



Waste Management

▼ Achieved
 ↑ Exceeded
 — Missed Target

Strategies

2030 Goals

2021 Targets

2020 Achievements



Source Reduction

Promote waste reduction by source separation and require vendors to provide low chemical consumption equipment

■ Outsourced unit waste disposal per wafer \leq **0.50**^{Note1}
 (kg/12-inch equivalent wafer mask layer)

■ Outsourced unit waste disposal per wafer \leq **1.15**^{Note2}
 (kg/12-inch equivalent wafer mask layer)

■ Outsourced unit waste disposal per wafer **1.01**^{Note3} —
 (kg/12-inch equivalent wafer mask layer)
 Target: \leq 0.88



Circular Economy

Collaborate with vendors to develop new waste recycling technology to increase the amount of waste recycled and reused

■ Develop multiple types of electronic-grade chemicals for TSMC resource circulation

■ In-house resource recycling rate \geq **22%**

■ In-house resource recycling rate **22%**^{Note3} —
 Target: \geq 23%



Audit and Guidance

Conduct audit, joint evaluation and guidance based on regulations governing waste treatment vendors in high-tech industry

■ All waste treatment vendors shall acquire ISO 14001 or other international EHS Management certifications^{Note4}

■ **82%** of waste treatment vendors shall acquire ISO 14001 or other international EHS Management certifications

■ **80%** of waste treatment vendors have acquired ISO 14001 or other international EHS Management certifications ↑
 Target: 75%

Note1: The unit product indicator for outsourced unit waste treatment per wafer is calculated based on 12-inch wafer equivalent starting in 2020. Accordingly, the goal was adjusted from 0.22 (kg/8-inch equivalent wafer mask layer) to 0.50 (kg/12-inch equivalent wafer mask layer).

Note2: See section on "Source Reduction" for reasons why targets were not achieved.

Note3: TSMC will be building advanced manufacturing facilities in 2021. Considering the initial demand for equipment cleaning and wafer testing in new facilities, the target set for outsourced unit waste

treatment per wafer in 2021 is higher than that of 2020. To achieve the \leq 0.50 target for 2030, TSMC will launch programs including raw material reduction, expanding in-house resources recycling equipment, building a zero waste manufacturing center and electronic-grade material recycling trials.

Note4: TSMC requires waste treatment vendors to at least acquire ISO14001 or ISO45001 certifications as the basis for standardized management. Waste treatment vendors include waste treatment and recycling vendors. Vendors exempted from online reporting, government-owned enterprises, or public-to-private enterprises, are excluded from the aforementioned vendors.

As a practitioner of green manufacturing, TSMC's waste management strategies abide by the principle of waste minimization, resource recycling, and reuse maximization. In 2020, the waste recycling rate reached 95% for the sixth consecutive year. TSMC achieves source optimization and minimization by adjusting raw materials usage parameters at the source and technical solutions for process technology. After raw materials are used in manufacturing processes, onsite recycling is prioritized so that resources are sufficiently reused instead of being disposed of as waste right away. TSMC also promotes source reduction throughout the supply chain to facilitate

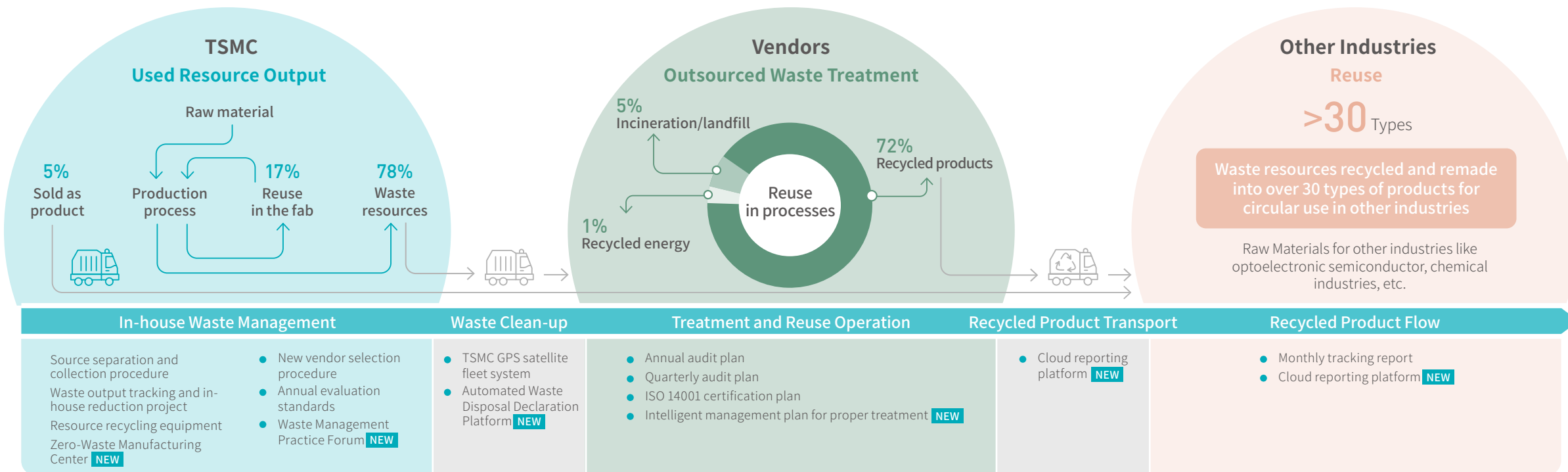
waste reduction upstream, and the reuse of wafer cassettes at downstream packaging and testing facilities.

TSMC's waste resource management makes use of in-house resource recycling equipment and turns waste into products. Furthermore, TSMC approved construction plans for our first Zero-Waste Manufacturing Center in 2020. When waste treatment needs to be outsourced, recycling and recovery are prioritized over incineration and landfill to ensure optimal resource utilization. The percentage of waste sent to landfills has been less than 1% for the past 11 years as of 2020.

