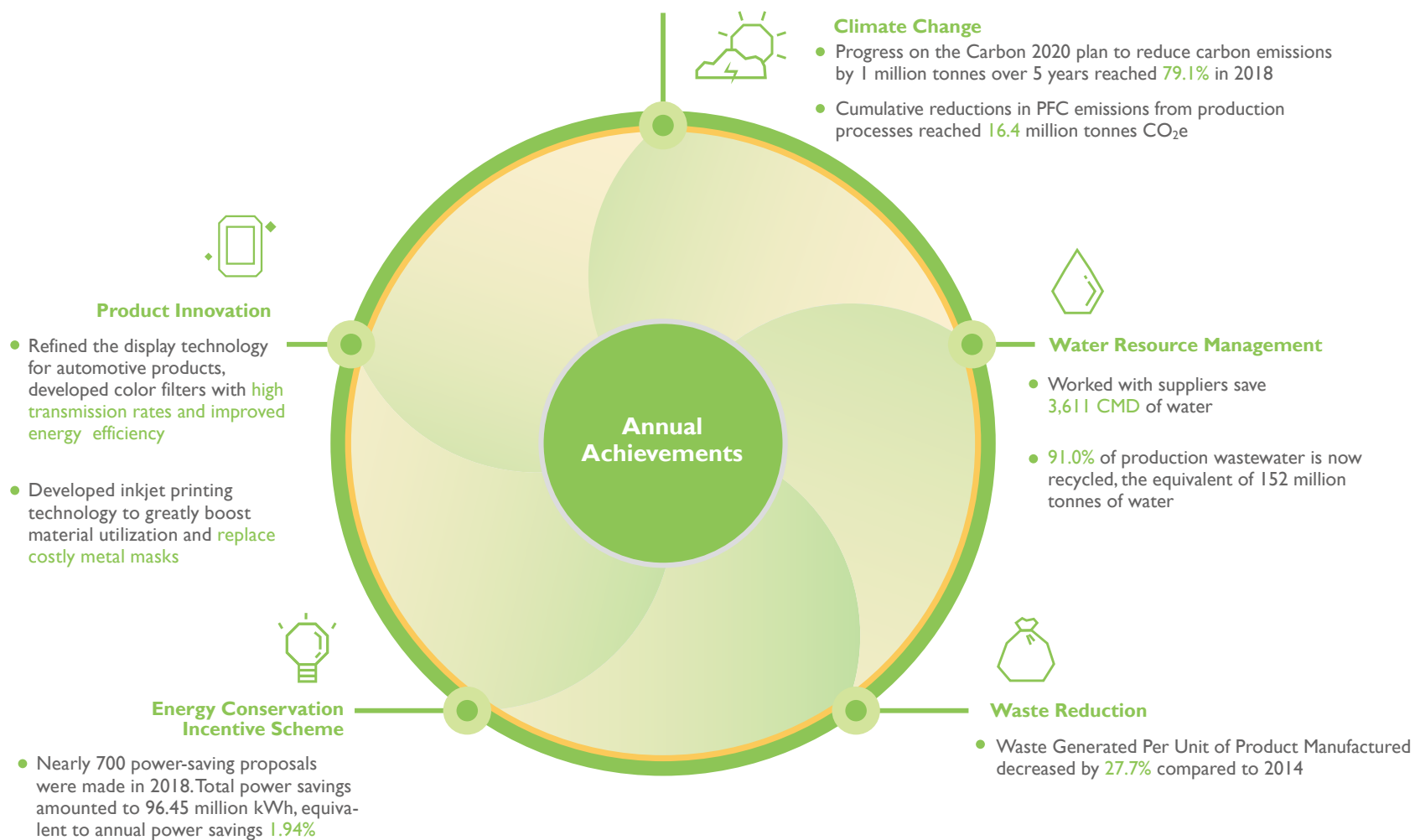




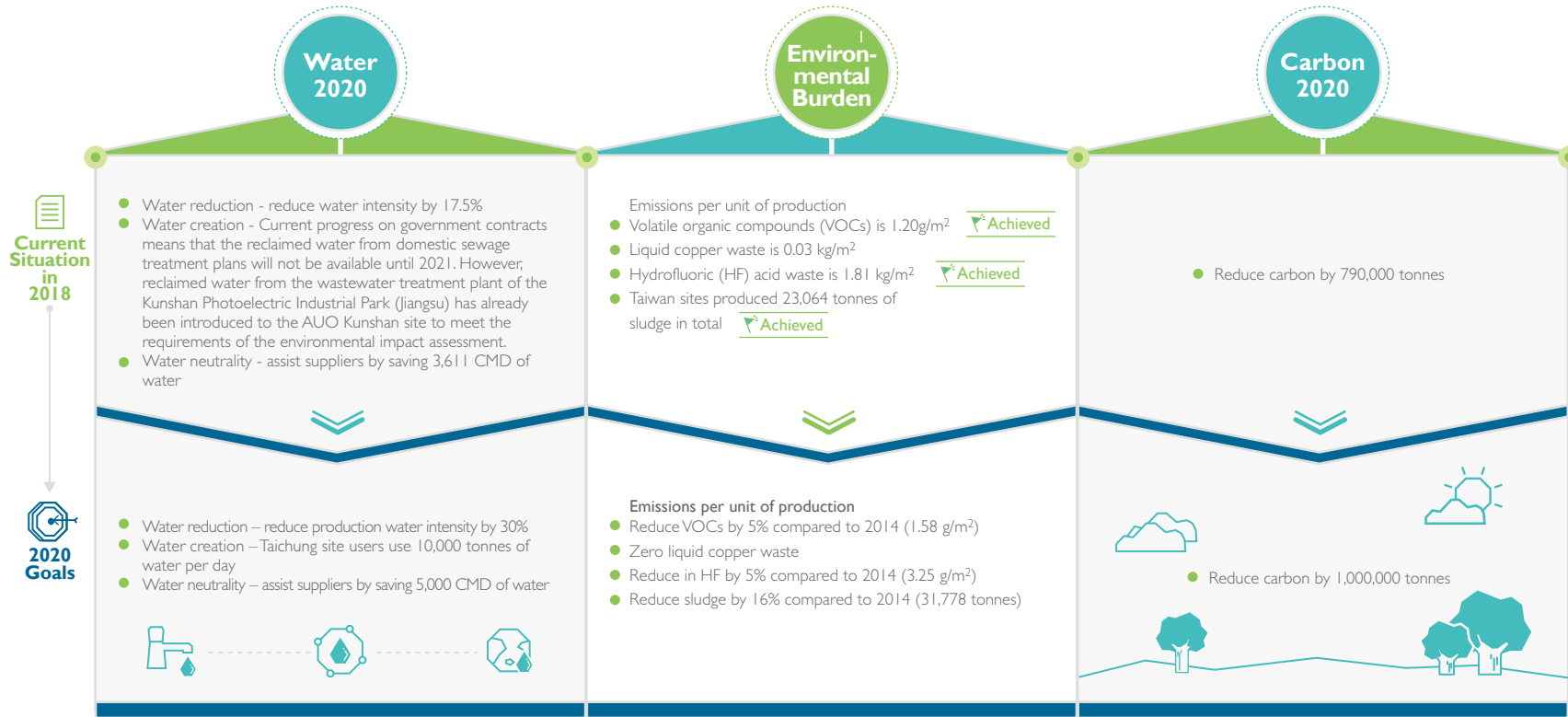
# 04

## Environmental Sustainability

- 4.1 Climate Change
- 4.2 Water Resource Management
- 4.3 Green Production
- 4.4 Product Innovation



