Product Packing Materials Management and Reduction
TSMC uses recyclable plastic and paper as packing materials for shipping products. These packing materials comply with EU regulations requiring lead, cadmium, mercury and chromium (IV) concentration of less than 100ppm, and also contain no polyvinylchloride (PVC).

We reuse packing materials as much as possible to control usage. TSMC recycles packing materials from products shipped to customers and testing and assembly facilities for reuse after cleaning. Packing materials from raw wafers are also reused in product shipping. Our wafer shipping boxes are completely made from reused sources. These measures have reduced both packing material consumption and waste generation.

8.6 Pollution Prevention
TSMC believes that pollution prevention is one of a corporation’s most important responsibilities. TSMC’s pollution prevention is based on the ISO 14001 environmental management system, and uses the “Plan-Do-Check-Act” management model to promote continuous improvement. We believe that conserving raw materials, energy, and resources as well as reducing waste and pollutants both saves production costs and protects the environment.

Pollution Prevention is the Bottom Line
Taiwan has very limited land, large population, and high density of industrial factories. Therefore, some of its environmental regulations may be among the strictest in the world. To address increasingly stringent environmental standards, TSMC has established good communication channels with the government, and participates in discussions in the early stages of legislation to facilitate reasonable and feasible standards. Each plant also performs assessments to evaluate conformity to new standards, and improvement and preventive measures are taken immediately if nonconformance is discovered.

TSMC has established comprehensive management and operations procedures for pipe-end treatments such as air and water pollution controls, and ensures these procedures are carried out precisely. TSMC has also installed monitoring systems on the discharging sides of pollution control facilities for online monitoring. Facility personnel follow emergency response and reporting procedures to take proper actions if operating conditions diverge from preset limits.
Assisting Non-semiconductor Subsidiaries in Early Pollution Control
TSMC assists its non-semiconductor subsidiaries, TSMC Solid State Lighting and TSMC Solar, in assessing risk for their specific wastewater, air emissions, wastes, and chemicals to reduce their environmental impacts.

Resource Recycling is Our Consensus
For waste management, TSMC has transitioned from traditional “treatment and disposal” to a concept of effective resource management, and implements this concept in daily operations. We manage waste as a resource, categorize and collect waste at the source, raise waste recyclability, and also collaborate with waste treatment and recycling facilities to search for or develop possible recycling measures to reduce the amount of waste sent to incinerators and landfills. In addition, TSMC actively collaborates with raw material suppliers to reduce chemical usage and waste chemicals. We also study the feasibility of waste recycling by raw materials suppliers to reach our goal of sustainable resource recycling.

With this waste resource management model, TSMC has successfully raised its waste recycling rate each year, reduced its incineration and landfill rate, and cut waste disposal cost by generating waste recycling income. In 2012, TSMC’s waste recycling rate reached more than 93% and the landfill rate was less than 1%.

8.6.1 Source Reduction – Raw Materials Usage Reduction
TSMC seeks to optimize processes to minimize raw material use and waste production, protecting the environment while reducing costs at the same time. TSMC has a designated unit that periodically reviews raw materials reduction performance. Internally, we optimize our process recipe for raw material usage, which can not only reduce production cost but also reduce the generation of pollutants and wastes. Externally, we require our process tool suppliers to review and minimize their chemical usage step by step. We are now discussing with our process tool suppliers to adopt the SEMI-S23 guideline to optimize the consumption of energy, resource and chemicals. We have

TSMC Material Input and Output – Example of TSMC Fabs in Taiwan

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process Raw Material</strong></td>
<td><strong>Product</strong></td>
</tr>
<tr>
<td>Raw wafer (8-inch equivalent pieces) 15,386,813</td>
<td>Wafers (8-inch equivalent pieces) 14,044,000</td>
</tr>
<tr>
<td>Process chemicals (cubic meters) 1,597,392</td>
<td>Volatile organic compounds (kg) 65,580</td>
</tr>
<tr>
<td>Bulk chemicals (tons) 92,996</td>
<td>Nitrogen Oxides (tons) 50.73</td>
</tr>
<tr>
<td>Process gas (tons) 95,744</td>
<td>Sulfur Dioxide (tons) 40.84</td>
</tr>
<tr>
<td>Bulk gases (cubic meters) 1,306,343,023</td>
<td>General waste (tons) 33,158</td>
</tr>
<tr>
<td>City water (tons) 25,773,078</td>
<td>Hazardous waste (tons) 90,596</td>
</tr>
<tr>
<td>Electricity (KWH) 5,070,778,192</td>
<td>Wastewater (cubic meters)</td>
</tr>
</tbody>
</table>
also included SEMI-S23 as a process tool procurement specification.

