be a reference to THSR for managing valves.

Chia-Ho Chen
Senior Specialist of Taiwan High Speed Rail



Case Study

Host Tool Energy Saving Workshop, Accumulation of Green Innovation Energy

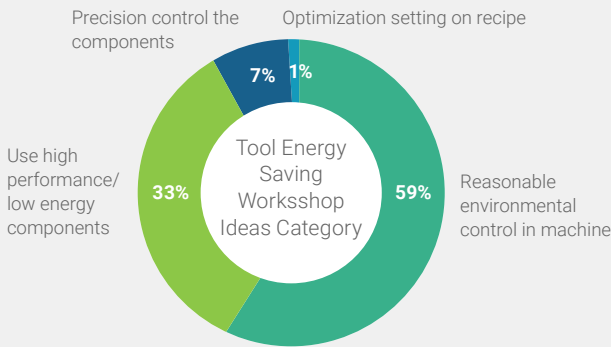
Green innovation is the responsibility of every TSMC employee. Through full implementation of energy reduction activities, hosts of cross-organizational energy-saving ideas competitions encourage their colleagues to continue to identify energy saving opportunities from daily operations and put them into action.

In 2017, TSMC initiated "Tool Energy Saving Workshop". Through competition prizes and praise, TSMC encourages colleagues to brainstorm for innovative and feasible energy-saving solutions. Driven through cross-function study and learning, TSMC improves colleagues' ability to solve tool energy saving problems.

Each competition proposal has to consider various power applications and process stability in the production process. All were reviewed in three aspects, as "Feasibility", "Energy Saving" and "Innovation" from 16 TSMC internal judges. After the first screening for nine finalists and reexamination, the best proposals stood out.

In 2017, there were 223 energy-saving cases presented in the workshop. Three "Best Energy Saving Awards", three "Innovation Awards" and three "excellent Awards" were chosen. The estimated energy saving from them is 198 GWh annually.

2017 Tool Energy Saving Workshop Ideas Category



2017 Tool Energy Saving Workshop Base Cases

Category	Cases	Benefit
Reasonable Environmental Control in Machine	Correct the temperature control mechanism of furnace tube, find the best energy saving mode	Energy Saving > 6%
Optimization Setting on Recipe	Simplify the running step of the clean tool, find out the optimization model for water and power consumption	Energy Saving > 10%
Use high performance /low energy components	Use high-efficiency, energy-saving motors and heat exchangers, find the most suitable and low-energy configuration	Energy Saving > 20%



Tasks of 2018

Source diversion to tools in production facilities.

Improve the efficiency of ammonia nitrogen treatment system

Case Study

Carried out the First Independent Ecological Survey of the Domestic Semiconductor Industry in Taiwan

In 2017, TSMC's aggressive response to the United Nation's Sustainable Development Goals (SGDs), (UN Sustainable Development Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems...and halt biodiversity loss.) and the Aichi Biodiversity Target, conducting the first independent eco-survey in the domestic semiconductor industry, as well as evaluating the impact of the Company's operations on the environment and on biodiversity. Results of the study showed that there were more than 493 species of plants and 209 species of animals found within TSMC's science parks. The results of the ecological survey highlighted not only the extremely abundant and rich variety of species found inside TSMC's science parks, but showed the balanced and harmonious stewardship of the Company with the environment.

TSMC has produced outstanding results in green sustainability. With its clearly defined ecological development goals and positive actions, the Company has, through its Green, conservation, Eco-Friendly, and Education Policies, sought to protect the country's natural resources. The Company has carried out multi-level greening within its science

parks as well as established a diverse habitat. For example, by establishing ecological zones, channels, and ponds to bring in water, the Company has provided a welcoming habitat for birds and butterflies. In addition, to ensure a balanced biodiversity, the Company has gradually introduced native plants on the ground, cultivating a rich collection of plant

species that will attract butterflies and birds by offering copious opportunities to feed.

In 2018, as the Company strives to exert a greater green influence on its environment, it will focus on the conservation of rare and endangered species, including the migration of threatened species such as the Cuora

flavomarginata (Chinese Box Turtle) to livable environments and the independent cultivation of Lavandulaealeaf dendranthema (delicate native flowers) and other endangered plants.



For more detail, please refer to our website: ["TSMC Strikes a Balance between Technology and Ecology"](#)

Four Ecological Sustainability Strategies of TSMC

TSMC's ecological sustainability of green park



Design of Green Belt in Series

- A Series of Disconnected Green Belt
- Expanding Green Area
- Planting of Trees



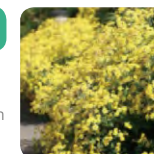
Ecological Environment Monitoring

- Ecological Environment Monitoring
- Non-toxic Maintenance Management
- Encouraging Environmentally Friendly Farming



Dendranthema Lavandulifolium Conservation

- Conservation of Native Endangered Plants
- Threatened Species of Protection
- Habitat Protection and Reconstruction



Ecological Education Activities

- Environmental Education Facility
- Green Building Visiting Activities
- Promoting Ecological Education



Natural Resource

Note: UN Sustainable Development Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems...and halt biodiversity loss

Material Issue

Water Management

Strategies

TSMC 2020/2025 Goals

Achievements & Targets

Water Resource Risk Management

Implement programs to reduce climate risks and continue practicing daily water conservation and adjustments for water shortage

- Reduce 2020 water consumption (liter/8-inch e wafer-layer) to 30% below 2010 level 2020
- Accumulate 12.77 million metric tons in water conserved through new conservation measures from 2016 to 2025 2025

Diversification of Water Resources

Integrate internal and external resources to develop recycled water technology and continue practicing water conservation and water reclamation during production process

- Replace at least 28,000 metric tons/day of tap water with recycled water by 2025 2025

Develop Preventive Measures

Improve the effectiveness of water pollution prevention and treatment in order to remove ammonia nitrogen and pollutants from wastewater

- Reduce ammonia nitrogen concentration in wastewater discharge to <25mg/L 2025

Strategies & 2020/2025 Goals

2017 Achievements

2018 Targets


24.7% Note 1

Reduced water consumption to 24.7% below 2010 level

Target: 21%

○ Reduce water consumption to 26% below 2010 level


1.97 million

Accumulated 1.97 million metric tons in water conserved through new conservation measures

Target: 1.57 million metric tons

○ Adopt new measures to save 1.28 million metric tons of water Note 2

< 35mg/L

The average concentration of ammonia nitrogen in wastewater discharge was reduced from 80mg/L to 35mg/L in the Tainan facility

Target: < 60mg/L


< 35mg/L

The average concentration of ammonia nitrogen in wastewater discharge was reduced from 50mg/L to 35mg/L in both Hsinchu and Taichung plants

Target: < 60mg/L


< 20mg/L

The average concentration of ammonia nitrogen in wastewater discharge was reduced to below 20mg/L in the new plant in Taichung

Target: < 20mg/L

○ Reduce the average concentration of ammonia nitrogen in wastewater for the entire company from 35mg/L to below 30mg/L

Note 1: Achieved the goal earlier than expected for 2018

Note 2: The conservation volume for each year is based on the measures scheduled and planned by every plant. Continue water conservation at facility-level and begin tool-level measures in 2018

Water is an important natural resource for TSMC's operation and development. The risk of water shortage and flooding has increased in recent years due to global climate change, and the stability of water resources has become an important issue for TSMC. Starting from 2017, TSMC has actively addressed this issue the three dimensions of, "Water resource risk management", "Diversification of water resources" and "Development of preventive measures", and ensures the Company's sustainable development by cultivating new water sources and reducing consumption.

Risk Management of Water Resources

Managing water shortage risk and taking pre-emptive action

TSMC believes water resources management plays an important role in the risk management of climate change

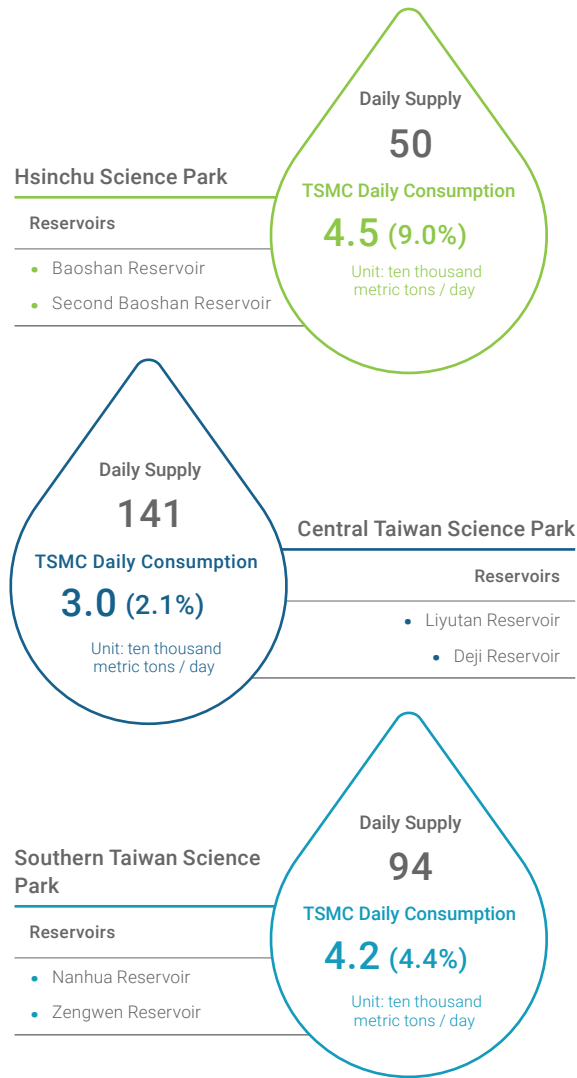
TSMC Water Shortage Contingency Measures

Emergency Levels	Water Restrictions by Government	TSMC Contingency Measures	Status in 2017
Normal	Stable supply	Establish a comprehensive water monitoring mechanism Early warning of long-term trends in water use	Regularly checked the status of all water reservoirs reported by the Water Resources Agency and held practice drills
Adequate	Farms advised to leave fields fallow	Establish a contingency team Assess the demand for water tankers/water reserve	Established a contingency team to take inventory of water resources and water tanker capacity
Level One	Water supply pressure lowered pressure at specific times	Voluntarily reduce water consumption by 3% Practice exercises in using water tankers to transport water	- Reduced landscape watering by 50% - Lowered pressure of water supply to achieve 3% voluntary water conservation
Level Two	Reduce supply to industrial use by 5~20%	Implement water restrictions at all levels and take necessary water conservation measures Intra-organizational drought emergency response team	Did not occur
Level Three	Water restrictions by zone	Implement water restrictions at all levels and take necessary water conservation measures Intra-organizational drought emergency response team	Did not occur

and the adaption to natural disasters. The Company uses a water reporting system to monitor the volume of each water reservoir and the water usage rate of every plant, and water training drills are held every year. Every plant maintains water pools, temporary water sources and water tankers to keep a 2-day supply of water at all times to ensure a stable supply in case of emergency.

From February to April and the month of December in 2017, Taiwan experienced water shortages, and TSMC facilities in some regions entered water restriction Level One (yellow light). TSMC immediately initiated a contingency plan to voluntarily reduce water consumption by 3% by reducing landscape watering by half and reducing water pressure. Due to steady routine preparation, TSMC production at all fabs were not affected by the government's water restriction measures in 2017.