Environmental Goal 2020 Progress



1. Only the representative environmental burden goals are listed.

Materials									
	Glass Substrates (tonnes)	Liquid Crystal (tonnes)	Photoresist (Kiloliters)	Array stripper Usage (tonnes)	Array stripper Use of Renewable Materials	CF Thinner (tonnes)	Developer <sup>2</sup> (tonnes)	Aluminum Etchant (Kiloliters)	PFCs Usage (tonnes)
2018	97,865.9	90.0	3,129.0	80862.3	87.8%	1,774.0	49,188	10,493	900.4
2017	95,134.5	88.6	2,931.8	78,320	88.55%	1,538.0	13,362.0	10,560.0	802.2
2016	62,232.0	83.8	5,818.4	77,110	88.05%	11,438.3	11,438.3	11,231.0	697.8

Energy <sup>3</sup> GJ							
	Total Energy Consumed	Purchased Electricity	Natural Gas	LPG	Diesel <sup>4</sup>	Self-generated Solar Power	Wind power <sup>5</sup>
2018	19,746,407.09	18,921,349.28	716,182.93	12,511.37	96,363.50	299.87	0
2017	18,948,808.8	18,215,728.2	622,388.00	12,904.53	97,306.30	481.8	0
2016	16,684,892.4	15,956,824.4	624,269.50	12,177.70	91,144.00	469.1	7.7

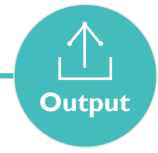
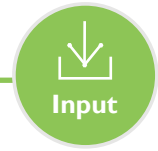
Water (megaliters)								
	Total Water Used	Domestic Water	Reclaimed Water <sup>6</sup>	Tap Water	Ground Water	Rainwater	Production Water Recycle Volume	Production Water Recycle Rate <sup>7</sup>
2018	33,735.21	2,455.90	2,472.20	31,155.63	88.23	19.15	152,207.8	91.0%
2017	32,570.44	2,393.81	0	32,542.70	8.76	18.98	146,685.7	90.71%
2016	26,982.20	2,436.95	0	26,926.70	40	15.5	133,163.6	92.20%

Energy GJ	GHG-related (10,000 Tonnes CO <sub>2</sub> e)			Emissions (tonnes)						
	Self-generated grid-tied solar power <sup>8</sup>	Scope 1	Scope 2	Scope 3	ODS emission	SO <sub>x</sub> <sup>9</sup>	NO <sub>x</sub> <sup>9</sup>	Fluorides	HCl <sup>10</sup>	Volatile Organic Compounds (VOC) <sup>11</sup>
2018	196,737.9	32.0	325	825	0.08	53.8	75.0	3.6	2.2	144.9
2017	190,061.3	31.7	304	173	0.09	47.3	64.3	1.1	1.42	135.6
2016	98,386.3	26.1	273.4	163.7	0.03	40.7	69.5	2.9	3.1	167.9

Waste Water Discharge				Waste Output (tonnes)		Panel Output (million pieces)		
Waste Water (megaliters)	COD <sup>12</sup> (tonnes)	Biochemical Oxygen Demand (BOD) (tonnes) <sup>13</sup>	Total Suspended Solids (TSS) (tonnes) <sup>14</sup>	Hazardous Waste	Non-hazardous Waste	Large size <sup>3</sup>	Small/medium size <sup>4</sup>	
2018	25,995.1	874.8	121.7	179.4	30,623.4	79,349.5	114.8	166.6
2017	24,176.3	977.5	108	335.5	34,903.2	75,242.6	111.8	168.9
2016	20,072.2	853.4	165.6	283.7	32,586.1	74,088.5	110.5	154



2. Only the developer from the Array process was previously counted. A re-inventory was conducted and developer consumption from the CF process is now included.

3. Energy coefficients (including total energy use, purchased electricity, natural gas, LPG, diesel and so forth) are taken from the statistics provided by the Bureau of Energy for reference purposes.

4. The energy conversion coefficient for diesel varies for each country. The coefficient given by the MOEA Bureau of Energy in Taiwan is cited in this report.

5. Wind turbines were installed by AUO on the exhaust ducts at the Taichung (3) site. Most of them gradually failed due to deterioration over the years and typhoon damage. An assessment determined that the wind turbines were uneconomic to repair and return to service, so all were shut down in 2017.

6. The Kunshan site uses reclaimed water from the Kunshan Photoelectric Industrial Park (Jiangsu)

7. Production water recycling rate = production water recycling volume / volume of purified water used.

8. Including Sungen I, Sungen II, Sungen III, Sungen IV and AUO sites (Hsinchu, Tainan, Kaohsiung,

Huaya, Longtan and Longke).

9. Annual emissions volume was monitored and calculated in accordance with the local laws. (Applicable only to Taiwan)

10. Annual emissions volume was calculated in accordance with the local laws for the respective sites. (Applicable to Taiwan and Singapore sites only)

11. Annual emissions volume was monitored and calculated in accordance with the local laws. (Applicable to Taiwan and Singapore sites only)

12. As company waste water discharge may have an environmental impact on natural water bodies, waste water is discharged in one of two ways: proprietary and collective (applicable to sites in Taiwan, China and Singapore) Proprietary discharge (water is self-treated until it conforms to standards); Wastewater is regularly tested for quality and measured for volume; Collective discharge (water is channeled and treated at the industrial park's water treatment plant); Wastewater is regularly tested for quality and measured for volume by the industrial park.

13. Large-size panels refer to 10-inch and above.

14. Small and medium-size panels refer to any size below 10 inches.

## Environmental Accounting

The environmental accounting system was introduced by AUO in 2009. The global roll-out of the system was completed in 2012. Environmental expenditure amounted to NT\$3.09 billion in 2018, including NT\$2.84 billion in current expenditure and NT\$250 million in capital expenditure. Today, the environmental accounting has become an integral reference point in AUO's environmental management system.

Unit: NT\$ 1,000		2016		2017		2018	
Expenditure Categories		Current Expenditure <sup>15</sup>	Capital Expenditure <sup>16</sup>	Current Expenditure	Capital Expenditure	Current Expenditure	Capital Expenditure
Operating Costs	Pollution Control Costs	615,939	524,393	703,116	1,072,288	870,692	205,930
	Global Environmental Protection Costs	574,061	6,494	407,672	17,430	457,944	2,310
	Resource sustainability usage costs	657,105	2,678	757,892	27,634	880,451	45,589
Upstream and Downstream Related Costs		186,090	0	227,844	0	232,743	0
Management Costs		53,294	0	52,739	95	65,665	0
R&D Costs		23,667	0	15,056	0	17,052	0
Social Activity Costs		6,593	0	2,934	0	4,886	0
Loss and Remedy Costs		416	0	87	0	3	0
Other Environmental Protection Costs		289,025	0	350,681	43,890	309,005	0
Sub-total		2,406,190	533,565	2,518,021	1,161,337	2,838,441	253,829
Total Costs		2,939,755		3,679,358		3,092,270	

## 4.1 Climate Change

Climate change is a global issue. Meeting the goal of keeping the global temperature from rising by more than 2° C represents challenges and opportunities for businesses in terms of expanding production and market opportunities. Businesses must prepare for these challenges in advance. The Climate Change Reporting Framework of CDSB<sup>17</sup> along with the TCFD<sup>18</sup> recommendations and guidelines on climate-related financial disclosures were adopted by AUO as the basis for our overall reporting and management efforts.