TSMC uses raw wafers as a major direct material in its manufacturing process. Raw wafers are composed of very high purity silicon, and cannot be recycled for wafer manufacturing processes. However, control wafers used for monitoring process conditions are reclaimed for reuse. We estimate one control wafer can be reused 10 times, which reduces both cost and waste.

8.6.2 Water Pollution Control
Strategy of Segregated Treatment, Strict Monitoring, and Environmental Protection before Production

TSMC’s water pollution control strategy is first to reduce pollutants in process wastewater, followed by water recycling and treatment of pollutants in water. Effluent water quality must be better than or compliant with governmental standards.

TSMC’s major water-using process is an ultra-pure water system which turns raw water into ultra-pure water, mainly used in process tools for cleaning chemical residue on wafer surfaces. To reduce total water usage, TSMC’s effluent water from ultrapure water systems and process tools are graded by purity. The cleanest is reused in the manufacturing process; the second grade taken from the recycling treatment is employed in secondary uses such as cooling-tower water. Wastewater that cannot be recycled is discharged to treatment facilities for final wastewater treatment.

TSMC adopts a strict front-end wastewater categorization strategy to improve treatment efficiency. Wafer fabs’ wastewater can be divided into fluoride, copper, general acid, and various polishing wastewaters. All types of wastewater are strictly categorized at process tools, and collected to wastewater treatment facilities through separated piping. In order to manage these drains strictly, there are more than 20 categories of drainage types, carefully operated and maintained by professional teams to comply with the standards of the Science Park Administration (SPA). The water is then discharged to the SPA wastewater treatment plant for further treatment after professional teams ensure the discharge complies with SPA standards. The treated wastewater is discharged to rivers from the SPA’s wastewater treatment plants in compliance with river discharge standards. The SPA also conducts random measurement of the discharges of each company in Science Park.

TSMC operates only after ensuring that the environment will not be polluted. Each fab is equipped with effective wastewater treatment systems, including complete backup systems such as emergency power supplies, to reduce the likelihood of abnormal discharge. Operating status of all of TSMC wastewater treatment systems are monitored 24 hours a day by shift personnel. If operating conditions diverge from the preset limits, a warning signal is sent and wastewater discharge is halted. Data gathered for monitoring system effectiveness have been designated an important tracking item to ensure effluent quality.

Developing New Technologies to Response to New Regulations

In addition to complying with SPA standards, TSMC continually works with industries and universities to improve discharge quality in areas such as COD (Chemical Oxygen Demand), TMAH (Tetra-methyl ammonium hydroxide) and NH3-N to reduce hazards to water bodies. For example, we reduced COD discharge for 12-inch fabs by 62.5%.

In addition, TSMC continues to explore new wastewater treatment and chemical recycling technologies. For example, TSMC led the industry in performing a series of experiments to obtain the optimal processing technology for NH3-N-containing backside grinding wastewater, high-concentration fluoride and phosphorus acid wastewater and TMAH recycled by external contractors, which attests to our dedication to protecting the environment.

Wastewater Discharge Quality Improvement in 2012

TSMC’s major wastewater pollution control measures are as follows:
- Establishment of waste Tetramethyl Ammonium Hydroxide recycling system to reduce nitrogen-containing pollutants.
- Reuse of high concentration acid or base wastewater through resin regeneration or reverse-osmosis membrane for use as wastewater neutralization chemicals to reduce wastewater conductivity.
- Replacement of sodium hydrosulfite by Catalase to reduce wastewater conductivity.
- Use of chemical-free immersion ultra filter to treat chemical mechanical polish wastewater to reduce suspended solids in wastewater.
- Use of chemical-free immersion ultra filter to treat backside grinding wastewater to reduce suspended solids in wastewater.
- Reuse of waste phosphoric acid to reduce phosphoric acid in wastewater.
- Installation of ammonia-biological wastewater treatment system in TSMC (China) to reduce ammonia in wastewater discharges.
- Installation of sewer biological treatment system in TSMC (China) to reduce chemical oxygen demand (COD) in wastewater discharges.
Wastewater Discharge Quantity
TSMC’s wastewater quantity per 8-inch wafer equivalent per mask layer (Note 2) in 2012 decreased by 8.0% compared to 2011 from 40.0 liters to 36.8 liters.

Wastewater Effluent Monitoring
All TSMC fabs are equipped with continuous monitoring equipment to monitor and record changes in water quantity and quality, such as acidity and fluoride ion concentration, in order to take appropriate responses when abnormal situations occur. We also conduct offsite sampling and analyze wastewater effluent quality at least four times a year, which provides a calibration reference for online analyzers, ensuring that TSMC complies with water quality standards.