Water Usage Ratio of TSMC in Three Science Parks



Note: Daily supply of reservoirs was based on Water Resource Agency data. Reservoirs for Taichung Science Park also supply Taichung and Miaoli area

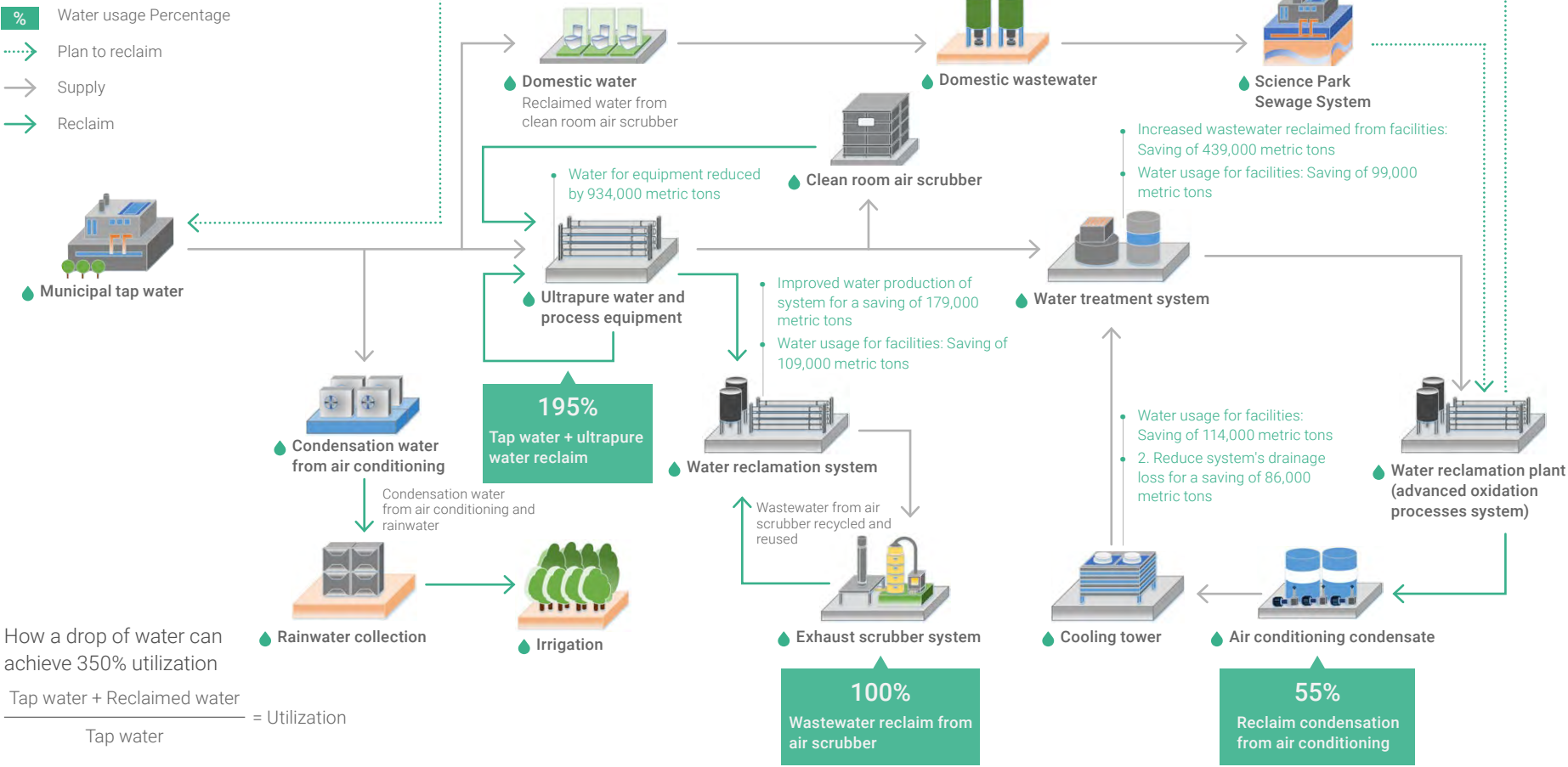
Water Recycling

To improve water usage efficiency, TSMC categorizes wastewater from purification equipment and production processes according to the cleanliness of discharge, and the cleanest water is given priority for recycling and purification

to return to the production processes. Water in the next grade of cleanliness can be used in the nonmanufacturing processes following treatment. Finally, unrecyclable wastewater is treated at an on-site wastewater treatment

plant before discharge. TSMC is committed to building a variety of water recycling systems to enable the reuse of water so that not a drop is wasted.

The Journey of Water in TSMC



87.5%

In 2017, the average recycling rate of the water used in production processes reached 87.5%, above the 85% required by the science park administration

With the increasing number of advanced products on the market, the demand for integrated circuits with smaller critical dimensions and product cleanliness is even stronger. The demand for water needed in the production of wafers continues to rise, and water recycling is growing more difficult, but necessary nonetheless. In 2017, the efficiency of existing recycling practices was improved and the water

use of facilities, equipment and production processes were constantly reviewed to find more opportunities for water conservation. The volume of water being recycled and the use rate of recycled water were both improved, further maximizing the efficiency of water resources. In 2017, the average recycling rate of the water used in production processes reached 87.5%, above both the 85% required by

the science park administration and the results from 2016, representing a breakthrough against the challenges posed by the increasing use of water. In 2017, TSMC added 15 new water conservation measures as well as continuing previous measures, leading the total volume of recycled water reach 103.4 million metric tons, which was equivalent to the capacity of 3.2 Second Baoshan Reservoirs.

Water Conservation Effectiveness

	2013	2014	2015	2016	2017
Average recycle rate of water used in the production process (%) ^{Note 1}	86.9	87.6	87.3	87.4	87.5
Total water saved (million metric tons)	66.9	81.0	85.6	94.3	103.4
Equivalent number of Second Baoshan Reservoir ^{Note 2}	2.12	2.57	2.72	3.00	3.29
Equivalent number of standard swimming pools ^{Note 3}	26,744	32,396	34,252	37,732	41,360
Number of times each drop of water is used	3.2	3.3	3.5	3.5	3.5

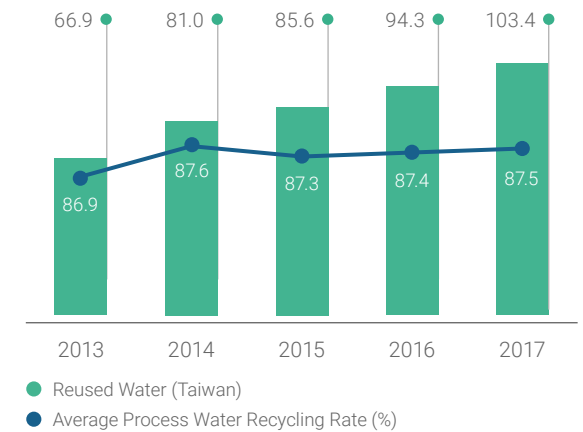
Note 1: Average process water recycling rate is defined by the Science Park Administration

Note 2: Second Baoshan Reservoir is the main reservoir serving Hsinchu Science Park and its full capacity is 31.49 million metric tons

Note 3: A standard 50x25x2m swimming pool contains up to 2,500 cubic meter of water

Water Recycling and Usage Efficiency

Unit: Million metric tons



Note 1: Total recycled water quantity includes process and scrubbers recycling

Note 2: Total recycled water quantity is about 2.5 times municipal water consumption in TSMC

New Water Conservation Methods and Achievements in 2017

In addition to the existing water conservation measures, TSMC develops approaches to improve water recycling as well as reduce water consumption, and assesses the water usage in each plant to find opportunities for water conservation. New water conservation measures are designed to achieve reduction in both water use and discharge. In 2017, the implementation of four water conservation aspects was continued - "Reduction of water consumption at facilities", "Increase facility wastewater recycling", "Improve system water production rate" and

"Reduce loss from system discharge". Further studies were conducted on "Reduce water used in manufacturing" and it was determined that three actions could be taken: "Shut down inessential supplementary tools", "Reduce water used in production processes" and "Improve water supply to tools".

In total, 15 water conservation measures were taken in 2017. 1.97 million metric tons of water were saved, equivalent to a savings of NT\$25.17 million, which was enough to provide 1 full year of water to nearly 20,000 people.^{Note}

In 2017, several newly built fabrication plants (Fab 12 P7 and Fab 15B) went operational. Facing the challenge of increasing water use, TSMC continued to offer various innovative water conservation measures to improve the water use for advanced production processes, as well as water recycling rate and volume. The water usage (volume needed per wafer unit) was reduced from 62.6 (liters/8-inch e wafer-layer) in 2010 to 47.2 (liters/8-inch e wafer-layer) in 2017, an achievement of 24.7% reduction. Not only was the goal for 2017 achieved, the 2018 goal was also reached ahead of time.

Note: According to statistics published by the Water Resources Agency, the average daily water consumption per person is 291 liters

New Water Conservation Methods and Achievements in 2017

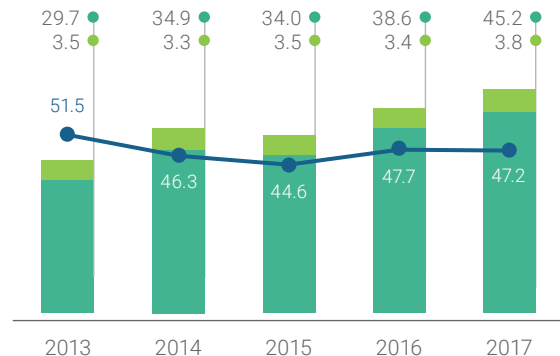
	Reduction of Water Consumption at Facilities	2017 New Measure	
		Water Conservation Measures	Volume Saved Per Year (metric tons)
		Reduce cooling tower and sand filter backwash water	114,050
		Extend the regeneration and backwash time for ultra pure water and reclaim system	84,372
		Office cleaning water conservation	15,263
	Improve System Water Production Rate	2017 New Measure	
		Water Conservation Measures	Volume Saved Per Year (metric tons)
		Increase reclaimed water RO production	111,899
		Improve the usage rate of reclaimed water	68,614
	Increase Facility Wastewater Recycling	2017 New Measure	
		Water Conservation Measures	Volume Saved Per Year (metric tons)
		Hydrofluoric acid wastewater recycling	57,203
		TMAH system water reclaim	154,736
		Reclaim acidic wastewater discharged at the chemical zone	42,320
		Wastewater reclaimed from air scrubber	186,188
		Reclaimed water is refined into industrial-grade water	109,060

	Reduce Water Use of the Manufacturing System	2017 New Measure	
		Water Conservation Measures	Volume Saved Per Year (metric tons)
		Shut down inessential supplementary tools	560,640
		Reduce water use of the production processes	200,385
		Improve water supply to production tools	174,470
	Reduce Loss from System Discharge	2017 New Measure	
		Water Conservation Measures	Volume Saved Per Year (metric tons)
		Drainage reclaim from cooling towers	22,850
		Reclaim backwash wastewater from activated carbon tower of the recycling system	64,071

Total Saved
1,966,121
metric tons

City Water Consumption and Water Consumption per Wafer-Layer

Unit: million metric tons



- Water Consumption (Taiwan)
- Water Consumption (Overseas)
- Water Consumption Per Wafer-layer (liter/8-inch e wafer-layer)

Note 1: Total water consumption includes TSMC (all fabs as well as packaging and testing facilities located in Taiwan) as well as its overseas subsidiaries WaferTech, TSMC (China), and VisEra Technology

Note 2: The indicator for water usage per wafer-layer represents the statistics for all wafer fabs of TSMC and subsidiaries.