15. Current expenditure: Refers to the expenditure that produces effect only within the current period. Also known as revenue expenditure, it generally includes personnel, utilities, materials, maintenance and testing expenses.

16. Capital expenditure: Refers to expenditure that produces an effect beyond one accounting period and can be capitalized into assets; it generally includes sites, equipment and construction projects.

17. CDSB, Climate Disclosure Standards

18. TCFD, Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures

## 4.1.1 Management Strategy

### Policies

To realize the UN SDGs, AUO works actively through the CSR Committee to mitigate and adapt to the challenges posed by climate change to sustainable development. A climate change management strategy has been formulated by AUO to serve as the basis for the assessment of risks and opportunities, GHG reduction and carbon asset management.

**Transparency :** Actively participate in international carbon disclosure initiatives while aiming to improve the accuracy and transparency of information in compliance with the international standards.

**Action :** Commit to the development of green products, carry out energy management and promote the recovery and effective utilization of water resources.

**Responsibility :** Participate in policy development, and support government and international initiatives to mitigate climate change.

**Cooperation :** Identify risks and opportunities in the value chain and supply chain; cooperate with stakeholders on the development of a low-carbon economy.

### Risk and Opportunity

The political and economic influence of climate change issues, both global and regional, form part of the risk identification process conducted by the Risk Governance Sub-committee of the AUO CSR Committee every year. Having considered international agreements, legislation and regulations on climate change, the actual impact of climate systems and other effects in the social aspect, the CSR Committee adopted the 58 risk and opportunity items defined by TCFD in accordance with CDP to quantify their probability and level of impact. Seven (7) main risks were identified for 2018, including international agreements, caps and emission trade schemes, renewable energy, extreme climates, change in precipitation patterns, change in consumer behavior and market reputation while 6 opportunities of water resource usage, participation in carbon market, low-carbon products and services, seek new sources of funding, participation in renewable energy and search for new opportunities have been selected as key issues for 2018. The risks and opportunities in the following three aspects require careful handling by AUO in particular:

1. Increase in risk of disruption to upstream or downstream value chains due to extreme weather events from long-term changes in the climate system

2. Impact on the operating costs from energy stability and electricity fee fluctuations during the energy transition period
3. Pressure for transformation in manufacturing from the mandatory emission controls, financial markets and carbon reduction targets



## Diagram of AUO climate change risks, opportunities and financial impact



## Analysis of Material Issues in Climate Change

Risk Aspect					
Risk Type	Aspect	Item	Stakeholder	Challenges and Opportunities	Management Approach
Transformation Risk	Policies and Laws	International Agreement	AUO	National carbon reduction commitments and policies will not only boost low-carbon production and the development of green products but also increase the responsibility and risk of carbon reduction	<ul style="list-style-type: none"> <li>● Continue to engage in carbon reduction management through the Carbon 2020 goals</li> <li>● Set commitments based on life-cycles</li> <li>● Fulfill the annual target to reduce electricity consumption by 1.5% through the continued operations of the ISO 50001 system and investment in energy-saving solutions</li> </ul>
Transformation Risk	Policies and Laws	Emissions Control and Trading	AUO	Implementation is planned by Taiwan EPA. Most AUO manufacturing sites will soon face emission controls that increase the operating costs.	<ul style="list-style-type: none"> <li>● Participation in industry organizations/associations and government policy development processes</li> <li>● Establish internal carbon pricing, engage in carbon credit management through energy-saving projects and reductions</li> <li>● Greenhouse Gas Inventory Management</li> <li>● Apply with the EPA for carbon credits</li> </ul>
Transformation Risk	Technology	Renewable Energy	AUO Customer	Increase in international demand for renewable energy, policies and the requirements of the green supply chain now require the installation or use of renewable energy	<ul style="list-style-type: none"> <li>● Investment in solar business unit</li> <li>● Installation of rooftop solar farms at 8 sites throughout Taiwan (goal was accomplished in 2017)</li> <li>● Prepare for trading in renewable energy certificates</li> </ul>
Physical Risk	Acute	Change in Rainfall	AUO	Changes in rainfall would cause a prolonged period of water shortage and present challenges to production water supply	<ul style="list-style-type: none"> <li>● Continue to engage in water resource management through the Water 2020 goals</li> <li>● Publicly announce the adoption of green building concepts in new factory buildings</li> <li>● Development of 100% process water reclamation technology</li> </ul>

Risk Aspect					
Risk Type	Aspect	Item	Stakeholder	Challenges and Opportunities	Management Approach
Physical Risk	Chronic	Extreme Weather	Supply Chain	Develop the ability of the supply chain to adapt to or mitigate heightened probability and severity of disasters such as storms, floods and droughts	<ul style="list-style-type: none"> <li>Develop risk identification and BCP management throughout the supply chain</li> <li>Conduct annual supplier risk identification</li> <li>Develop a supplier risk map</li> </ul>
Transformation Risk	Market	Consumer Behavior	AUO	Implementation is planned by Taiwan EPA. Most AUO manufacturing sites will soon face emission controls that increase the operating costs.	<ul style="list-style-type: none"> <li>Continue R&amp;D into low-energy panels</li> <li>Development of high-efficiency solar panels</li> <li>Establish product environment footprint management.</li> </ul>
Transformation Risk	Reputation	Business Reputation	Investor	Rise of ESG investment where investors select their investment products based on non-financial performance indicators	<ul style="list-style-type: none"> <li>Establish a corporate CSR committee to manage CSR performance</li> <li>Take part in international assessments such as DJSI, CDP, MSCI and FTSE to review and improve internal management behavior</li> <li>Share experiences with other industry groups</li> </ul>