In addition to implementing a circular economy, TSMC also takes full responsibility for the management of waste clean-up, treatment, and recycled product flow. Under the Waste Treatment Vendor Sustainability Enhancement Project, 80% of waste treatment vendors have acquired ISO14001 certification. At the same time, the existing waste life cycle management procedure is continuously being upgraded towards the more systematic, automated, and smart Intelligent Waste Management Procedure with Full Traceability. In 2020, TSMC collaborated with the Environmental Protection Administration (EPA) to establish the first

Automated Waste Disposal Declaration Platform in the industry. It provides a mechanism for real-time waste declaration and clean-up monitoring launched along with TSMC's GPS Satellite Fleet System. In addition, the Intelligent Management Plan for Proper Waste Treatment was started to launch to fully replace manual inspection. Systematic cloud-based tracking is used to trace recycled product transport and flow to prevent illegal waste disposal. Waste treatment vendors are encouraged to keep pace with TSMC in achieving environmental sustainability.

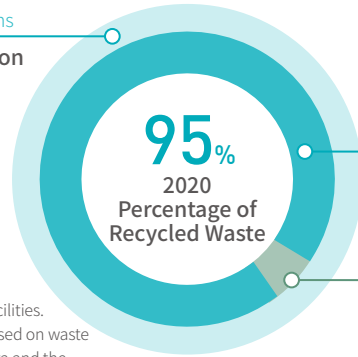
Intelligent Waste Management Procedure with Full Traceability



- Waste treatment vendor management project

Unit: Metric tons

705,850 Metric tons
Total Waste Production



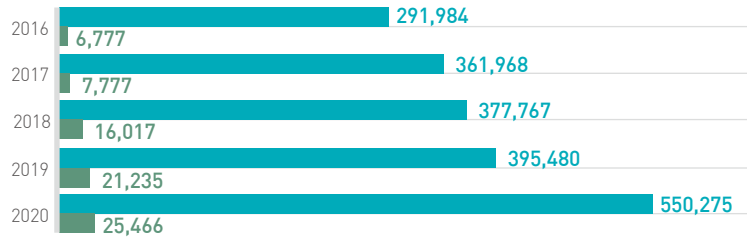
72%	Recycled Materials	513,643 metric tons
17%	Reused in Fabs	120,188 metric tons
5%	Converted to Products and Sold	35,387 metric tons
1%	Recycled Energy (Auxiliary Fuel)	3,971 metric tons
5%	Incineration	31,252 metric tons
	Landfill	1,409 metric tons

	Outsourced General Waste	Outsourced Hazardous Waste
72% Recycled Materials	240,728	272,915
17% Reused in Fabs	0	120,188
5% Converted to Products and Sold	14,575	20,812
1% Recycled Energy (Auxiliary Fuel)	2,711	1,260
5% Incineration	24,792	6,460
5% Landfill	1,409	0

Note1: Data includes Taiwan facilities.
Note2: The data is compiled based on waste disposal declaration data and the processing capacity of in-house resource recycling facilities.
Note3: Subsidiaries will start recycle evaluation plan to reduce landfill rate in 2021.