40%

TSMC enhanced reclaimed water technology and successfully reduced the unit cost of water by 40% in 2017

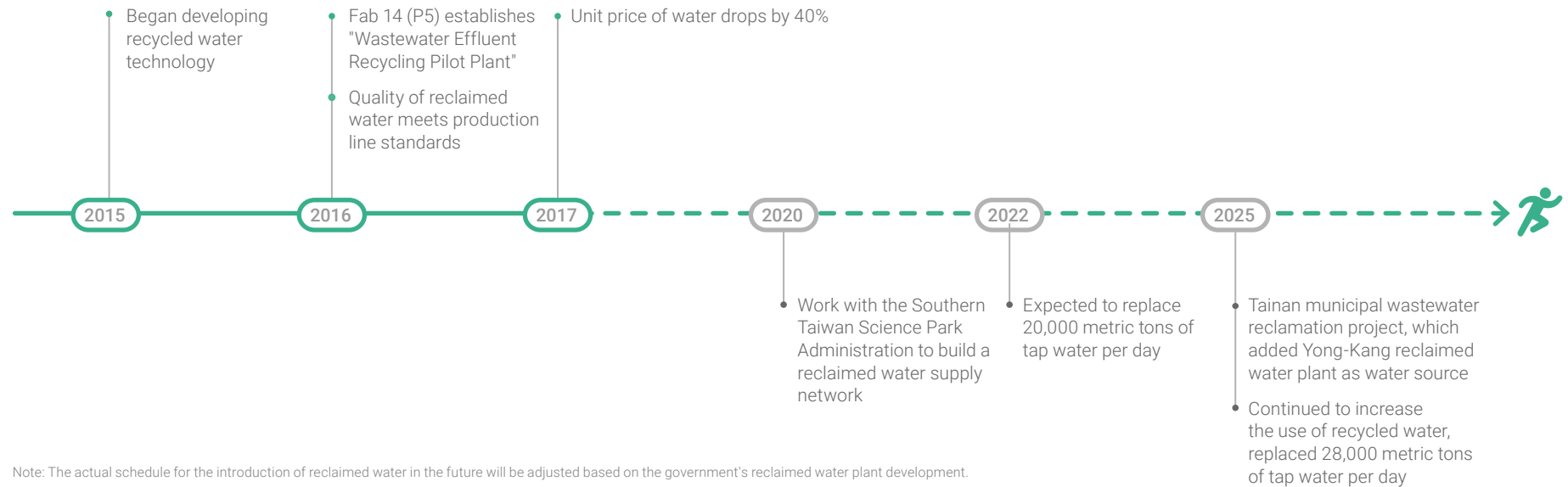
Diversification of Water Resources

TSMC's sources of water include municipal tap water, condensation water from air conditioning, and rainwater. Municipal tap water is used in production processes and domestic purposes. Recycled condensation water is used in the production processes and landscaping irrigation. Rainwater is used for irrigation. In order to reduce reliance on municipal tap water, TSMC has been developing reclaimed water technology since 2015. Currently, recycled

water generated in-house has successfully reduced the total organic carbon (TOC), urea, conductivity and other major factors related to water quality, conforming to the standards required for the water used in production processes. The quality of wastewater also meets discharge standards. These are milestone for the development of recycled water at TSMC, and in the future, the Company will continue working with the government to promote the use

of reclaimed water, taking actions to support the national policy on industrial-use reclaimed water. In 2017, TSMC's approach toward streamlined development process and water quality successfully reduced the unit cost of water by 40%. Although it is 5 times the price of municipal tap water, it has demonstrates the future availability of reclaimed water.

Development of Reclaimed Water at TSMC



Development of Preventive Measures

Classification of sources is the key to pollution prevention. Only a robust classification of sources at the beginning can result in effective prevention of pollution afterward.

Wastewater Classification and Recycling

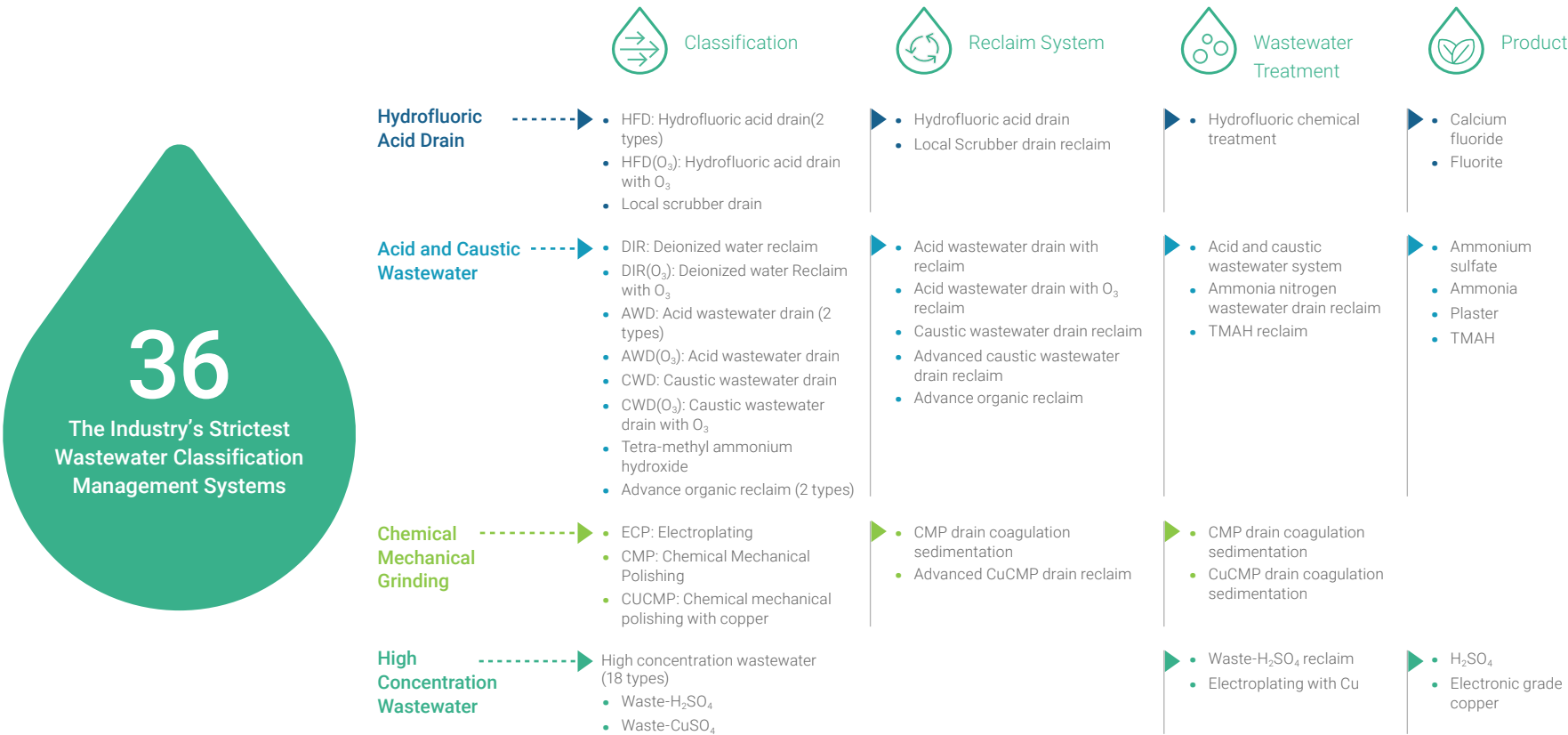
TSMC has adopted the industry's strictest classification and diversion strategy for front-end wastewater. To improve

treatment efficiency, 36 diversion systems are established according to the composition and concentration of process wastewater, and further detailed classification can provide even more appropriate treatments based on water quality and characteristics. Wastewater from all fabs can be divided into hydrofluoric acid wastewater^{Note 1}, acid and alkaline wastewater^{Note 2}, chemical-mechanical planarization wastewater and high-concentration wastewater. All go

through robust classification at the manufacturing tool and then enter processing facilities for specific types of wastewater through diversion pipes. Reusable portions are recycled for further use. The detailed classification is shown in the figure below.

Note 1: wastewater containing fluorine

Note 2: containing normal acid, alkali, ammonia nitrogen and tetramethylammonium hydroxide(TMAH)



Note 1: TMAH is the abbreviation for Tetramethyl Ammonium Hydroxide

Note 2: Among the reclaimed products, sulfuric acid and electronic-grade copper are reused at TSMC, and the rest are recycled and provided for other industries

Wastewater Monitoring and Pollutant Emissions

Wastewater Discharge

The amount of wastewater discharged is closely related to the usage of municipal tap water and the amount of water recycled. With the increasing proportion of products involving advanced processes, both the volumes of water required and wastewater discharge per product unit are also increasing. TSMC adheres to the principle of "Optimal Efficiency in Water Use", and in 2017 water recycling was

improved to reduce wastewater discharge. The discharge volume per product unit was reduced to 31.1 (liter/8-inch e wafer-layer), down 1% from 2016.

Wastewater Discharge Quality

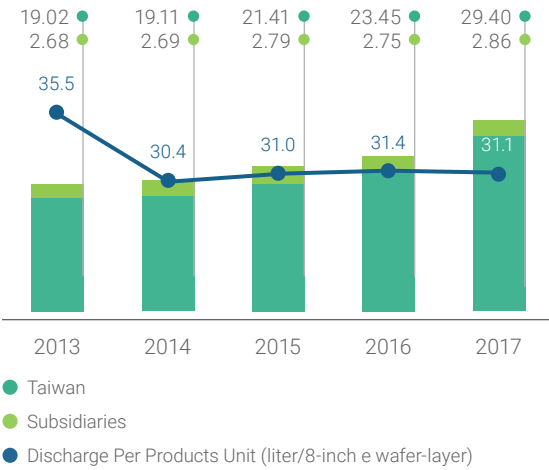
All of TSMC's plants have continuous monitoring systems for water quality and volume installed at the discharge outlets of wastewater processing equipment, enabling immediate action in the event of abnormal conditions. Every year, TSMC performs off-line sampling and testing at least four times on all types of water discharge. Online

detection equipment is available for calibration to ensure that the quality meets the standards of the Science Park Administration. In 2017, the suspended solids, chemical oxygen demand, ammonia in water and other controlled items of water discharged from all of TSMC's plants were far better than the standards required by the Science Park Administration.

Note: pH and suspended solids

Wastewater Discharge Per Product Unit

Unit: Million metric tons



Note 1: Total wastewater volume includes TSMC (all fabs and backend packaging and testing plants in Taiwan) and its subsidiaries WaferTech, TSMC (China) and VisEra

Note 2: The indicator for wastewater discharge per wafer-layer represents the statistics of all wafer fabs of TSMC and subsidiaries

Comparison of Wastewater Discharge Quality

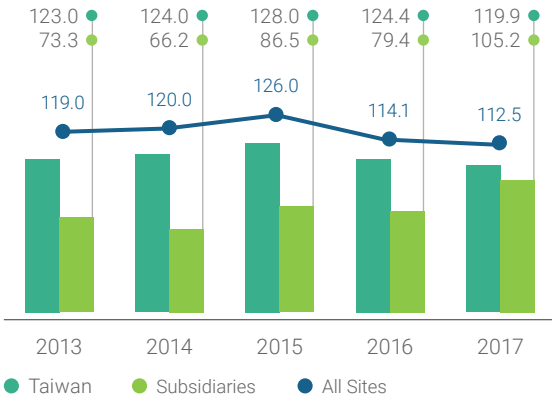
Unit: mg/L

	2017	Standards of the Science Park Administration	TSMC 2025 Goal
Suspended Solids	30	HSP: 300	30
		CTSP: 300	
		STSP: 250	
Chemical Oxygen Demand	104	HSP: 500	100
		CTSP: 500	
		STSP: 450	
Ammonia Nitrogen	35	HSP: 50	25
		CTSP: 50	
		STSP: 60	

Note: Hsinchu Science Park (HSP) Central Taiwan Science Park (CTSP) Southern Taiwan Science Park (STSP)

Statistics of Chemical Oxygen Demand for TSMC

Unit: mg/L



Note 1: The Hsinchu and Central Taiwan Science Park Administrations set 500 mg/L as the standard for wastewater treatment plants while the Southern Taiwan Science Park Administration sets it at 450 mg/L

Note 2: Statistics for chemical oxygen demand for TSMC (all fabs and backend packaging and testing plants) and its subsidiaries TSMC (China) and VisEra

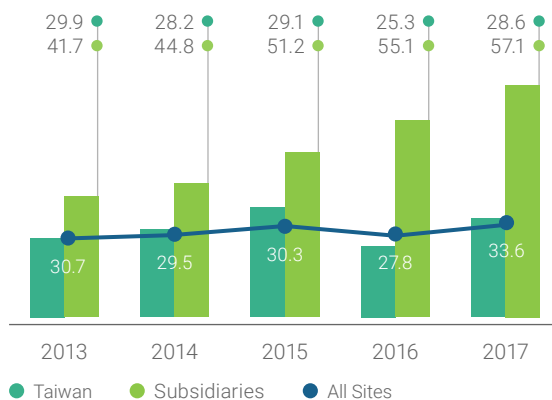
Reduction of Ammonia Nitrogen in Wastewater

In 2017, TSMC found that it was difficult to prevent ammonia-nitrogen solution from being mixed in a small proportion into other diverted wastewater. Therefore, the Company re-examined the "Ammonia-nitrogen wastewater recycling system"^{Note} developed in 2016 and continued to implement even more precise diversion to successfully guide low-concentration ammonia-nitrogen wastewater into the recycling system, before further treatment by the wastewater system. This action solves the problem with low-concentration ammonia nitrogen, which is difficult to remove, improves the treatment efficiency of wastewater and also achieves the goal of reducing ammonia nitrogen in wastewater for every plant.