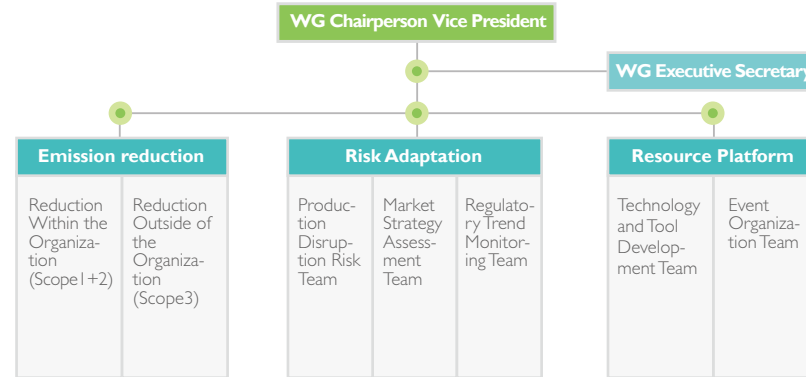
Opportunity					
Opportunity Aspect	Item	Stakeholder	Challenges and Opportunities	Management Approach	
Resource Efficiency	Water Resource Usage	AUO Customer NGO	Reduce dependence on water resources through manufacturing transformation to realize the vision for sustainability	<ul style="list-style-type: none"> <li>Zero process water discharge technology to achieve 100% reclamation</li> <li>Established a water resource museum to promote environmental education</li> <li>Set up U-FRESH Technology as a new business unit specializing in circular economy products and services for water resources</li> <li>Participate in the government's policy-making process on water resource recycling issues</li> </ul>	
Market	Carbon Trading	AUO Customer	The government is responding to the impacts of climate change by offering various initiatives for the adoption of alternative energy sources that reduce the demand for traditional energy supplies and carbon emissions	<ul style="list-style-type: none"> <li>Participate in green energy policy and initiatives to increase development opportunities for the solar business</li> <li>Evaluate renewable energy investments in emerging countries</li> </ul>	
Market	Find New Business Opportunities	AUO Value Chain	Create new business opportunities by responding to reduction targets and energy policies in each country	<ul style="list-style-type: none"> <li>Develop new business models through multi-lateral cooperation</li> </ul>	
Products/ Services	Low-carbon Products and Services	AUO Customer	Track market trends to ensure continuity of supply then satisfy customer requirements to improve satisfaction with sustainable products and services	<ul style="list-style-type: none"> <li>Establish supply contract mechanism</li> <li>Strengthen product or service differentiation</li> <li>Strengthen value chain partnerships</li> </ul>	
Resilience	Expand Sources of Funding	AUO Banks Shareholders	Investors invest in ESG or solar-related businesses in accordance with green finance and Equator Principles	<ul style="list-style-type: none"> <li>Set up a CSR committee and work actively to enhance ESG-related activities</li> <li>Improve transparency of disclosure on climate change and carbon management to boost the willingness of investors to make loans and promote green investment</li> </ul>	
Energy Source	Renewable Energy	AUO	Investment in the solar business and promote market for green power	<ul style="list-style-type: none"> <li>Provide an integration ability for the construction of turn-key solar power plants</li> </ul>	

## Carbon-Energy Working Group

The aforementioned risks highlight the diversity and complexity of climate issues. Investments in mitigation and adaptation management will not produce results right away either. Medium and long-term sustainability-oriented targets must be set to progressively review and improve operational resilience. A mission-oriented “Carbon-Energy Working Group” was therefore set up by the AUO CSR Committee in 2019 with the following missions:

- Monitor trends and integrate resources across different platforms for mitigating the effects of GHG through smart technology and science. External influence is to be expanded as well in order to develop low-carbon business opportunities.
- Enhance the ability of the organization to adapt and strengthen its operational resilience in order to reduce the impact of climate change risks.

- Establish the necessary mechanisms and supporting measures to fulfill the CSR EPS vision of AUO.



Please refer to Section I.1 SDGs and EPS 2025 Goals

## Link between Carbon Energy Mission and SDGs

AUO is practicing emission mitigation and climate adaptation to manage the risks associated with climate change. The mission of the Carbon-Energy Working Group corresponds to the SDGs and seeks to fulfill the 2025 targets.

**7 AFFORDABLE AND CLEAN ENERGY**  
**Affordable and Clean Energy**

- Set reduction targets based on life-cycle and reduce carbon emissions by up to 6.5 million CO2e cumulatively

**13 CLIMATE ACTION**  
**Affordable and Clean Energy**

- Increase the resilience of climate adaptation and continue to reduce the risk of financial impact from Climate Change issues

**17 PARTNERSHIPS FOR THE GOALS**  
**Partnerships for the Goals**

- Establish a platform for the sharing of internal and external resources to boost the incentives for technology and innovation

- Respond to the global consensus on climate change through reduction targets based on life cycles. In addition to organizational carbon reduction targets, embrace carbon emission management that encompasses the Scope 3 value chain including supplier reduction, design of low-energy products, materials reduction and other elements.

- Conduct an inventory of risks and opportunities associated with climate change using the TCFD framework including supply chain disruption management due to physical risks, market strategies for transformation risks and monitoring of regulatory trends. Identify and respond to potential financial losses in advance through a systematic identification process.

- Build consensus on climate change action among all employees by establishing performance rewards, professional training and system platforms for energy-saving and carbon reduction. Engage with external stakeholders to create more opportunities.

## CDP Disclosure

AUO has been voluntarily responding to the CDP investor survey since 2007. AUO also takes part in the "Supply Chain Program" survey at the request of our customers and it provides an important strategic tool for information on how businesses are responding to climate change. AUO has declared its support for the "CDP Commit to Action" initiative by committing to provide honest and responsible reports on climate change information<sup>19</sup> while also responding to international expectations on transparency of carbon emissions data. The types of information disclosed include: AUO strategies for adapting to climate change, analyses on possible risks and opportunities, GHG emissions and third-party verification, GHG reduction goals and performance, and the company's approach to carbon-related issues. AUO has been named a corporate member of the Climate Disclosure Leader Index (CDLI)<sup>20</sup> for three years in a row by distinguishing itself in climate change governance, risk and opportunity management, and verification. The level of disclosure and performance was consolidated by CDP into overall performance in 2018. The B rating from CDP placed AUO in the Management Grade. For more information on climate change management strategy and emission reduction performance, please refer to 4.1 Climate Change.

For the CDP Water disclosure survey, we focused on water reduction, water creation and water neutrality management initiatives of AUO Water 2020. We also shared our zero-process wastewater discharge technology along with the unique technical capabilities of U-Fresh Technology. AUO received a B- rating for water disclosure, which also placed us in the Management Grade of CDP.



For more information on water resource strategy and targets, please refer to 4.2 Water Resource Management.

For the "Supply Chain Program," AUO was ranked alongside 125 benchmark enterprises from around the world in the A grade Leader Board for Supplier Engagement Rating (SER). Recognition was given to efforts on using "water neutrality targets" to drive common water reduction projects for the supply chain in order to reduce the pressure from water consumption, develop partner relations and enhance their operational resilience, as well as using the "2020 Carbon Reduction Targets" to set medium and long-term targets to drive the development of low-carbon production and products.

## TCFD Response to CDP

The TCFD response to CDP in 2018 attempted to quantify the financial risks for key scenarios in climate change and explore risks in the regulatory dimension including

increase in carbon emission costs due to emission controls, increase in verification costs from mandatory GHG emission reporting as well as the financial impact of policy requirements for the installation or use of renewable energy. In addition, scenarios on the operational impact of water resource shortages, rising water utility rates or power consumption from higher temperatures due to long-term climate change as well as reference benchmarks for their quantitative financial analysis have all been incorporated into the CDP survey.

## 4.1.2 GHG Emission Reduction

### Carbon Reduction Goal 2020 Progress

The voluntary carbon reduction plan proposed by AUO in 2005 has been progressively accomplished over time. In 2015, the Carbon 2020 plan to reduce carbon emissions by 1 million tonnes over 5 years was proposed. A product life-cycle approach was to be taken to reduce carbon emissions through materials design and selection, localized purchasing and 4R strategy, energy-saving production, green transport and low-power panels. Cumulative progress reached 79.1% in 2018 with 2% coming from green transport and logistics, 32% coming from green manufacturing and 66% coming from product innovation. AUO supports the Science Based Targets (SBT) for a 2°C<sup>21</sup> scenario and has taken action in this direction.