Outsourced Waste

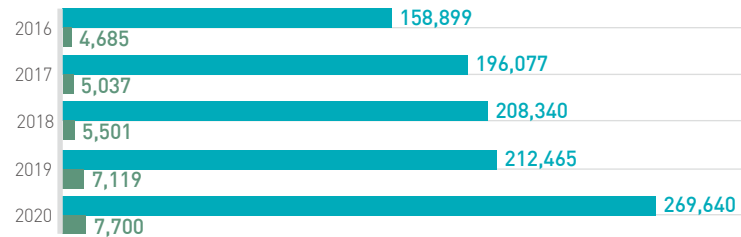
Unit: Metric tons/year



Year
■ Taiwan facilities ■ Subsidiaries

Outsourced General Waste

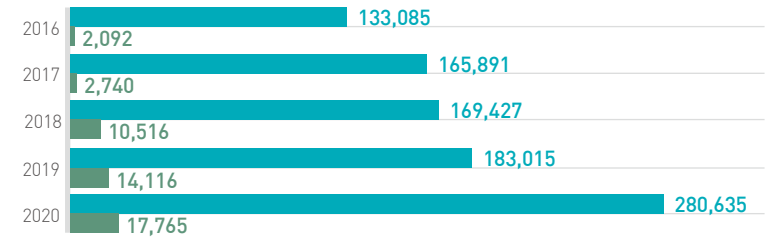
Unit: Metric tons/year



■ Taiwan facilities ■ Subsidiaries

Outsourced Hazardous Waste

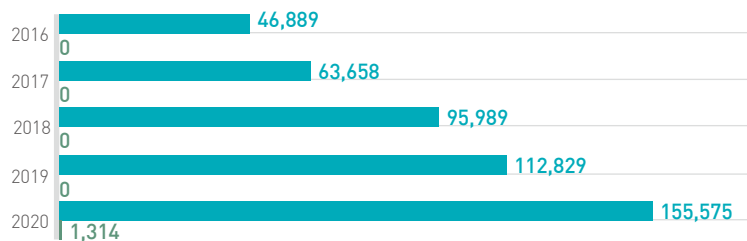
Unit: Metric tons/year



■ Taiwan facilities ■ Subsidiaries

In-house Recycled Resources

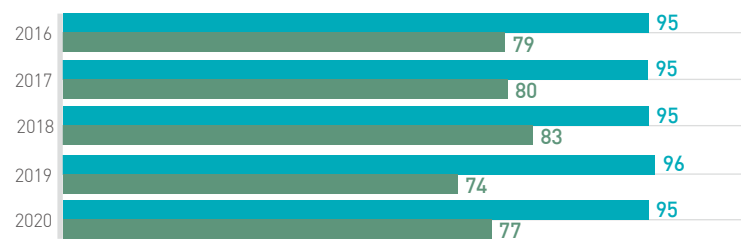
Unit: Metric tons/year



■ Taiwan facilities ■ Subsidiaries

Percentage of Recycled Waste

Unit: %



■ Taiwan facilities ■ Subsidiaries

Percentage of Waste Sent to Landfill

Unit: %



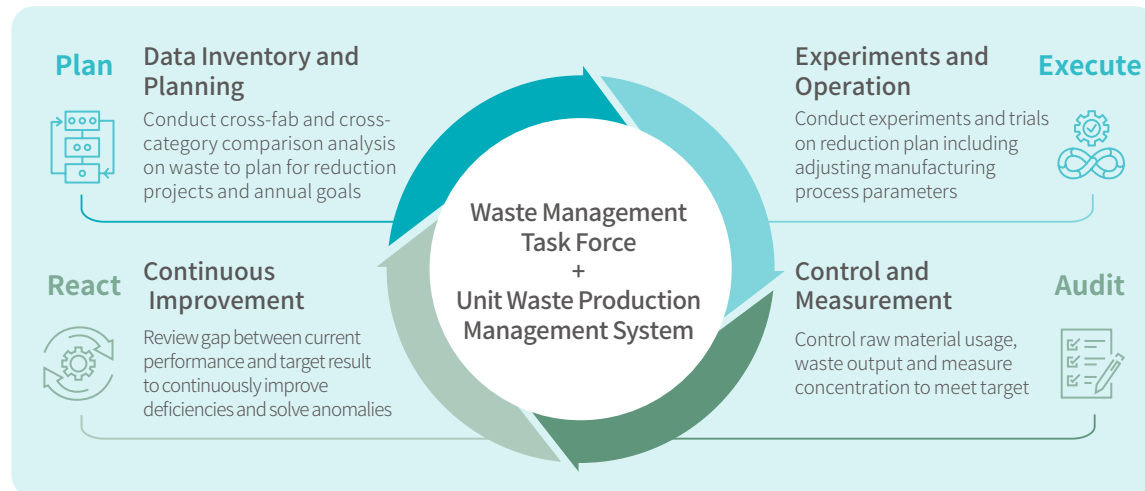
■ Taiwan facilities ■ Subsidiaries

Source Reduction

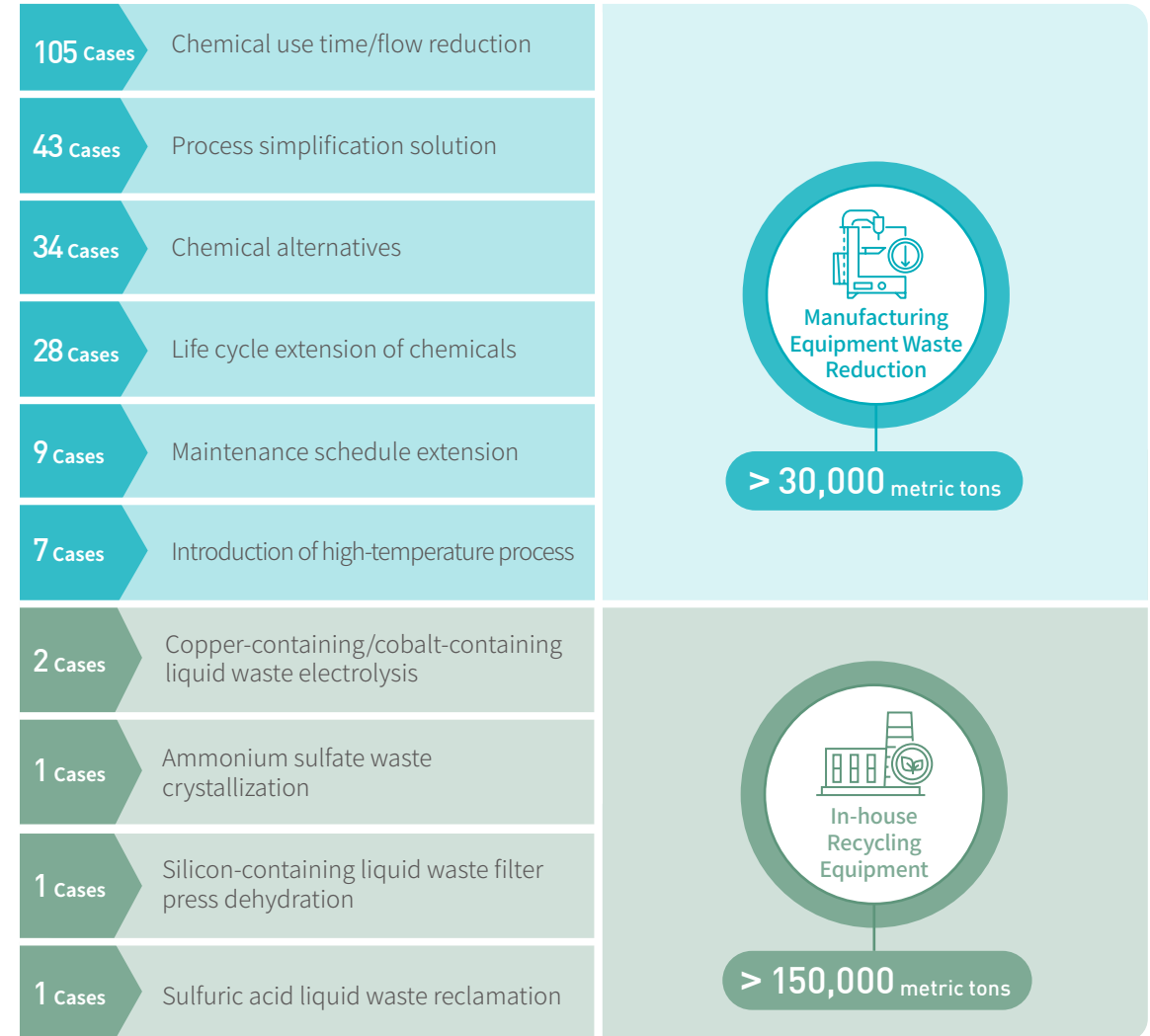
As complexity and production capacity increase in advanced processes, TSMC's raw material consumption increases along with waste generation. To reduce environmental impact, TSMC established a Waste Management Task Force and the Unit Waste Production Management System in a cross-organizational effort. The self-imposed management mechanism is enhanced with the Plan-Do-Check-Act (PDCA) management cycle to commit to source reduction. In 2020, TSMC implemented 226 waste management improvement measures, including process simplification, extending the life cycle of chemicals and maintenance schedule, exploring new chemical alternatives, and introducing high-temperature manufacturing processes. A total of 37,858 metric tons of waste were reduced as TSMC strives to lower material

use and waste production from all dimensions. New TSMC facilities began operations in 2020. Due to the complexity of new process development, higher demand for wafer cleanliness, and the need to continue adjusting and optimizing operations system, the outsourced unit waste treatment per wafer was 1.01 (kg 12-inch equivalent wafer mask layer). The in-house resource recycling rate was 22%, which also missed the original goal for the year. In the future, TSMC will continue to implement measures such as reducing chemicals at the source, expanding in-house resource recycling facilities, building and launching the Zero-Waste Manufacturing Centers, and reusing electronic-grade materials to meet the 2030 goal of achieving 0.5 kg outsourced waste treatment per wafer.