Note: the first in the semiconductor industry

Statistics of Suspended Solids for TSMC

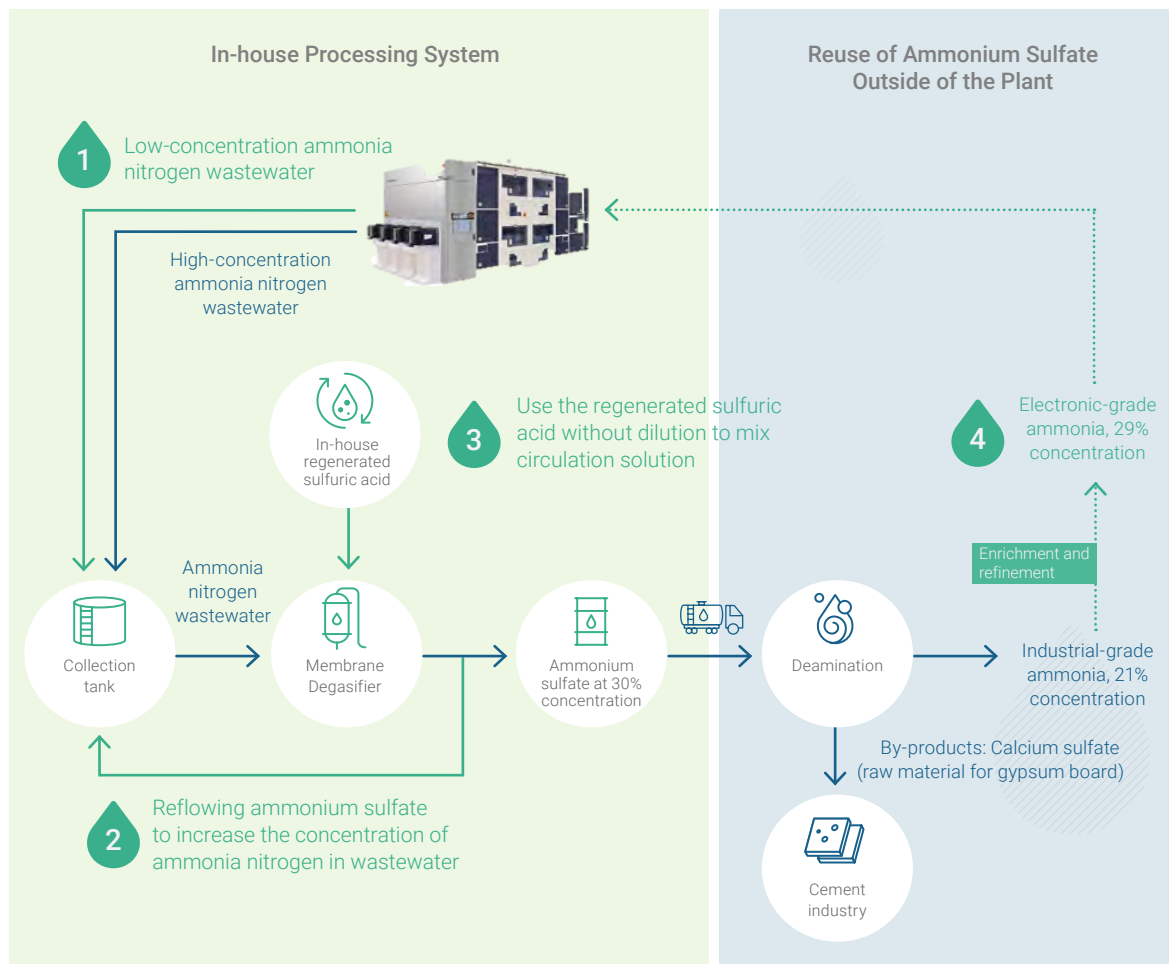
Unit: mg/L



Note 1: The Hsinchu and Central Taiwan Science Park Administrations set 300 mg/L as the standard for wastewater treatment plants while the Southern Taiwan Science Park Administration sets it at 250 mg/L

Note 2: Statistics for suspended solids in wastewater for TSMC (all fab plants and backend packaging and testing plants in Taiwan) and its subsidiaries TSMC (China) and VisEra

Flowchart of Ammonia Nitrogen Wastewater Reclamation



Note 1: Measures to reduce ammonia nitrogen wastewater: Refine the diversion and reduce ammonia nitrogen in wastewater.

Note 2 and 3: Measures to reduce waste: Sodium sulphate enrichment (please refer to the [Waste Management](#)).

Note 4: TSMC converts ammonium sulfate into industrial-grade ammonia water via deamination of the ammonia nitrogen recycling system, and the water undergoes a refining procedure to become electronic-grade ammonia solution. The used chemicals are recycled to other industries for further uses.



Tasks of 2018

Source diversion from
production tools

Improve the efficiency of
ammonia nitrogen treatment
system

Case Study

New Water Conservation Measures for Production Tools to Reduce the Water Consumption by 47.5%

In 2017, TSMC's water conservation measures had another breakthrough. It was determined that by taking three innovative approaches, "Shut down inessential supplementary tools", "Improve water supply to production tools" and "Discharge recycling during tool standby", the water consumption of production tools were successfully reduced by 47.5%.

Shut Down Inessential Supplementary Tools

In 2017, improvements in process quality reduced reliance on supplementary tools that handle low-concentration ozone (O₃) and hot water (HDIW). Repeated verification and comparison showed that product quality was maintained even after shutting down supplementary tools. Water consumption was also reduced, achieving both water and electricity conservation.

Improve Water Supply to Production Tools

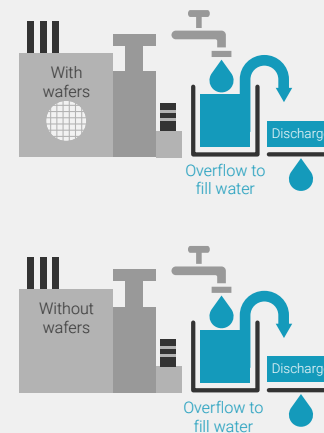
Advanced processes have higher requirements for both the quality and quantity of ultrapure water. To seek balance between product quality, efficiency of water consumption, and reduction in discharge frequency, TSMC in 2017 changed the water supply method for acid tank wafer scrubber systems. Through thorough verification and analysis of water quality and testing of wafers from various stages of processes by precision instruments, the optimal

amount of water for each step was successfully derived, achieving the best operation approach to water consumption and product quality. In 2017, the total volume of water conservation reached 200,000 metric tons.

Schematic showing how water supply to acid tank wafer scrubber system was improved

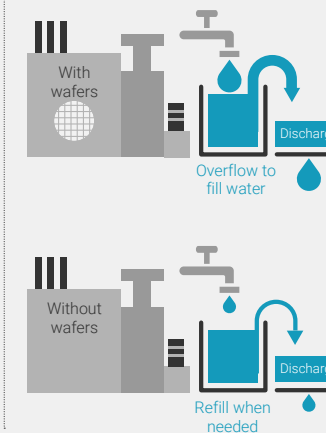
Before improvement

Overflow to refill water with/without wafers



After improvement

With wafers → Overflow to refill water
Without wafers → Refill when needed



Discharge Recycling During Production Tool Standby

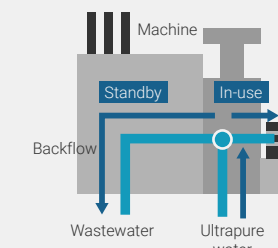
To keep the system clean and stable, ultrapure water is constantly replenished during tool standby. In the past, this unused ultrapure water goes directly into the wastewater treatment system. In 2017, a different approach was taken by recycling the

water back to the ultrapure system for reuse, increasing the recycle volume of discharge. At the same time, the operating flow rate of production tools were also adjusted to maintain the optimal amount of water. In 2017, the total volume of water conservation reached 170,000 metric tons.

Schematic showing the recycling of water during tool standby

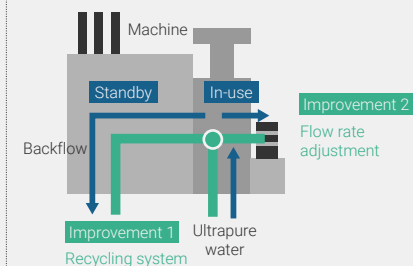
Before improvement

During standby → Backflow is discharged to wastewater
In use → Use large flow



After improvement

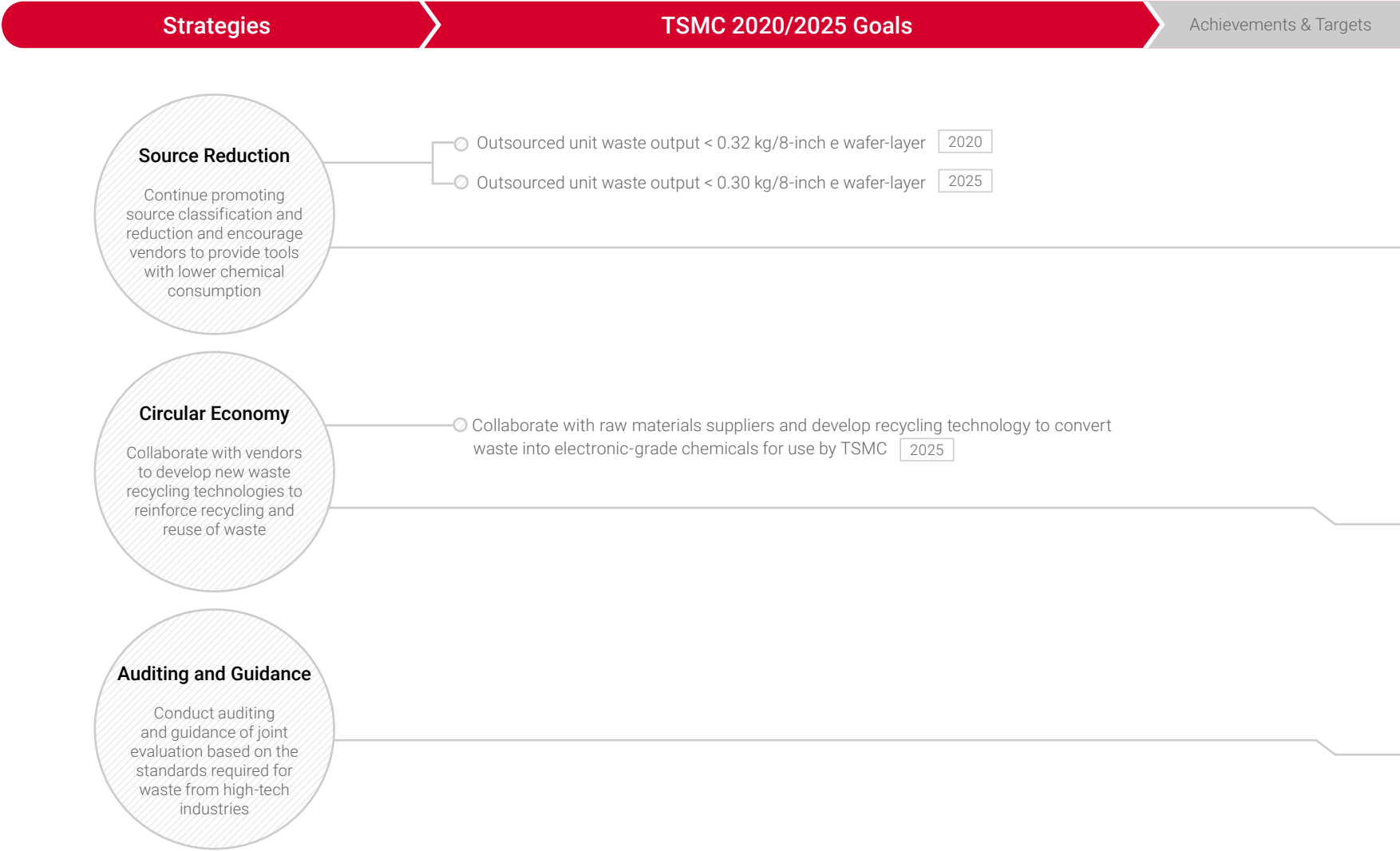
During standby → Backflow is recycled to the system
In use → Use small flow