### Process PFC Reduction

For PFCs emissions produced by the use of gases with high global-warming potential (GWP) such as NF<sub>3</sub>, SF<sub>6</sub> and CF<sub>4</sub>, IPCC<sup>22</sup>-approved abatement devices were voluntarily installed by AUO in all new factories built after 2003. This was later expanded to 100% of all AUO sites after 2010. ISO 14064 verification determined that the reduction in PFCs complied with IEEE P.1680.1 standards<sup>23</sup> making products on each production line eligible for EPEAT<sup>24</sup> certification.

AUO facilities have reduced cumulative emissions by 16.4 million tonnes kgCO<sub>2</sub>e as of 2018. PFCs emissions per unit area produced has been reduced to 2.7 kgCO<sub>2</sub>e /m<sup>2</sup> in 2018, down from 56.8 kgCO<sub>2</sub>e/m<sup>2</sup> in 2005. F-GHG has therefore been reduced by over 95 %.

19. Report climate change information in mainstream reports as a fiduciary duty

20. CDLI, Climate Disclosure Leader Index

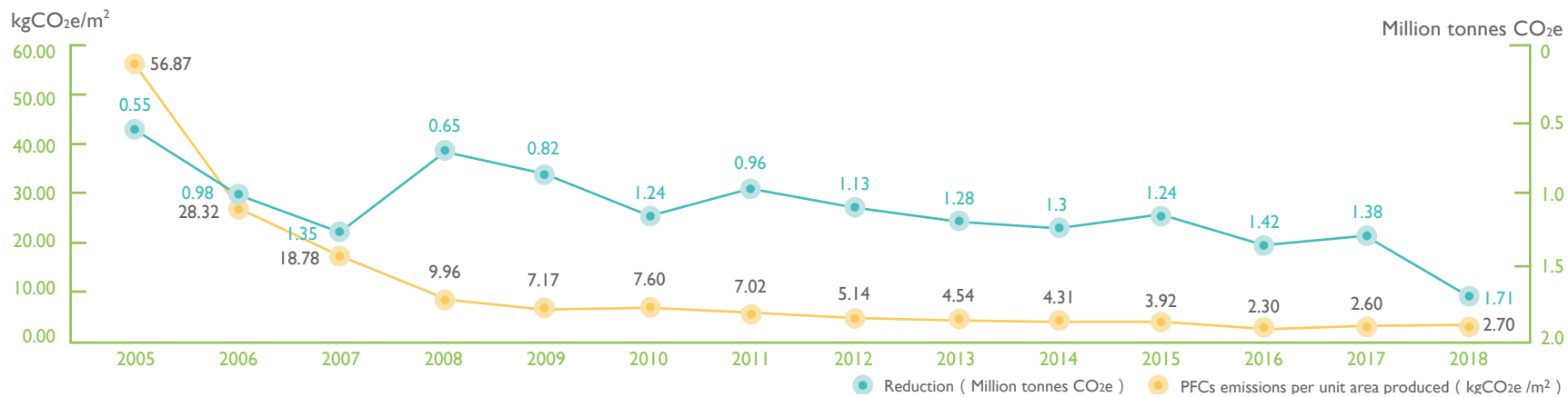
21. Science Based Targets (SBT), use a hypothetical scenario from the IPCC to set carbon reduction targets based on scientific calculations.

22. Intergovernmental Panel on Climate Change (IPCC), is a UN inter-government expert committee on climate change.

23. The Standard for Environmental and Social Responsibility Assessment of Computers and Display Sets PFCs reduction scoring guidelines for panel manufacturing.

24. Electronic Product Environmental Assessment Tool (EPEAT), is a US environmental mark for assessing the environmental performance of electronic products.

### PFCs emissions per unit area produced



## 4.1.3 Value Chain Carbon Footprint

### Greenhouse Gas Inventory

AUO began inventorying GHG emissions from global manufacturing sites and overseas offices in 2003. External verification and disclosure of emission data in accordance with ISO 14064-1 started in 2005. A corporate carbon inventory system and eco-efficiency index system (EELs)<sup>25</sup> were developed and deployed in 2010 to provide tools for managing long-term operational carbon reduction targets.

#### Greenhouse Gas Inventory Milestones

Year	Event
2003	Commenced greenhouse gas inventory
2005	Introduced third-party verification for ISO 14064-1
2006	GHG inventory procedure v1.0 takes effect; all manufacturing sites worldwide obtained ISO 14064-1 statement
2007	Began disclosing carbon management mechanism to CDP
2009	Training and mentoring of the supply chain on GHG inventory through the TTLA platform
2010	Began inventorying Scope 3 data for business air travel; developed the Enterprise Carbon Information Management (ECA) system; hosted the supplier carbon inventory and validation demonstration project.
2011	Expanded the targets for supplier carbon inventory and validation; Scope 3 expanded to include carbon emission inventory for ground public transport; took part in 3rd-party external supplementary validation of the EPA pilot GHG program; began using the ECA system to complete GHG inventory and external verification.

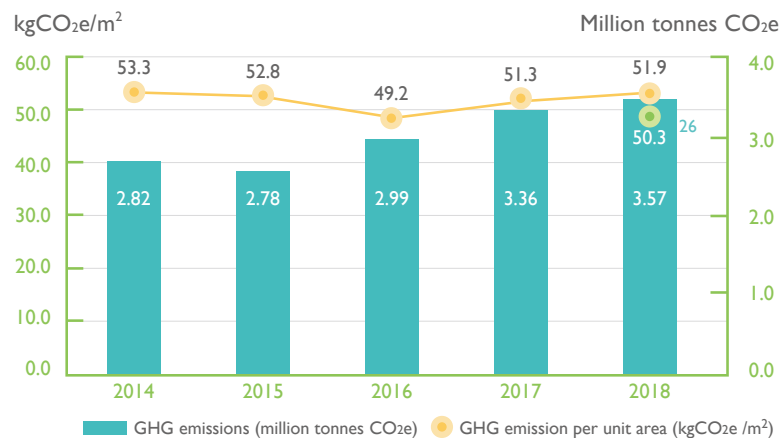
25. EELs, Eco-efficiency Index System

## Greenhouse Gas Inventory Milestones

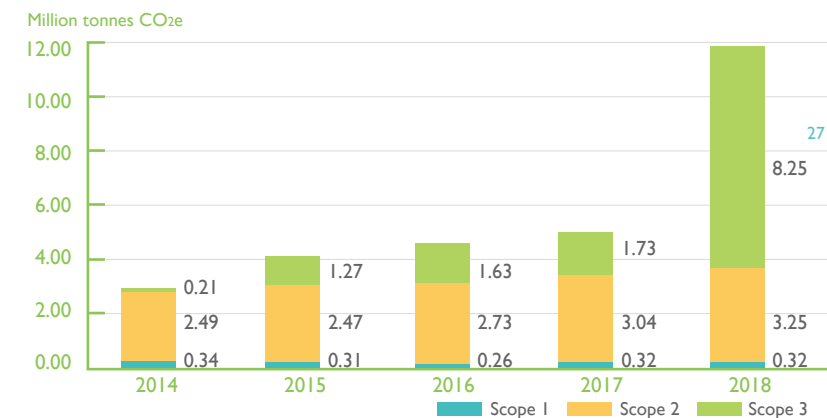
Year	Event
2012	Waste GHG inventory incorporated into Scope 3; applied for EPA GHG pilot and credit program; took part in developing the methodology for the EPA GHG credit system.
2013	Obtained GHG reduction quota under the EPA pilot GHG program; expanded Scope 3 survey to include subsidiaries; reported GHG emissions according to EPA legal requirements
2014	Expanded Scope 3 survey to include employees' commuting activities and uses of fuel that were not part of Scope 1 or Scope 2
2015	Expanded Scope 3 survey to include product usage
2016	Expanded Scope 3 survey to include purchased products and services
2017	Optimized Scope 3 quantification management by adding upstream transport and distribution
2018	Continued to expand Scope 3 by adding downstream product transport and distribution