Waste Reduction Management Mechanism



Waste Reduction Measures and Results in 2020



Circular Economy

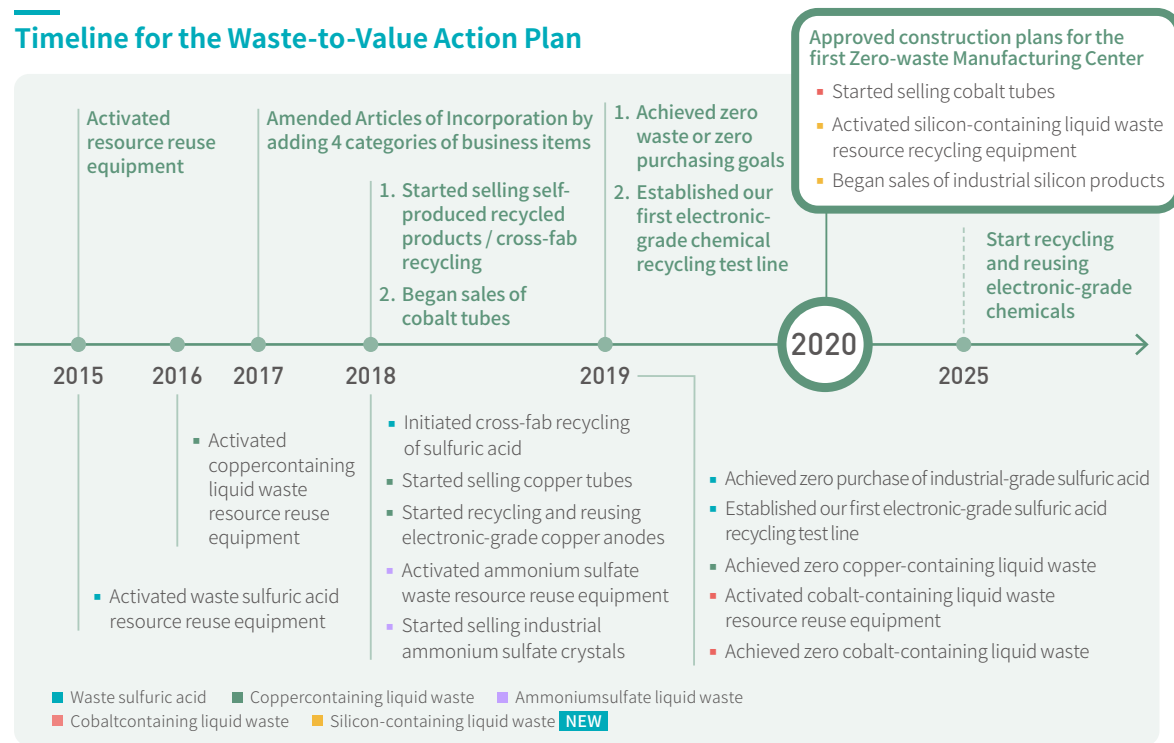
Dedicated to the implementation of a circular economy, TSMC is no longer just a waste resources producer. To strengthen control over product flow and reduce risks derived from mishandling by outsourced vendors, TSMC continues to implement the "Action Plan to Turn Waste into High-Value Products", which includes the development and introduction of resource recycling technologies and equipment. Waste resources produced in manufacturing processes are revitalized and remade into products to be used within TSMC facilities or sold to other industries.

Since 2015, TSMC has been actively implementing on-site reuse of waste sulfuric acid, and has set up equipment to recycle cobalt-containing and copper-containing liquid wastes to reduce sulfuric acid consumption and outsourced treatment of cobalt-containing and copper-containing liquid wastes. To increase the value of materials recycled from copper-containing liquid waste, TSMC worked with raw material suppliers on developing purification procedures that remake pure recycled copper tubes into electronic-grade copper anodes. A cumulative total of over 10 metric tons of electronic-grade copper

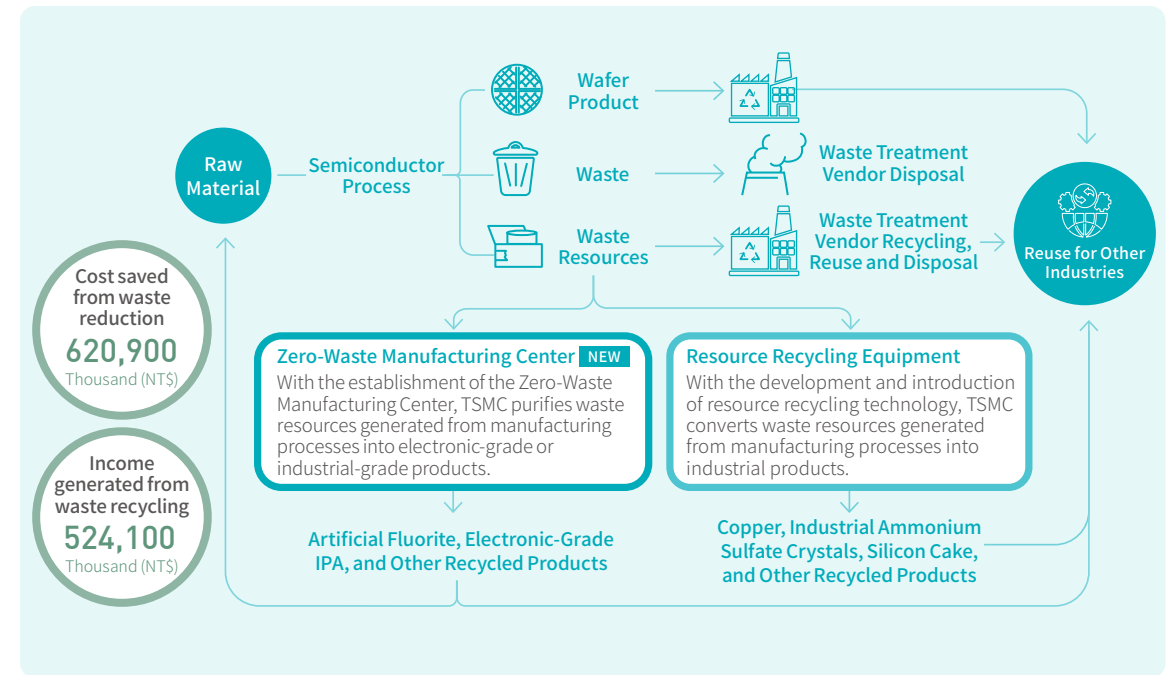
anodes have been reused in TSMC manufacturing processes as of 2020. In addition, TSMC has built the Ammonium Sulfate Waste Crystallization System to optimize operational procedures and efficiency. In expanding in-house resource recycling equipment, TSMC introduced the "Physical Regeneration Technique for Backgrinding Wastewater" that turns silicon-containing liquid waste into industrial silicon cake, TSMC's fifth recycled product. In 2020, TSMC recycled over 150,000 metric tons of waste and produced 120,000 metric tons of products, creating more than NT\$500 million of value in resources circulation.