Material Issue

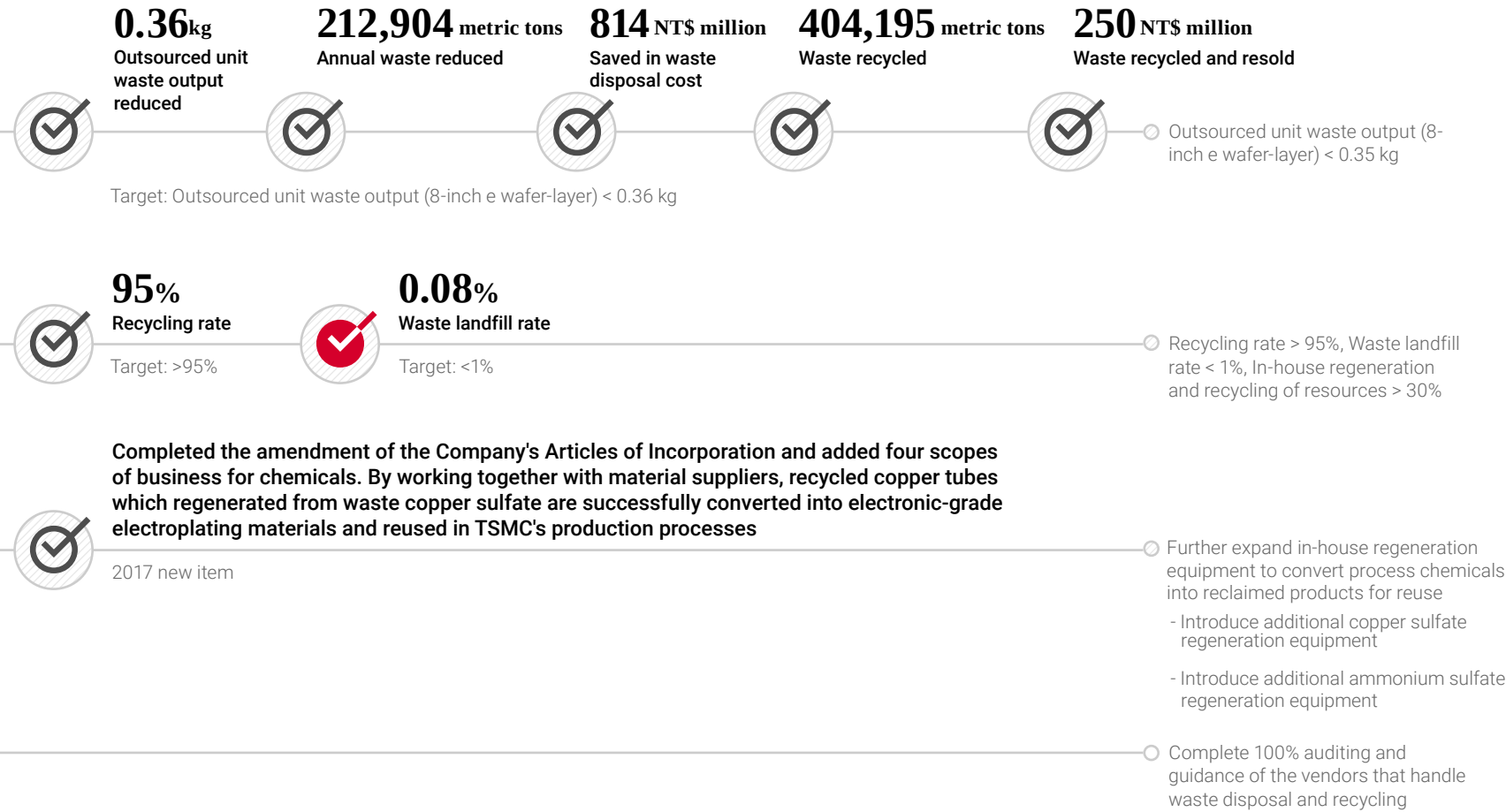
Waste Management



Strategies & 2020/2025 Goals

2017 Achievements

2018 Targets



TSMC understands the importance of waste management in green manufacturing and our supply chain. In order to achieve sustainable use of resources and ensure proper disposal of waste, TSMC continues to promote source minimizing waste disposal by maximizing recycling. Besides persisting in doing sustainable in business, TSMC has established a strict "Waste Vendor Control and Operating Management Procedure" and conducts regular audits to ensure that recycled products are legally regulated.

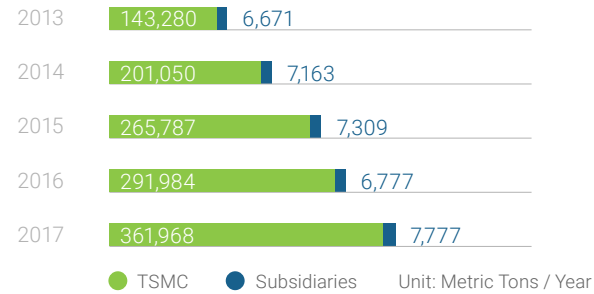
To achieve sustainable use of resources, TSMC is shifting our management strategy from conventional "waste management" to "sustainable materials and resources management", with the goal of reducing environmental impact and preserving natural resources. TSMC continues to assess the minimization of resources usage at sources (Reduce), and evaluates the reuse of raw materials after processes (Reuse) to mitigate outsourced waste disposal. Only after these steps will material recycling (Recycling), energy recovery (Recovery) and waste incineration and disposal in landfills (Disposal) take place. At TSMC, the usage of all chemicals is reviewed and differentiated for its ultimate treatment after use. Through 25 different types of chemical waste treatment systems to improve waste recycling, the usage of all chemicals is reviewed and differentiated for its ultimate treatment after use. Using a comprehensive diversion system for 36 types of wastewater and solutions, the mixed collection of wastewater and solutions is prevented, so that chemical waste can be reused and recycled by our contractors to make a variety of recycled products that will be circulated for use in other industries.

Life Cycle and Management of Material and Resource Sustainability

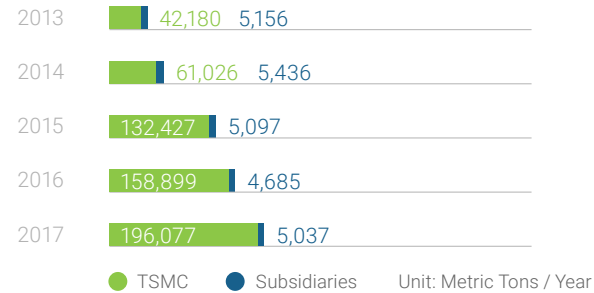


Waste Quantity and Treatment Status Statistics

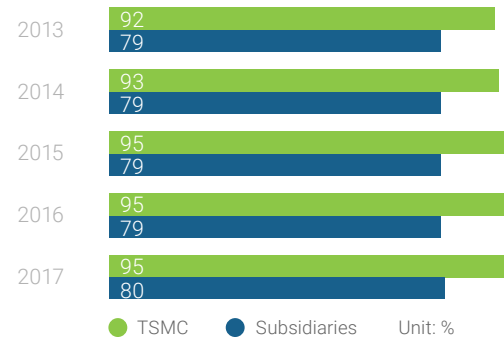
Outsourcing Disposal Waste



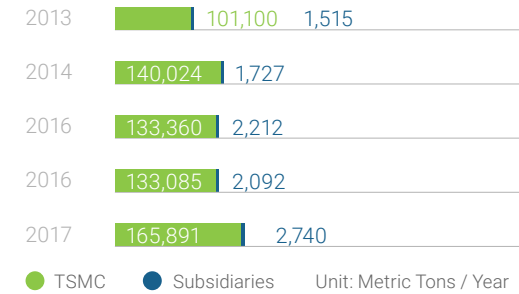
General Waste



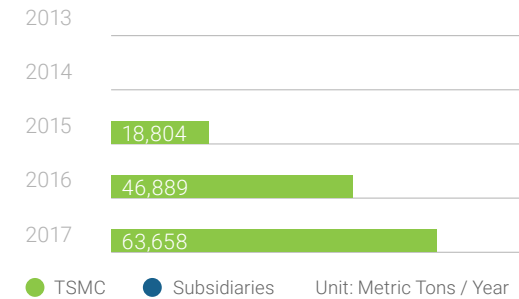
Waste Recycling Rate



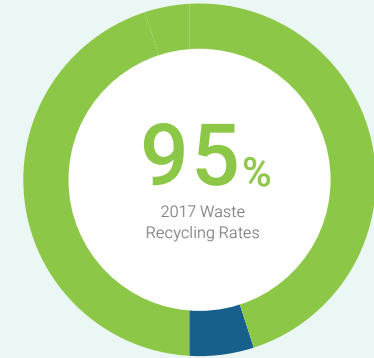
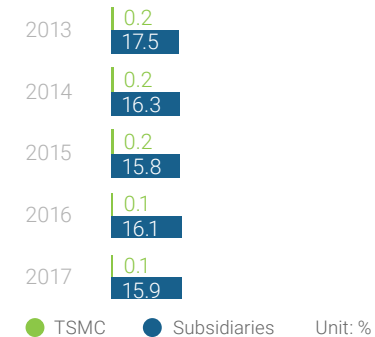
Hazardous Waste



In-house Recycling Waste



Waste Landfill Rate



Recycled Waste

404,195 Metric Tons

425,626 Metric Tons

Total Waste

95% Recycled Waste
(404,195 Metric Tons)

- 19% In-house reused
- 0.4% Converted to products for resale
- 74.6% Outsource recycled
- 1.0% Outsource energy recycle (Alternative fuel)

5% Non-recycled Waste
(21,431 Metric Tons)

- 4.9% Incineration/Treatment
- 0.08% Landfill

Note 1: Waste quantity includes TSMC (all fab plants and backend packaging and testing plants) and its subsidiaries (WaferTech, TSMC (China) and VisEra)

Note 2: Total waste = Outsourcing disposal waste = General waste + Hazardous waste