In 2018, AUO's total global GHG emissions amounted to 3.57 million tonnes kgCO<sub>2</sub>e. The leading contributor was electricity emissions in Scope 2 and these accounted for 91.13% of all company emissions; the rest came from Scope 1 use of PFCs during the production process and fuel emissions of utility systems at 8.87%. To continue meeting international reduction trends, AUO set "GHG emission intensity per unit area produced" as our primary GHG management indicator and reduction progress is tracked through the CSR Committee. In 2018, GHG emission per unit area produced was 51.9 kgCO<sub>2</sub>e /m<sup>2</sup>, a reduction of 69% compared to 2005; this was however slightly higher than the preceding year due to a very significant rise of nearly 5% in the Scope 2 national electricity emission coefficient. Absolute emission volume and intensity in 2018 were therefore increased. In the future, conversion to intelligent manufacturing as well as setting management requirements for 3rd-party measurement and maintenance of PFCs will be used to boost carbon reduction in the production process. A GHG emission per unit area produced of 51.3 kgCO<sub>2</sub>e /m<sup>2</sup> has now been set as the 2019 target.

## GHG emissions



## GHG emissions by scope



26. GHG emission per unit area produced based on the same electricity coefficient (0.529kgCO<sub>2</sub>/m<sup>2</sup>) as 2017.

27. Carbon emission during the product use phase was calculated using the life-cycle method, so emissions increased in 2018

## GHG emissions by site

Million tonnes CO <sub>2</sub> e	2013	2014	2015	2016	2017	2018
Taiwan	2.45	2.48	2.45	2.63	2.72	2.91
Mainland China	0.22	0.21	0.20	0.23	0.52	0.55
Singapore	0.12	0.13	0.12	0.12	0.11	0.10
Europe	0.0078	0.009	0.0104	0.01102	0.01052	0.0058
Overseas offices	0.00013	0.00044	0.00044	0.00043	0.00044	NA <sup>28</sup>

## Scope 3 Survey

AUO commenced Scope 3 surveys and disclosures of greenhouse gases in 2010 based on the GHG protocol. It continues to expand the scope of its survey today.

Scope 3 Standard	Survey Status	Approach
1. Purchased goods and services	A	Voluntary inventory management has been conducted since 2016. Key materials identified include glass substrate, liquid crystal, photoresist, developer, etchant, stripper and thinner. Green manufacturing is also used to reduce carbon emissions and environmental impact. Total emissions for 2018 were approximately 362,028 tonnes CO <sub>2</sub> e in total.
2. Capital goods	C	
3. Fuel and energy related activities (not included in Scope 1 or Scope 2)	A	A transportation company was contracted to provide shuttle buses between Taiwan sites. Disclosure of emission data based on shuttle bus mileage and the carbon footprint database set up by the EPA commenced in 2014. Total emissions for 2018 were estimated to be 608 tonnes kgCO <sub>2</sub> e with diesel being the main type of fuel used.
4. Upstream transportation and distribution	A	In 2008, AUO launched the green logistics plan to reduce carbon emissions from distribution activities through local purchasing, recycling of packaging materials, increasing load-factors and intermodal transport. Inventory scope was increased in 2018 to quantify carbon emissions from the transport of key materials. Total emissions were estimated to be 3,717 tonnes CO <sub>2</sub> e based on weight, mode of transport, distance and other parameters.
5. Waste generated in operations	A	The tracking of GHG emission intensity data for waste disposal and waste contractors commenced in 2011. Carbon emissions were calculated using the actual amount of waste removed and processed each year along with reasonable coefficients based on experience. The types of waste surveyed include sludge, organic solvents, waste glass, waste acid liquids, waste dust, empty barrels and scrap metals. Carbon emissions from waste disposal totaled approximately 12,042 tonnes CO <sub>2</sub> e in 2018 and accounted for more than 83% of all waste in Taiwan.

## Scope 3 Implementation

- A Applicable to AUO and quantified
- B Applicable to AUO; managed but not quantified
- C Applicable to AUO; no plans to quantify
- D Not applicable to AUO

Scope 3 Standard	Survey Status	Approach
6. Business travel	A	Management commenced in 2010 with the aviation carbon emission calculator developed by <sup>29</sup> ICAO used to calculate employees' air miles and carbon footprint. Total emissions were approximately 756 tonnes CO <sub>2</sub> e in 2018.
7. Employee commuting	A	The tracking of carbon emissions generated by employees at Taiwan sites when commuting to and from work started in 2014. Average employee commute distance and the carbon emissions they generated were calculated using the latest statistics issued by the MOTC. Carbon emissions totaled approximately 20,207 tonnes CO <sub>2</sub> e in 2018; this included cars and motorcycles.
8. Upstream leased assets	D	
9. Investments	A	AUO began disclosing the carbon emissions of key subsidiaries in 2015. Total emissions in 2018 were estimated to be 143,411.1 tonnes CO <sub>2</sub> e. <a href="#">Please refer to section 3.4 Subsidiary Overview in this report.</a>
10. Downstream transportation and distribution	A	Carbon inventory for downstream product transportation and distribution was included for the first time in 2018. Just like upstream transportation and distribution, calculations are based on product weight per trip, mode of transport, distance and other parameters. Scope of calculation includes product carbon emissions when transported by road from the factory to the port or airport as well as the carbon emissions for transport by sea or air to the destination port or airport. Total emissions were estimated to be 69,525 tonnes CO <sub>2</sub> e.
11. Processing of sold products	C	

28. Overseas offices were in leased premises in 2018, so they were classified under Scope 3 for the inventory

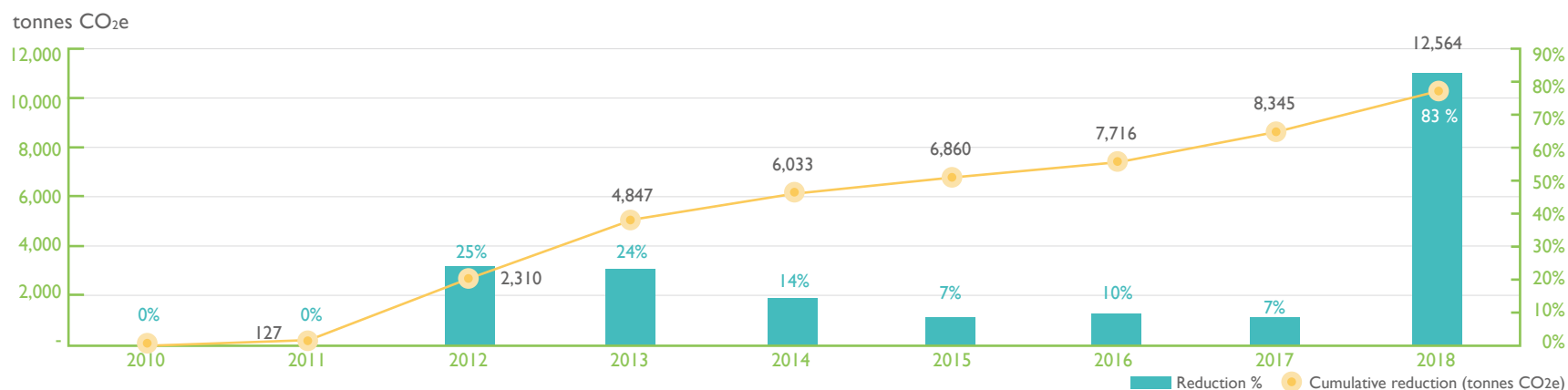
29. International Civil Aviation Organization (ICAO)