In 2020, TSMC approved construction plans for the Zero-Waste Manufacturing Center in the Central Taiwan Science Park. Construction is scheduled to complete in 2023. At the same time, TSMC participated in technology development and launched the electronic-grade chemicals recycling pilot line including IPA and cyclopentanone and ammonia. The goal is to purify IPA, cyclopentanone and ammonium sulfate waste into reusable materials for TSMC processes and subsequently reduce environmental impact through material reclamation.

Timeline for the Waste-to-Value Action Plan



TSMC Aspires to be a Practitioner of Circular Economy



Note: Income value statistics cover Taiwan facilities.

Case Study

Ammonium Sulfate Waste Crystallization System 2.0 Significantly Increases Treatment Capacity by 400%

In response to the advancement of manufacturing processes and capacity, TSMC continues to strengthen efforts towards achieving a circular economy and effectively reducing the environmental impact of increased waste. TSMC collaborated with vendors throughout the supply chain to assess and improve the Ammonium Sulfate Waste Crystallization System. In 2020, TSMC completed the development of Ammonium

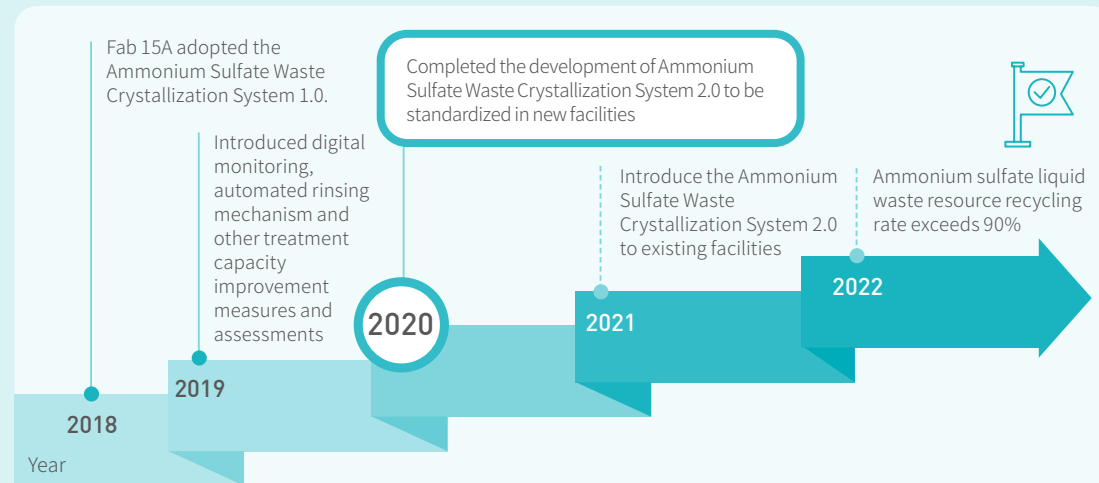
Sulfate Waste Crystallization System 2.0. Heating equipment is introduced to accelerate the heating cycle and reduce production loss after regular maintenance. Digital dashboards monitor ionic concentration of the system to stabilize evaporation capacity. Also, the automated rinsing mechanism prevents blockage of process route to maintain solid-liquid separation performance. The upgraded system can increase treatment capacity by 400% from 400 metric tons to

2,000 metric tons a month. Accordingly, the system will become standardized in new facilities built in the future.

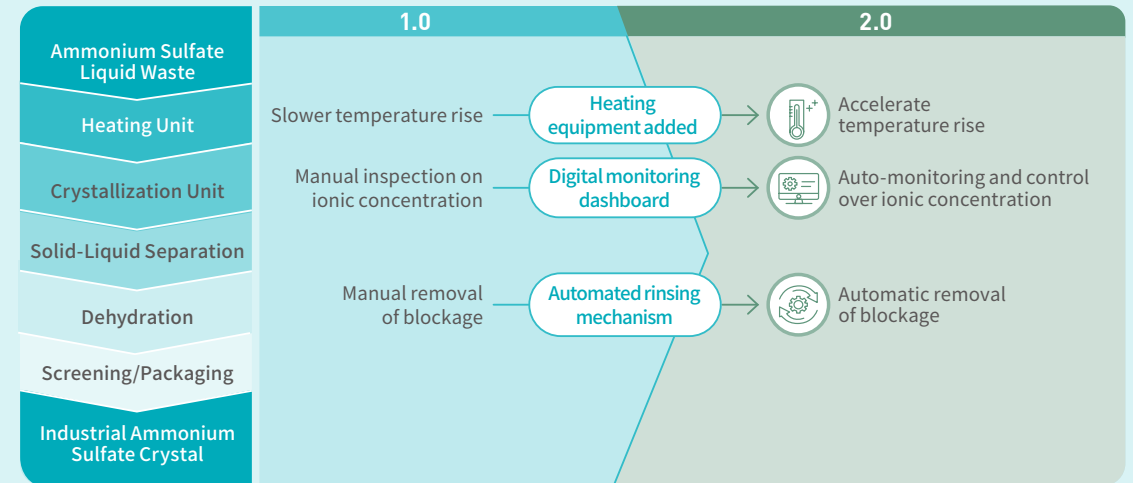
Since 2018, TSMC has reduced over 15,800 metric tons of ammonium sulfate liquid waste outsourced for treatment and produced 4,200 metric tons of industrial ammonium sulfate crystals. The value created from waste recycling and reduction has exceeded NT\$35 million. TSMC will adopt the "smart copy" technique

to introduce the Ammonium Sulfate Waste Crystallization System to existing facilities. In 2022, the system can reduce ammonium sulfate outsourced for treatment by an estimated 60,000 metric tons per year and yield more than 15,000 metric tons of industrial ammonium sulfate crystals, which will create NT\$130 million in value.