Note 3: Hazardous wastes are defined by local governments

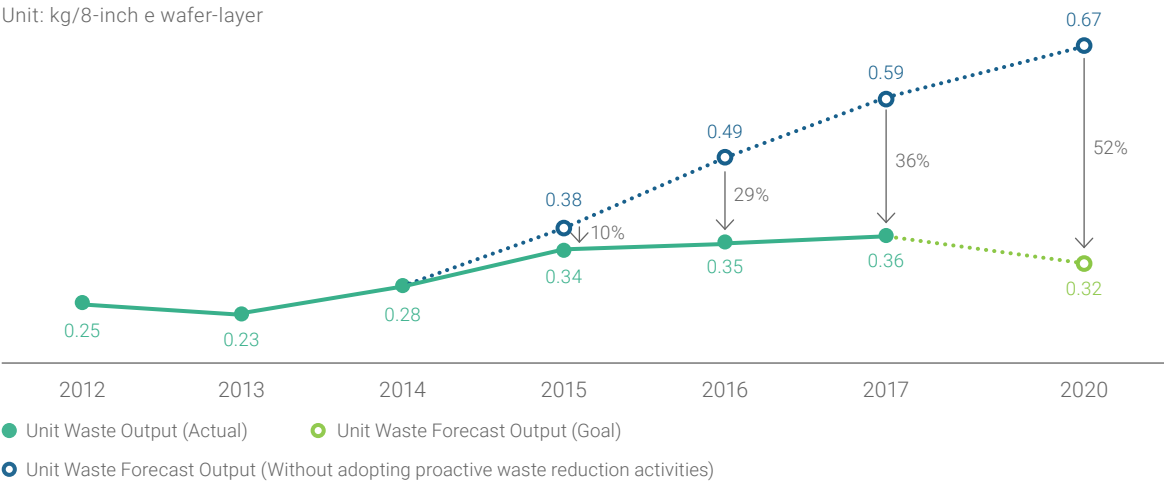
Note 4: Difference in previously disclosed 2015 and 2016 hazardous waste is due to subtraction of waste recycled in-house

Source Reduction

As a result of the increasingly strict environmental protection regulations and TSMC's significant increase in demand for raw materials and the expansion of advanced production processes, the Company expects that the amount of waste outsourced for 2020 will increase substantially. To effectively curb the growth of outsourcing waste disposal and reduce the impact on local environment, TSMC established a "Waste Management Task Force" in 2015 to actively implement a variety of reduction and improvement activities. In 2017, a total of 252 waste reduction projects were taken. In the same year, TSMC set short-, intermediate- and long-term reduction goals for the purpose of lowering the amount of waste outsourced per 8-inch e wafer-layer to 0.32 kg for 2020. The goal for 2025 was set even higher at 0.30 kg. To achieve these goals, the Committee members discuss waste reduction proposals at the beginning of each year with managers responsible for their respective production processes and monitor the progress monthly. The major categories of wastes such as sulfuric acid and ammonium sulfate have been effectively reduced and recycled. In 2017, the unit waste output to be outsourced for disposal was reduced to 0.36 kg from the original estimate of 0.59 kg. TSMC will continue to expand improvements on source reduction to other chemicals and the scope of in-house recycled waste.

Unit Waste Output Trendchart

Unit: kg/8-inch e wafer-layer



Note 1: Unit waste output has continued to rise due to 1. the increased complexity of TSMC manufacturing process and 2. TSMC transforms NH₃-N into waste ammonia sulfate to comply with new wastewater regulation standards

Note 2: TSMC has adopted proactive waste reduction measures since 2015, and therefore our waste output forecast is based on 2014 unit waste output estimates

Note 3: Waste quantity includes TSMC (all fabs and packaging and testing facilities located in Taiwan) as well as its overseas subsidiaries WaferTech, TSMC (China), and VisEra Technology

Unit: thousand NT\$

Category	Description	2017
Waste reduction project	Cost saving for waste treatment fee from chemical waste reduction of 120,234 metric tons waste (Chemical waste H ₂ SO ₄ , H ₂ O ₂ , (NH ₄) OH, CuSO ₄ , Photoresist solvent Developer...)	814,023
Income from waste recycling	Recycling of used chemicals, wafers, targets, batteries, lamps, packaging materials, paper cardboard, metals, plastics, and other wastes	251,043

Note: Benefits cover all TSMC fabs

Case Study

"Project Big Green" – Source Reduction of Process Chemicals

TSMC launched "Project Big Green" to reduce the use of process chemicals. The database managing the in-house use of raw materials and waste output is available to all production units to monitor the usage of wafer materials and waste output in real time. Comparisons can be run between fabs to find more improvement opportunities for waste reduction, and the validated results and efficiency can be promoted to every facility.

In 2017, various source reduction measures taken by TSMC enabled reduction of unit waste output by 0.1 kg, equivalent to annual waste reduction of 59,139 metric tons and additional savings of NT\$240 million in waste disposal for the year.

Source Reduction of Process Chemicals



Other Case Studies in Source Reduction

Reduction of Cleaning Fluid for VOC Carousel Rotor

Zeolite rotor maintenance produces a great deal of organic waste liquid with high water content. TSMC built three concentration systems at its Hsinchu, Taichung and Tainan sites to reduce the waste liquid by 70%. In 2017, total organic waste chemical was reduced by 1,020 metric tons.

1,020 Metric Tons

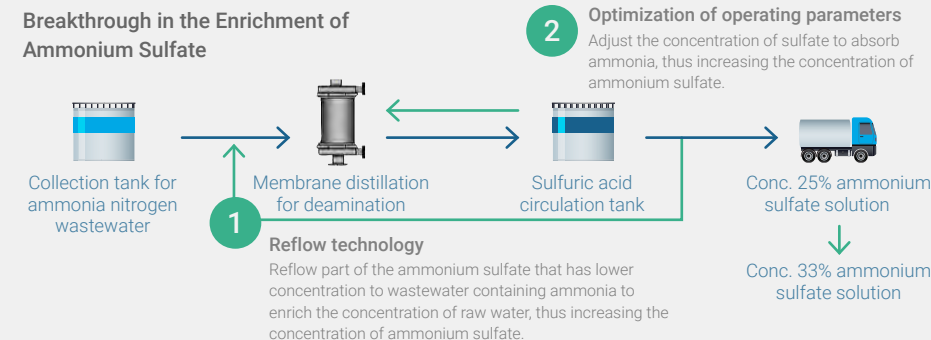
total organic waste chemical was reduced by 1,020 metric tons

Refinement and Enrichment of Ammonium Sulfate Dewatering Technology

Through membrane contactor technology, TSMC is able to regenerate ammonia nitrogen in wastewater and waste sulfuric acid into ammonium sulfate solution after production processes. As ammonium sulfate solution has a water content of 75% after recycling and the subsequent recycling processes require much energy to remove moisture during crystallization, TSMC adjusted the parameters for processing ammonia nitrogen wastewater to find optimal

conditions through continuous testing. The application of reflow technology improves membrane distillation of ammonia nitrogen, and sulfate concentration is adjusted to absorb ammonia more efficiently, further increasing the concentration of ammonium sulfate. The water content was reduced to 67% from 75% originally. In 2017, the total ammonium sulfate waste output was reduced by 5,003 metric tons, for a savings of NT\$15 million in waste disposal per year.

Breakthrough in the Enrichment of Ammonium Sulfate



Reduction of Sludge the Water Content

With a robust diversion system at the source, waste water content is kept simple, and waste water treatment systems can be set up in accordance with the characteristics of each water source. By comparing the data from each plant, the optimal dosage parameters can be adjusted for different types of sludge, further reducing their water content. In 2017, total sludge volume was reduced by 1,450 metric tons.

1,450 Metric Tons

Total sludge volume was reduced by 1,450 metric tons

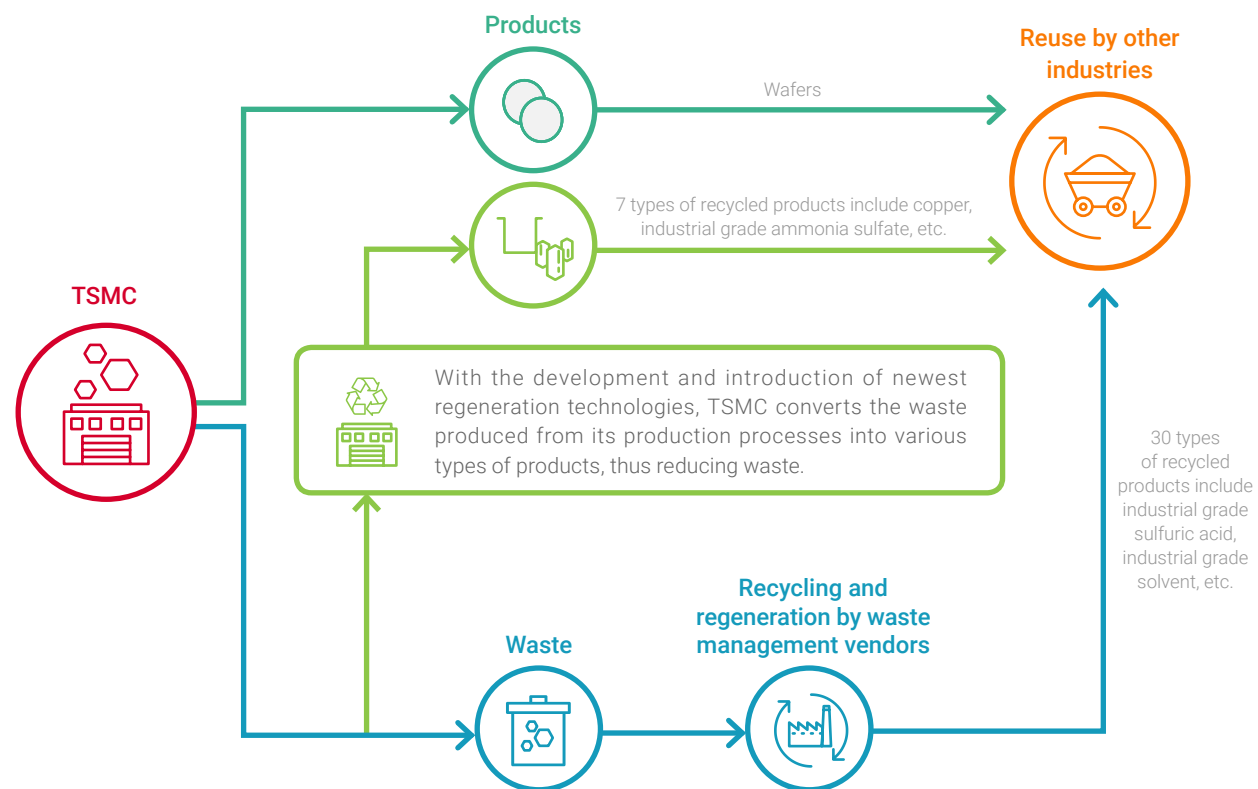
Circular Economy

To improve product traceability, reduce risks of outsourcing vendors not handling materials properly and enlarge recycling opportunities for the used raw materials, TSMC completed the amendment of the Company's Articles of Incorporation and added four scopes of business for chemicals^{Note} in 2017 and successively invested in a number of in-house recycling facilities. With the development and introduction of various recycling technologies, wastes produced from diverse production processes are converted into products which can be reused in-house or sold to other companies. The accumulated experience and technologies can be shared with other industry players, in hopes of improving the recycling capabilities of Taiwan's manufacturing sector, transforming manufacturers from waste producers to participants in the circular economy.

In 2017, TSMC introduced regenerated copper tubes converted from the copper sulfate produced from in-house production processes. The company further cooperated with raw material suppliers to add refining processes and successfully converted the regenerated copper tubes into electronic-grade electroplating materials that can be recycled back to the Company's manufacturing processes. TSMC also continued to expand and assess in-house waste recycling and regeneration facilities. TSMC expects that further equipment will be introduced to convert the aforementioned waste into reclaimed products, such as the ones that convert recycled ammonia nitrogen wastewater into ammonium sulfate powder, and low-concentration solvents dewatering to industrial grade solvent, meeting the objective of circular economy.