In 2012, TSMC wastewater effluent quality was close to 2011 levels, indicating good stability in all fabs. The wastewater effluent quality data includes: pH between 5 to 9 (SPA standard is 5 to 10), suspended solids were controlled from 4.3 to 250 mg/L (SPA standard is below 300), and COD was controlled from 11.1 to 343 mg/L (SPA standard is below 500).

8.6.3 Air Pollution Control
Effective Treatment Based on Waste Air Specification
TSMC’s air pollution control strategy is to optimize process to reduce pollutants in air exhaust, and then to abate pollutants in air exhaust through high-efficiency equipment to comply with or surpass legal requirements. Air pollutant concentrations in TSMC’s exhaust are far below the standards required by Taiwan’s EPA, according to actual measurements performed over the years.

Wafer fabs emit three major types of exhaust: acid exhaust, base exhaust, and volatile organic compounds. Heat exhaust emitted by process equipment does not cause air pollution. Air pollution control systems depend on various categories and characteristics of pollutants. TSMC installs local scrubbers behind process tools in order to treat toxic, flammable and PFC gases. First, high temperatures or other physical and chemical measures are used to significantly reduce the concentration of pollutants in tool exhaust. The gas is then inducted to central waste gas treatment equipment for endpoint treatment. Endpoint treatment includes zeolite-rotary-wheel absorbing equipment for
facilities, is fully compliant or exceeds the air pollutant emissions standards in the areas where they operate. TSMC has deployed high performance air pollution control equipment with at least N+1 backup systems so that all pollution control equipment can continue waste gas control 24 hours a day, 365 days a year in case of equipment breakdown. Operational status of all of TSMC air pollution control systems is monitored 24 hours a day by shift personnel. Data collected by system efficiency monitoring have been classified as an important tracking item in order to ensure air exhaust quality. In 2009, we added an electronic quarterly air pollution report system that can automatically confirm the accuracy of declarations.

To ensure normal equipment operations and reduce abnormal pollutant emissions, TSMC has installed backup systems, including power generation, to back up malfunctions of operation equipment. TSMC has also installed backup fuel supply systems for VOC pollution control equipment that will engage if the original fuel supply systems experience difficulties.

**Air Emissions Record**

In 2012, the average removal efficiency of VOC exhaust remained at a relatively high level of 94.9% in TSMC’s Taiwan fabs and 92.3% in overseas fabs, well above the standard for local regulations.

TSMC’s VOC volume per 8-inch wafer equivalent per mask layer (Note 2) in 2012 decreased by 6% compared to 2011 from 0.166g to 0.156g. In addition, based on the Taiwan EPA’s formula for calculating SOx and NOx emissions, TSMC estimates that our NOx emission was 85 tons and SOx emission was 42 tons in 2012.

### TSMC VOC Destruction Removal Efficiency

<table>
<thead>
<tr>
<th>Year</th>
<th>Taiwan Sites</th>
<th>Overseas Sites</th>
<th>All Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>94.1%</td>
<td>88.3%</td>
<td>91.1%</td>
</tr>
<tr>
<td>2009</td>
<td>94.8%</td>
<td>83.6%</td>
<td>94.1%</td>
</tr>
<tr>
<td>2010</td>
<td>95.3%</td>
<td>83.3%</td>
<td>94.7%</td>
</tr>
<tr>
<td>2011</td>
<td>93.3%</td>
<td>90.6%</td>
<td>93.1%</td>
</tr>
<tr>
<td>2012</td>
<td>94.9%</td>
<td>92.3%</td>
<td>94.9%</td>
</tr>
</tbody>
</table>

Note 1: The statistical data for VOC emission includes all fabs in Taiwan, as well as all overseas fabs, packing and testing facilities, bumping, EBO, and R&D.

Note 2: Prior to 2009, VOC emission density was defined by total VOC emission quantity divided by total wafer out. Beginning in 2009, this index was rationalized by introducing a layer index due to product complexity.
8.6.4 Waste Reduction and Resource Recycling

TSMC has transitioned from traditional waste cleaning and disposal to integrated resource management, and has a designated waste resources management unit to treat waste as valuable resources to be recycled as much as possible. In order to sustainably use our resources, the first priority of our waste management is reduction; the second is recycling, followed by energy recovery, and finally disposal through incineration and landfill.

TSMC has made great efforts in reducing raw materials usage with significant achievements on waste reduction and recycling over the past decade. Although the categories of waste are growing more complex, TSMC continues to develop new waste recycling technology with suppliers to raise its recycling rate and reduce waste disposed in landfills. TSMC’s Taiwan sites continued to carry out reduction and recycling programs in 2012, and our waste recycling rate reached 93%, exceeding 90% for the fifth consecutive year, while our landfill rate was below 1% for the fifth consecutive year. Our overseas subsidiaries are also endeavoring to improve their waste recycling rates.