TSMC In-House Ammonium Sulfate Waste Recycling Timeline



Ammonium Sulfate Waste Crystallization System



Case Study

Zero-waste Manufacturing Center Facilitates Circular Economy

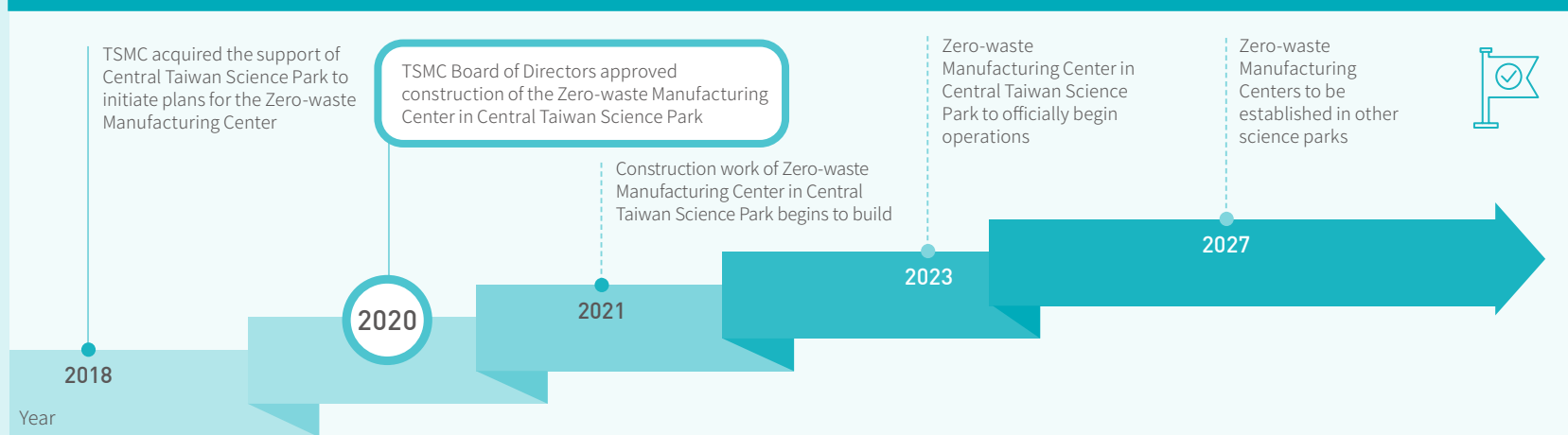
In addition to proactively developing waste recycling technologies to recycle and reuse waste materials, TSMC initiated a project to build our first Zero-waste Manufacturing Center. Proposing a novel circular economy model, the project aims to purify waste resources into semiconductor-grade chemicals that will return to TSMC manufacturing processes. The recycled material will substitute for at least 30% of raw material demand. The project also plans to

recover residual heat from waste resources as assisting energy, which will reduce energy demand in recycling processes, enabling TSMC to truly meet its sustainability goal of developing green manufacturing using green technologies.

TSMC's first Zero-waste Manufacturing Center, which will be located in Central Taiwan Science Park, was approved by the Board of Directors in 2020. The construction work begins in 2021. Guided by the three principles of

maximum waste reduction, optimal environmental benefits, and minimized management risk, the center is expected to reduce outsourced waste treatment by 140,000 metric tons each year and create NT\$1.2 billion of value in waste recycling and reduction. It will be our first facility based on circular economy model. The Zero-waste centers will gradually expand to be built in Hsinchu and Tainan as TSMC continues to pursue its sustainability goals.

Timeline for TSMC Zero-waste Manufacturing Center



Audit and Guidance

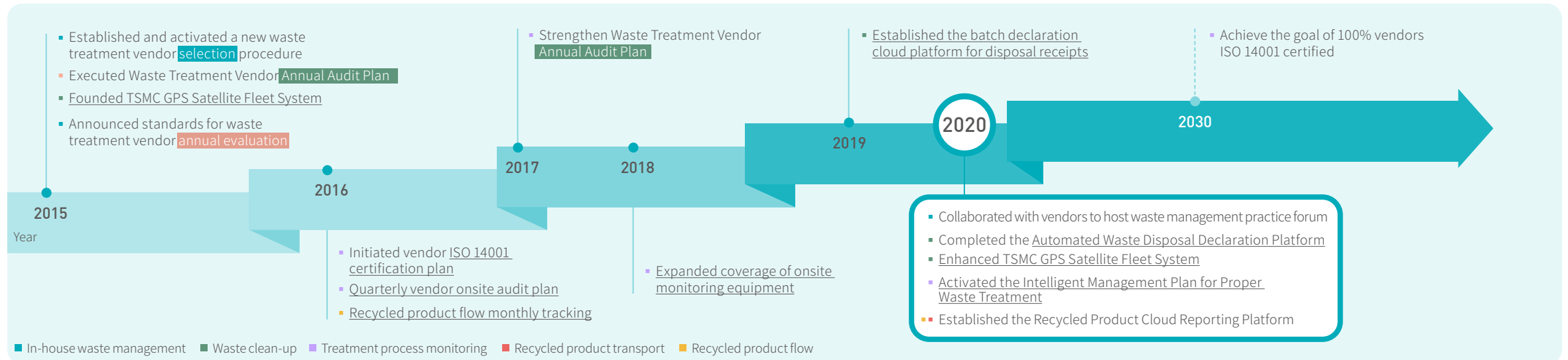
Committed to source reduction and achieving a circular economy, TSMC also takes full responsibility for the management of outsourced waste treatment through the Waste Treatment Vendor Sustainability Enhancement Project. For new vendor selection, TSMC has a cross-division team of experts and a comprehensive selection procedure to carefully choose outstanding vendors to work with. A document review and onsite operational inspection will be conducted in six dimensions. Qualified vendors are subjected to weekly and monthly document reviews and quarterly and annual onsite inspections. Eight dimensions covering 166 inspection items are listed in accordance with the Waste Treatment Vendor Annual Audit Plan. Lastly, vendor replacement is carried out based on the three dimensions stipulated in the Annual Evaluation for Waste Treatment Vendors.