Scope 3 Standard	Survey Status	Approach
12.Use of sold products	A	AUO began calculating the carbon emission of panels during the user phase.This included key products such as televisions, mobile phones and notebook monitors.The calculations were based on the power-rating of each product and usage scenarios while in service.Total emissions were estimated to be 7,641,475 tonnes CO <sub>2</sub> e in 2018.
13.End-of-life treatment of sold products	B	Introduced green product designs to provide customers with recyclable solutions
14.Downstream leased assets	B	Leased premises of subsidiaries
15.Franchises	C	

## Low-carbon Transportation

AUO is committed to sustainable logistics<sup>30</sup> and implemented intermodal transport routes in 2018 to reduce carbon emissions by 4,219 tonnes CO<sub>2</sub>e, an improvement of 83%. Low-carbon transport reduced emissions by 12,564 tonnes CO<sub>2</sub>e in total between 2011 and 2018.AUO will continue to develop new modes of low-carbon transport in 2019 in order to realize the targets for sustainable logistics and carbon reduction.

### Carbon Reductions from Intermodal Transport



## Recycling of AUO Product Packaging

The recycling of customer product packaging is promoted by AUO.The recycling of product packaging reduces the amount of packaging that needs to be re-purchased and lowers incoming material costs. Recycling rate of packaging materials at all TV display sites averaged 40%<sup>31</sup> in 2018. Around 2,970,000 sets of packaging materials were recycled which reduced the carbon footprint of production activities by around 2,869 tonnes CO<sub>2</sub>e. Except where the nature of the materials led to damage, staining, scratching, denting or warping of dimensions during the transportation or customer production process, all packaging materials were recovered, cleaned and re-used.

## Recycling of Supplier Packaging Materials

AUO has been working with suppliers on the recycling of packaging materials for many years. In addition to being more environmentally friendly, the savings from incoming materials can also be passed on to the company, customers and even end-users. The target recycling rate for packaging materials at all panel manufacturing sites continued to be set at 91.5% in 2018. Actual recycling rate was 93.04%<sup>32</sup> so the target was met. The reduction in repeat purchasing of packaging materials reduced the carbon footprint by 40,441 kgCO<sub>2</sub>e.

30. Transported by Hai Xia Hao and Cosco Star to Pingtan or Dama Islet before continuing on to Suzhou by land to reduce the amount of air freight. Containers from the Suzhou are shipped to Shanghai Port by rail branch line and barges instead of semi-trailers. Xiamen uses trucks instead of air freight to ship to Hong Kong using integrated customs.

CO<sub>2</sub>e emission formula:[Total CO<sub>2</sub> emissions before introduction (g) - Total CO<sub>2</sub> emissions after introduction (g) / Total CO<sub>2</sub> emissions before introduction (g)]

31. Recycling rate for packaging materials: Total amount recovered from TV customers in China that support recycling/ Total shipments from TV customers that support recycling.

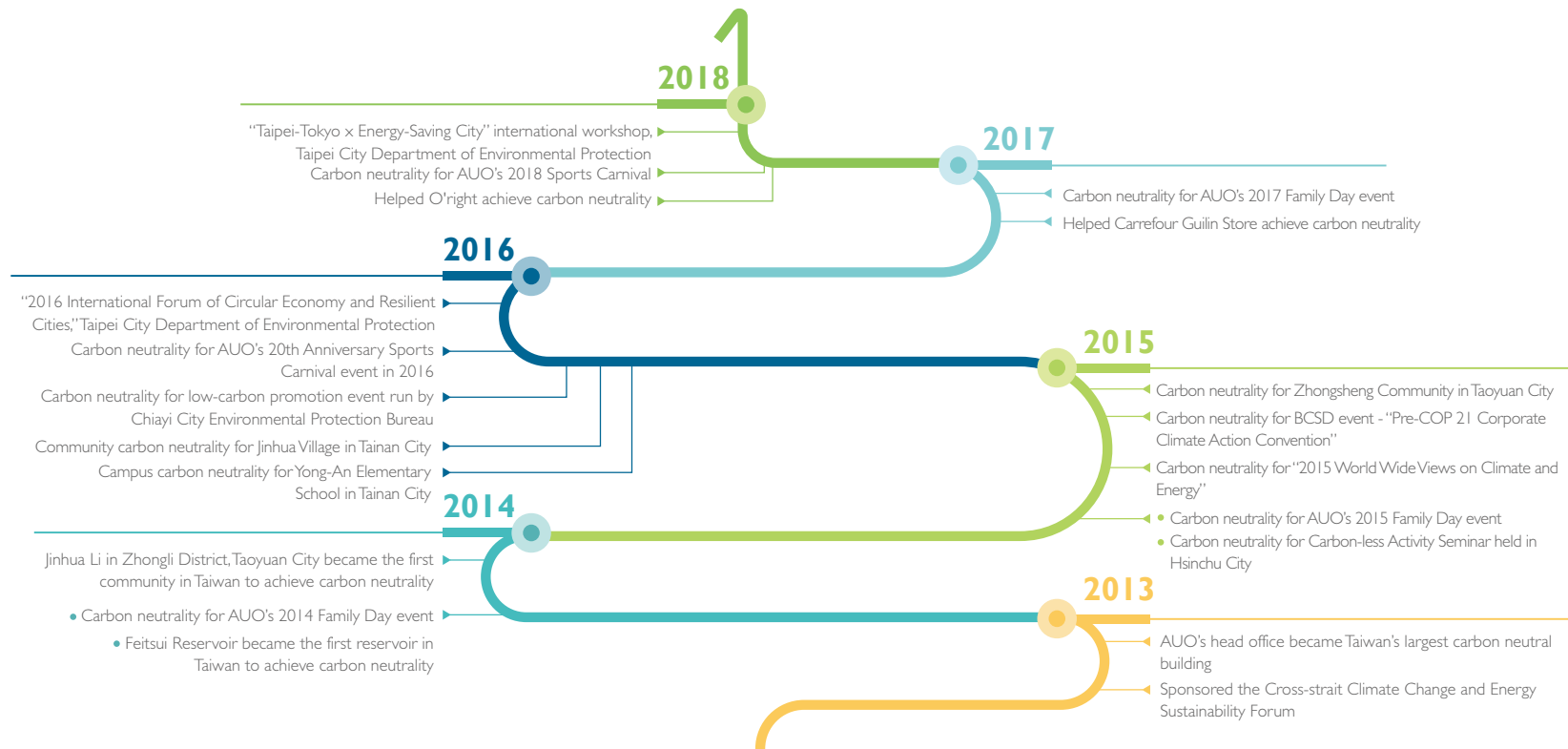
32. This was calculated using the amount of packaging material recycled each month / amount of packaging materials shipped each month by each site. Carbon footprint was calculated using the reduction in weight of packaging materials each month \* carbon footprint factor for each type of packaging material.