Innovative 3R Waste Projects

In 2012, TSMC initiated several environmental programs which focused on selected less-hazardous chemicals for reduction, recycling and reuse. For example:

- Process chemical replacement: Replaced copper etching chemicals with heavy metal-free chemicals to reduce environmental impact, reducing waste by 52%, or 5,300 tons.
- Chemical waste recycling technology development: Worked with supplier to develop a method to re-use developer fluid in other industrial processes to conserve natural resources and reduce ammonia waste; recycled 3,100 tons of developer fluid in 2012.
- Sulfuric acid reduction: We collaborated with process equipment vendors to reduce sulfuric acid usage and waste generation.
- Calcium fluoride sludge reduction: Installation of drying equipment to reduce weight and volume of calcium fluoride sludge.

TSMC’s U.S. wafer fab, WaferTech, has successfully reduced hazardous waste by more than 77% since 2003 by actively seeking & implementing reuse opportunities for a number of fab waste materials. In 2012 WaferTech established a Green Team with the goal of reducing waste to landfill and increase recycling. The team has identified and started recycling several materials which were previously disposed of directly. One corrosive waste was changed from landfill to “waste to energy”. This will eliminate approximately 25,000 lbs annually from disposal by landfill. In 2012 WaferTech was approached by the local state agency to submit an article on their waste reduction projects. WaferTech was showcased on the agency’s web site in early 2013. http://www.ecy.wa.gov/programs/hwtr/P2/success/WaferTech.html
Computer Reuse and Recycling Campaign
TSMC fully supported ASUSTek Computer Inc.’s “Computer Reuse and Recycling Campaign” project, which has also received support from the Ministry of Economic Affairs. TSMC has donated more than 37,495 used personal computers, notebook computers, and LCD monitors since 2007, making up one third of the total amount received in this project to become the largest donor.

Our purpose in participating in this campaign is to promote the concept of material recycling. Through this recycling campaign, refurbished computers are donated to students in rural elementary and junior high schools and to disadvantaged minorities to narrow the digital divide, caring for society and protecting the environment at the same time.

8.7 Environmental Management System
8.7.1 Environmental Management System Establishment
Establishing A Pro-Active Environmental Management Vision
TSMC aims to be a world-class company in environmental protection. Our environmental performance complies with legal requirements and also measures up to recognized international practices.

A Comprehensive Internal Environmental Management Organization
TSMC’s environmental management organization consists of: the central Environmental, Safety & Health Planning unit; the Industrial Safety and Environmental Protection Technical Board; and designated Industrial Safety and Environmental Protection departments in each manufacturing facility.

These organizations work together collaboratively with clearly defined responsibilities. We use ISO 14001 and QC 080000 standards to manage environmental performance at all our manufacturing facilities. It is mandatory for all new manufacturing facilities to receive these certifications within 18 months of installing their first manufacturing equipment.

TSMC Leadership in Data Center and Wafer Fab ISO 50001 Certification
TSMC adopted the ISO 50001 Energy Management System in 2011 to extend its energy conservation efforts. The Fab 12 Phase 4 data center completed ISO 50001 Energy Management System certification in 2011, becoming Taiwan’s first company to earn this certification for a high-density computing data center. TSMC believes ISO 50001 supports energy saving and carbon reduction, and continues to apply the ISO 50001 Energy Management System to additional manufacturing facilities. In 2012, the Fab 12 Phase 4/5 and Fab 14 Phase 3/4 facilities and offices also adopted the ISO 50001 system and earned certifications.

Continuous Improvement according to the Spirit of Our Management System
To sustainably mitigate enterprise risks and to fulfill our corporate social responsibilities, we focus on:

- Air and water pollution prevention and control
- Waste reduction and recycling
- Greenhouse gas reduction (energy efficiency and perfluorinated compound emission reduction)
- Resource conservation (water savings and chemical substance use reduction)
- Energy-saving products and restriction of hazardous substances

In addition to annual internal audits conducted by designated Industrial Safety and Environmental Protection departments in each manufacturing facility on the operational status of environmental management systems, we also invite external verification parties to conduct audits and provide recommendations for improvement. The central Environmental, Safety & Health Planning unit also selects topics for annual audits on legal compliance and environmental risk control to enhance the whole company’s ESH management.

Collaborating with Suppliers to Expand Sustainability Performance
TSMC also collaborates with our suppliers proactively on managing global ESH risks and working towards supply chain sustainability. Our efforts include:

- Carbon footprinting
- Water footprinting
- Conflict minerals management
- Hazardous substance restriction management