In 2020, TSMC audited over 55 waste treatment vendors on site, reaching a 100% inspection rate, and 79 deficiencies were improved. The percentage of vendors evaluated as "excellent" and "good" has improved from 36% in 2015 to 75%. The number of vendors certified for ISO14001 increased to 44, accounting for 80% of all vendors. In striving for excellence, TSMC initiated the Intelligent Waste Management Procedure with Full Traceability. Through the introduction of smart automation, manual inspections can be replaced with systematic management of suspicious activities through auto-detection and reporting. The procedure will enhance vendor sustainability as TSMC is committed to achieving green manufacturing.

Waste Cleanup and Disposal Vendor Management Process

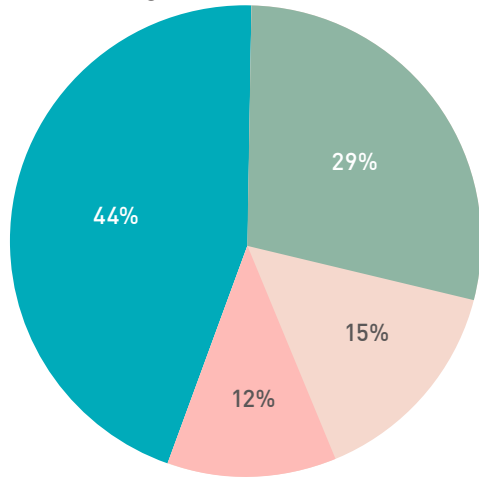


Timeline for Waste Treatment Vendor Management



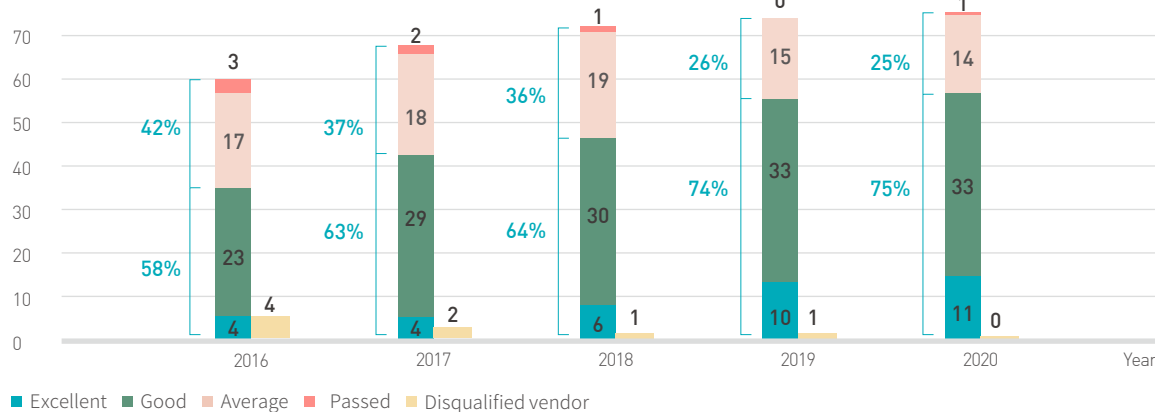
Waste Treatment Vendor Audit and Guidance Results in 2020

■ Waste Management
 ■ Safety and Health Management
■ Wastewater Management
 ■ Air Pollution Management



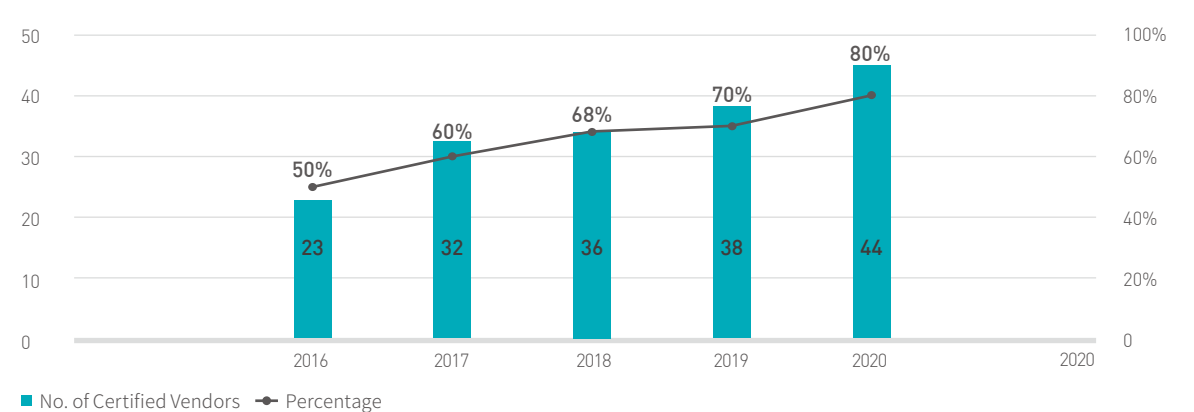
Deficiency Type	Number of Deficiencies	Legal Compliance Correction	Onsite Environment/Operational Improvement	Setting regulations and procedures
Waste Management	35	<ul style="list-style-type: none"> Amend waste disposal contracts to comply with laws and regulations Correct waste storage area labelling to comply with laws and regulations 	<ul style="list-style-type: none"> Improve waste storage environment 	<ul style="list-style-type: none"> Set regulations for waste treatment vendor audits
Safety and Health Management	23	<ul style="list-style-type: none"> Designate supervisors to specific chemical operations 	<ul style="list-style-type: none"> Improve Globally Harmonized System of Classification and Labelling of Chemicals and safety data sheet (SDS) conformity onsite 	<ul style="list-style-type: none"> Set regulations to ensure correct use of safety harness, helmet, and other protective gear when operating at height or exposed to noise
Wastewater Management	12	<ul style="list-style-type: none"> Amend onsite operational records and comply with the water pollution prevention measures plan and permit 	<ul style="list-style-type: none"> Improve onsite effluent discharge labelling and wastewater pipe labelling 	
Air Pollution Management	9	<ul style="list-style-type: none"> Improve onsite operational records and comply with the stationary pollution source installation, operating and fuel use permit 	<ul style="list-style-type: none"> Increase inspection frequency at sampling checkpoints onsite 	