Note: Other chemical materials manufacturing / other chemical products manufacturing / other fabricated metal products manufacturing / other plastic products manufacturing

TSMC Committed to Becoming a Participant in the Circular Economy



Case Study

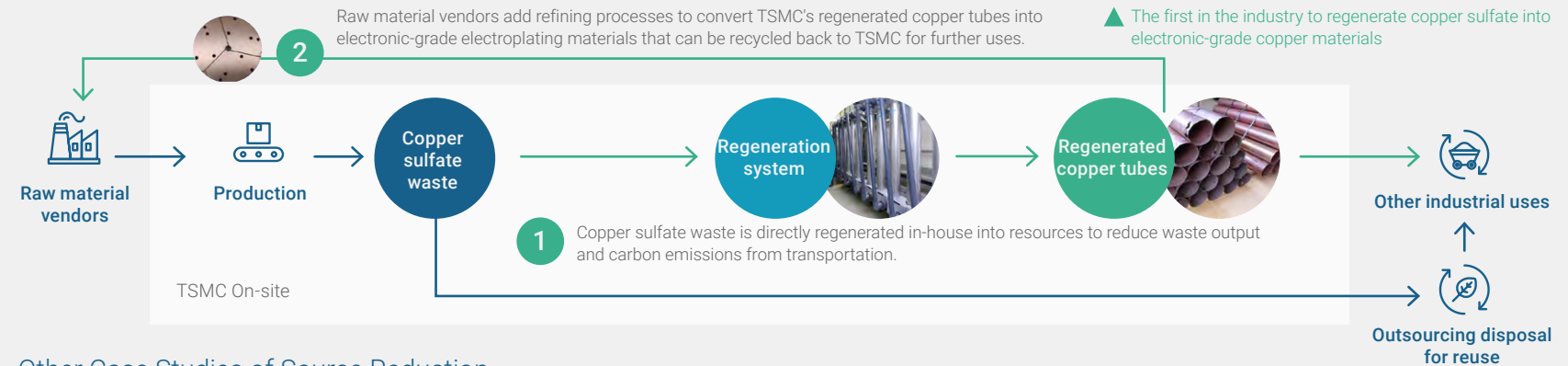
The First in the Industry to Regenerate Copper Sulfate into Electronic-Grade Copper Materials

In 2016, TSMC cooperated with vendors to develop and implement in-house copper extraction and waste regeneration technology to reduce the amount of copper sulfate outsourced for treatment. Some 1,942 metric tons of waste copper sulfate intended for

outsourcing treatment were regenerated in-house into 42 metric tons of copper tubes. Based on this successful experience, TSMC continued to invest in regeneration systems for copper waste at each plant in 2017 and further collaborated with vendors to develop additional

production processes to make regenerated copper tubes that can be manufactured into electronic-grade electroplating copper. At the end of 2017, the regenerated materials were successfully returned to TSMC's product processes in small-volume validation, and it

is expected that in 2018 the validation will be expanded, keeping the Company's journey toward circular economy on schedule.



Other Case Studies of Source Reduction

On-site Regeneration and Reuse of Waste Sulfuric Acid

In 2015, TSMC developed a waste sulfuric acid pretreatment system and expanded its application to all plants in 2017. Waste sulfuric acid is recycled and reused in-house then combined with ammonia nitrogen wastewater to convert the wastewater into usable ammonium sulfate. In addition to reducing the volume of waste sulfuric acid outsourced for treatment, it also reduced the purchase of industrial-grade sulfuric acid. In addition, the waste sulfuric acid also replaced hydrochloric acid as materials used for

resin regeneration; this approach expanded the opportunities for improvement and reduced the purchase of raw materials. In 2017, the amount of waste sulfuric acid to be outsourced for treatment was reduced by 62,595 metric tons (equivalent to the amount of industrial-grade sulfuric acid that had to be purchased in the past), and outsourced treatment expenses were reduced by NT\$150 million per year.

62,595 metric tons

The amount of waste sulfuric acid to be outsourced for treatment was reduced by 62,595 metric tons

150 million

Outsourced treatment expenses were reduced by NT\$150 million per year

With TSMC's waste traceability checks and annual counseling programs, we remind ourselves to keep an eye on the operation of equipment in the factory and monitor the flow of waste both upstream and downstream of the supply chain.

Juang Horng Cheng

Production Manager
E-shine Advanced Chemical Co., Ltd

Auditing and Guidance

Waste Cleanup and Disposal Vendor Management Process

TSMC uses its "New Waste Vendor Selection Procedure" and "Waste Vendor Auditing Program" to manage waste treatment vendors and revises the content of the auditing

program in accordance with results from on-site auditing. This allows vendors to implement best practices in their daily routine through standardization of auditing requirements. The audit covers not only proper waste treatment but also the environmental protection, safety, health and risk management of the entire plant.

2017 amendments to the auditing articles cover eight major aspects. They are: operations management, waste management, wastewater management, air pollution control, equipment maintenance records, safety and health management, fire protection and emergency response, for a total of 163 auditing items. Vendors are required to perform

New Waste Vendors



All Existing Waste Vendors ^{Note 1}



Vendor Audit ^{Note 2}

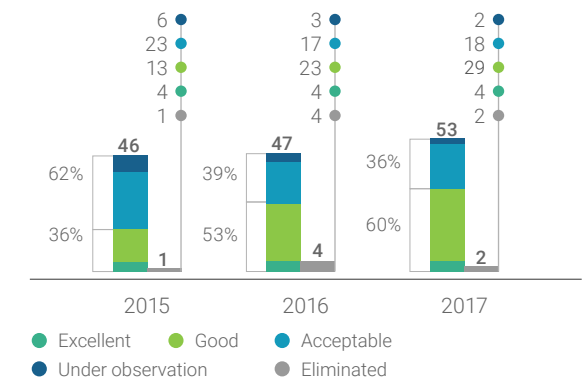


Note 1: Public or municipal waste treatment facility were not included in audit process

Note 2: Vendors are required to perform self-evaluation checklist and review their management performance on their own

Evaluation Result ^{Note 3 & 4}

Unit: Number



Note 3: Monthly waste flow mapping and seasonal on-site inspection to continuously improve the disposal measures and reduce the frequency of lines and penalties

Note 4: Continue to guide vendors to obtain ISO certification and improve their operations and management



Tasks of 2018

Continue to promote optimization of process parameters and source reduction

Continue to collaborate with vendors to work on development and application of recycling and regeneration of waste, thus reducing the risk of outsourced vendors not properly conducting waste disposal

self-evaluation using those checklist items before auditing. This is to verify the documents with the actual on-site audits to ensure the proper outsourcing disposal of TSMC's waste. At the same time, TSMC reinforces the tracking of recycled products. All vendors producing the recycled or regenerated products are to report their production and sales records on a monthly basis. TSMC also periodically visits the vendors and verifies the disposals and recycling of their processing waste and compares that with the product sales records to ensure that recycled products are of legal use.

Qualified vendors are subject to an Annual Vendor Evaluation, with three dimensions: "company scale and reputation", "past operational records" and "control and management of waste". For vendors with poor scores, counseling, recommendations and improvement monitoring are provided during the annual audits. They are also required to obtain ISO/OHSAS certification to improve their environmental and safety management capabilities. Their coordination efforts and improvement becomes part of the assessment criteria on whether they can remain as a supplying vendors. In 2017, the proportion of waste disposal vendors with excellent and good ratings improved to 60% from the 36% performance in 2015.

Policy Consultation and Social Engagement

In addition to handling internal waste management, TSMC assigns environmental protection personnel to actively participate in briefings, seminars and policy consultation symposiums hosted by government agencies, and international conferences on waste management issues. The Company also participates in the "Research Conference on Recycling and Reuse of Industrial Waste Sulfuric Acid" held by the Industrial Development Bureau, mainly to share its experience in the use of sulfuric acid, feasibility assessment on recycling and implementation in the semiconductor industry, and to connect with the world's environmental protection advocates. TSMC also shares its experience in waste management with other industry players. In 2017, the Company participated in various seminars and forums related to circular economy organized by the Science Park Administration, SEMICON Taiwan, the Association for Taiwan Science Park Industries, and CTCI Foundation, in hopes of collaborating with the industry, government and academia sectors to improve the overall standard of waste disposal and the sustainable development of Taiwan.

Material Issue

Air Pollution Control



Note: Currently, the average reduction rate of volatile organic gases in each factory area has reached more than 95%. Because the expected target for 2020 was reached ahead of schedule, therefore it has been amended to pursue an even higher goal for air pollution prevention and control



96.4%

Reduction rate of volatile organic gases was 96.4%

Target: >90%

To decrease air pollutant emissions per unit product by 25%, compared to 2015 level^{Note}

Note: Air pollutants include a total of 8 chemicals : total hydrocarbons, sulfuric acid, hydrochloric acid, nitric acid, hydrofluoric acid, phosphoric acid, chlorine and ammonia





Two-stage type scrubber

The air pollution brought about by the semiconductor manufacturing industry is composed mainly of volatile organic compounds, as well as acidic and alkaline gases. In the field of pollution prevention and control, TSMC adopts the best available technology of source separation and multiple processing to deal with air pollutants effectively, so that when they are discharged in the atmosphere, they meet or surpass government regulations. Moreover, in order to maintain the effectiveness of control equipment and the discharge of pollutants, equipment is supplied with real-time monitoring systems and an N+1 backup system. The relevant monitoring results are transmitted to the facility monitor control system room and the industrial safety emergency response center simultaneously to ensure that air pollutants are treated appropriately when the system is not running normally.

Best Available Technology

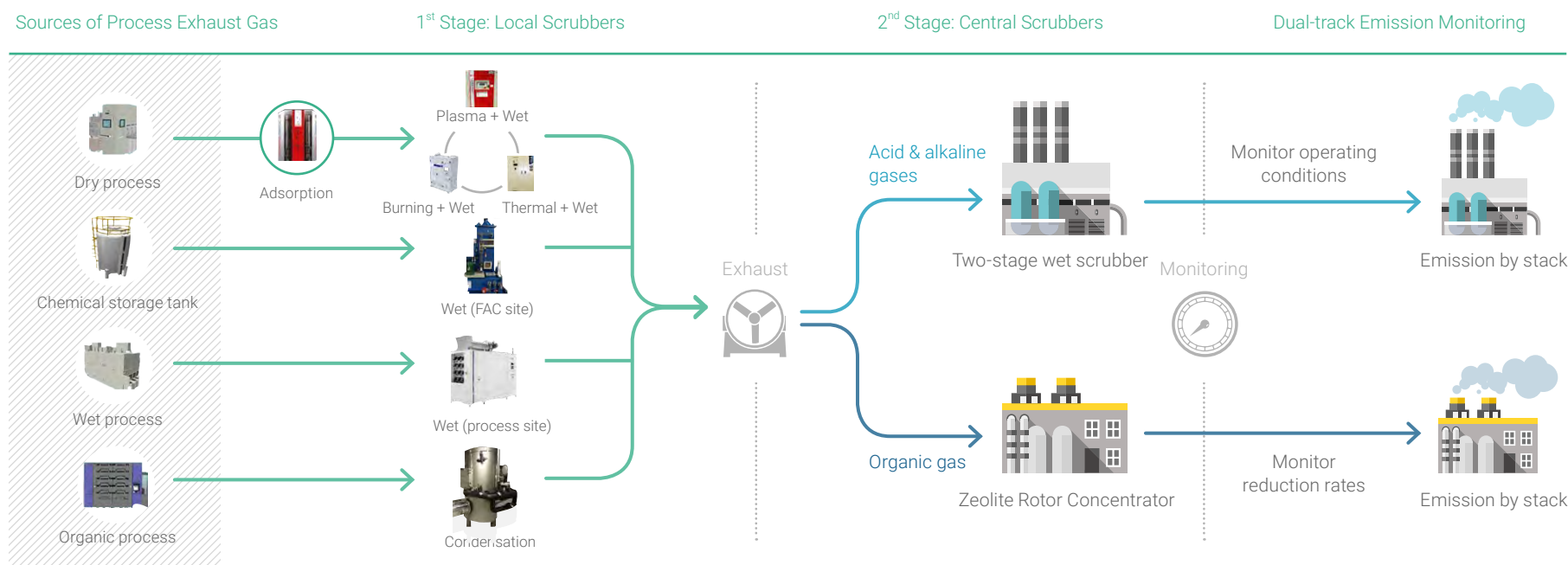
TSMC has spared no effort to reduce air pollution. In order to achieve the best available technology in the prevention and control process, TSMC has adopted the method of "effective reduction of exhaust sources and enhanced treatment of terminal control equipment". In the first stage, high-efficiency air treatment equipment (local scrubber) will be installed to treat specific acid-alkaline process exhaust materials, which are toxic, corrosive, flammable or greenhouse perfluorinated compounds depending on their process characteristics. Special equipment such as combustion, plasma, or other types of equipment will treat the remaining process exhaust gas. Finally, the exhaust gas, left with trace amounts of inorganic acids and alkalis, is sent to the central processing

equipment (central scrubber) for second-stage water rinsing and neutralization treatment. Two-stage processing and multi-stage treatment can improve the efficiency of air emission treatment.