Evaluation Results^{Note}



Note: Total score 100: ≥ 90 Excellent; < 90 Good ≥ 80; < 80 Average ≥ 70; < 70 Passed ≥ 60; < 60 Disqualified vendor

ISO-certified Waste Treatment Vendors



Case Study

TSMC Leads the Industry to Embrace an Era of Intelligent Waste Management with Full Traceability

In 2020, TSMC built an industry-leading intelligent waste management procedure with full traceability. Through multiple automated and intelligent projects, TSMC strengthens management of three outsourced areas of waste clean-up, treatment, and recycled product transport and flow to continue improving waste product life cycle management.

Waste Clean-up: Enhanced Traceability with Automated Declaration Platform

In 2020, TSMC collaborated with the Environmental Protection Administration (EPA) to establish the Automated Waste Disposal Declaration Platform. Along with TSMC's enhanced GPS Satellite Fleet System, the real-time, comprehensive, automated,

and highly efficient waste clean-up monitoring procedure, it will save 16,000 hours of labor and 240,000 papers used for receipts in 2021 at most. It increases accuracy and efficiency for the industry in waste declaration. TSMC was invited by EPA to share its experiences developing the platform and shared a video on the Industrial Waste Report and Management System website to encourage others in the industry to follow suit.

Waste Treatment: Replace Manual Inspection with Advanced Technology & Smart Management

Once waste enters a treatment facility, proper handling is of utmost importance. TSMC started to upgrade the onsite remote monitoring system at 6 key waste treatment vendors to replace

conventional manual inspections. First, TSMC worked with waste treatment vendors on stipulating checkpoints in treatment processes and set up onsite equipment. The system automatically tracks and integrates data, images, and declaration information. In addition, it supervises treatment processes and sends out anomaly alerts through license plate and image recognition technology. After that, TSMC carries out onsite anomaly investigations and manages suspicious activities in treatment processes based on the auto-detection and report system mode.

Recycled Product Transport and Flow Tracking: Build Systematic Cloud Platform and Convert from Monthly Declaration to Itemized Reporting

After waste is properly treated into products, transport and flow are vital to the results of TSMC's model of

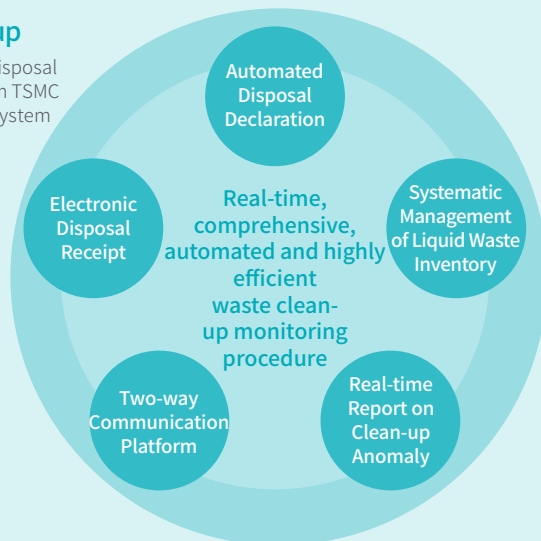
a circular economy. TSMC launched a Recycled Product Flow Cloud Reporting Platform in 2020 and will require vendors to report on recycling product transport and flow item by item instead of declaring on a monthly basis in 2021. As the transport footprint is more real-time and transparent, the life cycle of waste is more comprehensively managed based on full traceability.

In 2020, TSMC hosted the first Waste Management Practice Forum, providing a summary of regulatory changes to serve as a basis for legal compliance. TSMC also shared its management tips and experiences with common deficiencies and deficiencies subjected to penalties. Through face-to-face communication with vendors on enhancing the management procedure, vendors are also encouraged to advocate it to their clients as a joint effort to achieve environmental sustainability.

Improvement Actions for the Intelligent Waste Management Procedure with Full Traceability in 2020

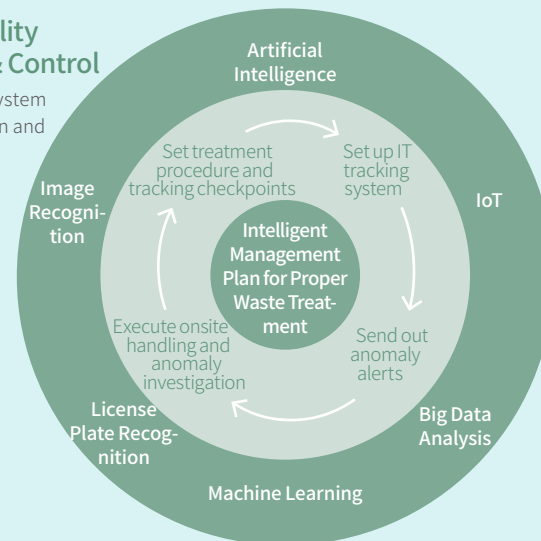
Waste Clean-up

Automated Waste Disposal Declaration Platform
TSMC GPS Satellite Fleet System



Treatment Facility Management & Control

Remote Monitoring System
Intelligent Recognition and Anomaly Reporting



Recycled Product Flow Management & Control

Itemized Cloud Reporting
Real-time and transparent transport tracing

Who	Driver transporting recycled products	
What	Type and weight of recycled products being transported	
Where	Target of recycled product sales	
When	Time required for transporting recycled products	
How	Vehicle used to transport recycled products	