For organic exhaust, the highly efficient Zeolite Rotor Concentrator is used to concentrate pollutants and then introduced into a regenerative thermal oxidizer to be burned before being discharged into the atmosphere. The reduction rate of organic emissions gas by the regenerative thermal oxidizer (RTO) alone can reach 95%, exceeding the 90% specified by regulations. If first stage site-based processing equipment is included, the total organic emission gas reduction rate^{Note} can reach above 99%.

Note: Calculation of total reduction rate after two-stage control equipment $1 - [(1 - \text{Local scrubber reduction rate}) \times (1 - \text{Central scrubber reduction rate})]$

Air Pollution Control Process



96.4%

Reduction rate of volatile organic gases reached 96.4% in 2017

24%

Air pollutant emissions per unit product decreased 24% compared to 2015 level

Effective Elimination of Exhaust Source – Local Scrubbers

TSMC classifies high-concentration exhaust gas into seven categories for in-site treatment according to pollutant characteristics. These are then treated by one of, seven different local scrubbers, including thermal type, burning type, plasma type, washing and dosing type, adsorption type, condensation type, and washing type. Third-party certification has verified that the reduction of target pollutants by in-site air pollution treatment equipment can reach more than 95%. At present, the proportion of advanced process products continues to increase and TSMC will continue to cooperate with supplier partners for the introduction of new local scrubbers for different pollutants so as to enhance the total reduction of pollutants.

Terminal Control Equipment Enhanced Processing – Highly-efficient Central Processing Equipment

After the first phase of emission gas treatment, which consists of low concentrations of inorganic acid and alkali components, it is sent to a two-stage scrubber for neutralization; in the case of volatile organic components, it is sent to the Zeolite Rotor Concentrator terminal control equipment for concentrating, burning and then is discharged it into the atmosphere. In 2017, the average reduction rate of volatile organic gas by TSMC's Zeolite Rotor Concentrator was 96.4%, which was significantly above the 90% required by regulations.

In addition to embracing the most advanced and suitable pollution reduction technology, TSMC has continuously improved the effectiveness of its existing pollution control facilities. Under these enhancement measures, in 2017 the emission per unit product from TSMC was 0.3 (g/8-inch e wafer-layer) compared to 0.4 (g/8-inch e wafer-layer) in 2015,

a decrease of 24%. The Company expects its target objective of 30% can be achieved in 2025. Based on actual test results over the years, the concentration of air pollutants emitted by TSMC is lower than the emission standards set by the Science Park Administration and the domestic Environmental Protection Bureau.

Classification of In-site Air Treatment Equipment and Facilities

Process exhaust gas sources	Target pollutants	Control technology	Equipment pictures	Reduction rates	Instant monitoring parameters
Dry Process	Toxic gases	Adsorption		> 95% or Outlet less than 50 ppb	Scrubber pressure difference Inlet Pressure
	Corrosive gases, perfluorocarbons	Plasma + Wet		> 99%	Current amperage Circulation water Inlet Pressure
	Corrosive gases, perfluorocarbons, combustible gases	Burning + Wet		> 95%	Natural gas flow Oxygen flow Circulation water Inlet Pressure
	Corrosive gases, perfluorocarbons, combustible gases	Thermal + Wet		> 95%	Reactor temperature Circulation water Inlet Pressure
Facility Chemical Storage Tank	Corrosive gas	Wet (FAC site)		> 95%	Scrubber pressure difference Circulation water Inlet Pressure
Wet Process	Corrosive gas + organic gas	Wet (process site)		> 95%	Scrubber pressure difference Circulation water Inlet Pressure
Organic Process	High boiling point organic gas	Condensation		Specific high boiling point organic gas > 95%	Scrubber pressure difference Condensation temperature

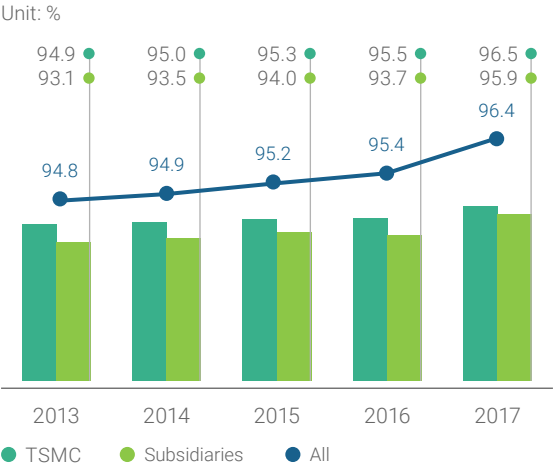
Zero Failure of Control Equipment

TSMC's air pollution control capability complies with Taiwan's "Air Pollution Control and Emission Standards for Semiconductor Manufacturing" and the "Air Pollutants Emission Standards for Fixed Pollutants", and overseas subsidiary companies also meet local regulatory standards. To ensure stable 24-hour and 365-day operation of pollution

control equipment, all equipment is provided with at least one set of backup systems (N + 1 design). In addition, TSMC has also established automatic monitoring systems to grasp the effectiveness of the exhaust gas treatment at all times. Relevant information is provided to the facility monitor control center and the industrial safety emergency

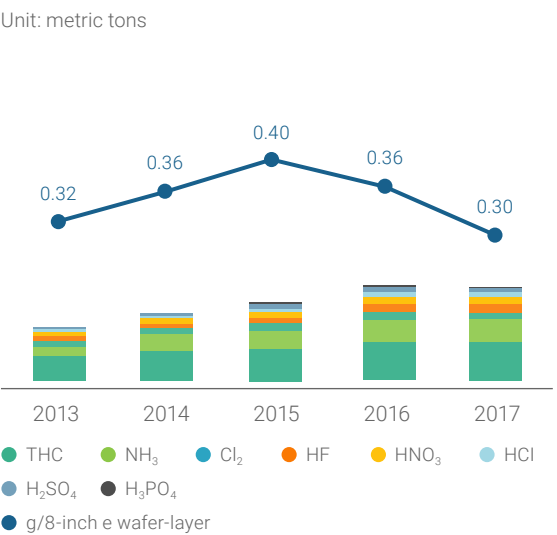
response center at the same time, so gas emissions are tracked under a dual-track independent monitoring system, ensuring that chimney exhaust gas is in compliance with specifications. Under the control of early warning systems and immediate response, there were no unusual events that required TSMC to inform relevant authorities in 2017.

Annual Emission Reduction Rates of Volatile Organic Gases from Central Processing Facilities



Note: Annual emission reduction rates of volatile organic gases in TSMC includes TSMC(included in all wafer fabs and packaging and testing plants in Taiwan) and subsidiary company (included in WaferTech, TSMC (China) and VisEra. VisEra taken into account in 2017)

Annual Emissions of Air Pollutants and Emissions Per Unit Product



Note 1: The air pollutants emissions in TSMC refer to the total amount of emissions reported to the governing authority, including in all wafer fabs and packaging and testing plants in Taiwan. Subsidiary companies (WaferTech, TSMC (China) and VisEra) were not included due to the different items declaration

Note 2: Total air pollutant emission includes total hydrocarbons (THC), sulfuric acid (H₂SO₄), hydrochloric acid (HCl), nitric acid (HNO₃), hydrofluoric acid (HF), phosphoric acid (H₃PO₄), chlorine (Cl₂) and ammonia (NH₃), a total of 8 kinds

Note 3: Air pollutant emissions per unit product in TSMC excludes packaging and testing plants (because they do not have actual wafer output to calculate)



Industrial Safety Emergency Response Center Facility Monitor Control Center



Tasks of 2018

Installation of the local scrubber at source equipment

Installation of wet scrubber and dosing system in the facility chemical storage tank

Effective separation of exhaust source for new process tools



Case Study

Application of Hydro-membrane to Enhance Pollutant Removal Efficiency Up to 47%

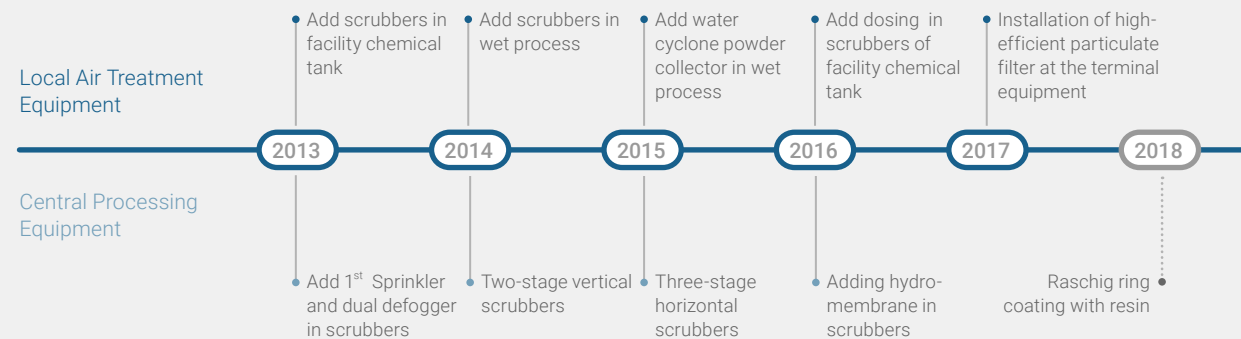
In order to improve the performance of air pollution control equipment, TSMC continues to cooperate with supplier partners to introduce the latest technologies. In 2016, "hydro-membrane"^{Note} technology was installed in the scrubber of Fab 14, Phase 5 in Tainan Science Park. It was found that the removal efficiency of acid and alkaline pollutants can be improved 5-47% depending on their different

physical and chemical characteristics. In 2017, the technology was extended to all 12-inch wafer fabs in Taiwan and is expected to be included in the standard design for new sites in 2018.

After modularizing the installation mode of the hydro-membrane and changing the membrane material, results from Fab 14 Phases 5, 6, and 7 showed

that the sulfuric acid (H_2SO_4) concentration of the scrubber was reduced up to 47%. The removal efficiency of other acid and alkaline pollutants can also be improved up to about 5~38%.

Improvement and Evolution of TSMC Air Pollution Control Equipment



Note: "Hydro-membrane" is a slight hydrophilic filler made of monofilament, the main material being polyamide fiber (nylon). The design principle is mainly to transfer mass with larger specific surface area. Compared with the traditional Raschig Ring, the "hydro-membrane" has a larger surface area making it easier for pollutants to come in contact with the "hydro-membrane" and dissolve. In addition, the material is woven into a V-shaped system, by which the circulating water droplets fall into single filaments and immediately collide with another filament, creating a new liquid membrane, increasing the contact efficiency and enhancing the reduction effect of acid and alkaline gas pollutants

Reduction in scrubber sulfuric acid concentration

Unit: mg/Nm³