## Carbon Asset Management

Voluntary reduction is encouraged by AUO. Carbon credit assets were used to promote carbon neutrality and reduction, so the goal of carbon neutrality could be achieved through GHG reductions of external organizations. The approach has been expanded to the government, organizations, suppliers, community, local neighborhoods and other stakeholders as of 2013 to help build a low-carbon society.

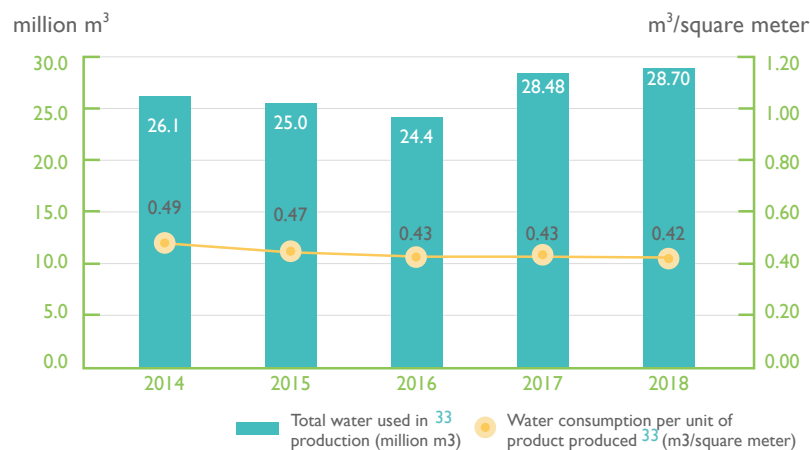
The carbon neutrality strategies disclosed by AUO in previous years focused mainly on promoting carbon neutrality for company buildings and activities as well as GHG reduction by office buildings and dormitories. Low-carbon elements were introduced for the hosting of the employees' sports carnival in 2018. For external carbon neutrality applications, AUO made 100,000 tonnes available for outside inquiries.

As of 2018, a total of 6 company building and activity carbon neutrality projects have been completed along with 15 carbon neutrality applications from external non-profit organizations. These included a request for carbon credit swap from O'right, and activities like the "Taipei-Tokyo x Energy-Saving City" international workshop hosted by the Taipei City Department of Environmental Protection. The workshop used low-carbon marketing and registration while also encouraging the use of public transport to reduce carbon emissions. The event has been registered with the EPA carbon neutrality platform and was canceled out on the national GHG registration platform.



## 4.2 Water Resource Management

The development, distribution and management of water resources have become a key issue for economies and societies across the world due to extreme climates. AUO is responding actively to the risks posed by future challenges through green technology and enhanced management. In keeping with the spirit of SDG 6, AUO has developed short-, medium- and long-term targets for water saving and water creation, and is continuing to review its water-saving performance. A number of improvements were implemented in 2018 and water per unit area produced was better than that of the preceding year. A management target of 0.40 tonnes/m<sup>2</sup> has been set for 2019.



### AUO Water 2020 and Progress in 2018

With regards to water resource development, AUO aims to achieve three specific goals: “water reduction, water creation and water neutrality” by 2020. “Water Reduction” will involve an active effort on AUO’s part to reduce its water usage by 30% through improved production processes and equipment efficiency; “Water Creation” will involve the use of 10,000 tonnes of reclaimed water on a daily basis at the Taichung site as a gesture of support to the government’s water resource policies while creating its own water supply; “Water Neutrality” involves taking one step beyond the zero discharge process of water that the Longtan site achieved by working with the rest of the supply chain to facilitate water conservation, so that AUO could become the first water neutral company in Taiwan.



**Water reduction target :** Reduce water intensity by 30%

<sup>34</sup>  
In 2018, the Houli site modified its bio-system and installed additional MBR/RO systems to recover highly concentrated organic wastewater. Taichung (1) site introduced a new type of highly-permeable UF film, while Taichung (3) site's inorganic wastewater recovery (IWWR) system switched from centrifugal pumps to pneumatic diaphragm pumps resulting in around 1,040,000 tonnes in savings from reclaimed water. Progress in the 3rd year has reached 58%. AUO will continue to engage in engineering improvements and actively cooperate with the government on the introduction of a reclaimed water supply in order to make further progress in terms of the water reduction indicators.



**Water creation target :** Introduce 10,000 CMD of reclaimed water at production sites.

Reclaimed water projects are now underway at key science parks around Taiwan. Current progress on government contracts means that reclaimed water from domestic sewage treatment plans will not be available until 2021. However, the requirements set by the environmental impact assessment for the AUO Kunshan site mean that reclaimed water from the development zone's wastewater treatment system has already been introduced and is operating reliably. In 2018, Kunshan used on average 6,773 CMD of reclaimed water every day, making this the main source of water for all production processes throughout the factory. Though improvements are continuing to be made to the purified water production rate, reclaimed water has effectively reduced the operational impact of water resource shortages.



**Water neutrality target :** Develop relations with supply chain partners Starting in 2016, AUO has been inviting its supply chain partners to join in promoting effective water conservation and management to counter the risks from water resource shortages due to climate change as well as the increased frequency of floods and droughts in Taiwan in order to reduce the uncertainty caused by water shortages on future operations. Water savings of 5,000 CMD were to be achieved through the value chain before 2020. In 2018, we collaborated with our key tier-I suppliers to save 3,611 CMD of tap water and surpassed our original annual target of 3,000 CMD. In the future, the Water Resource 2020 targets of AUO SDGs will be implemented by using our influence on the value chain and working with our partners to create environmental benefits.

<sup>33</sup>. The calculation of water consumed per square meter of panel manufactured is based on the total area of products manufactured in 2018 as the denominator.

<sup>34</sup>. 2020 targets are only applicable to water used for production at Taiwan sites

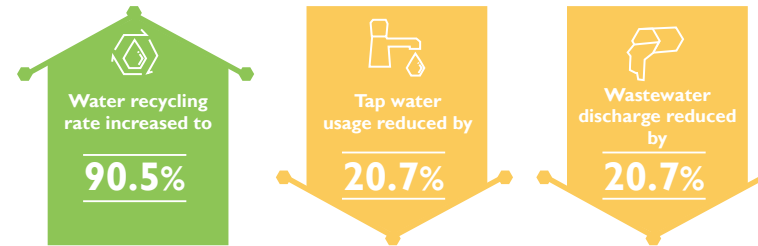
## Examples of Water Saving Technology

In terms of improvements to water recycling, Tainan site increased its water recycling rate from 85.5% in 2017 to 90.5% in 2018. The main action taken was testing the water quality of the recycling tank, so that cleaner reclaimed water could be directed to the industrial tank for re-use. This helped to mitigate the problem of insufficient tank capacity as well. The operating time of the resin column was also extended to reduce the frequency of resin column regeneration and the amount of water used for regeneration. The move successfully reduced the amount of wastewater discharge and tap water usage.

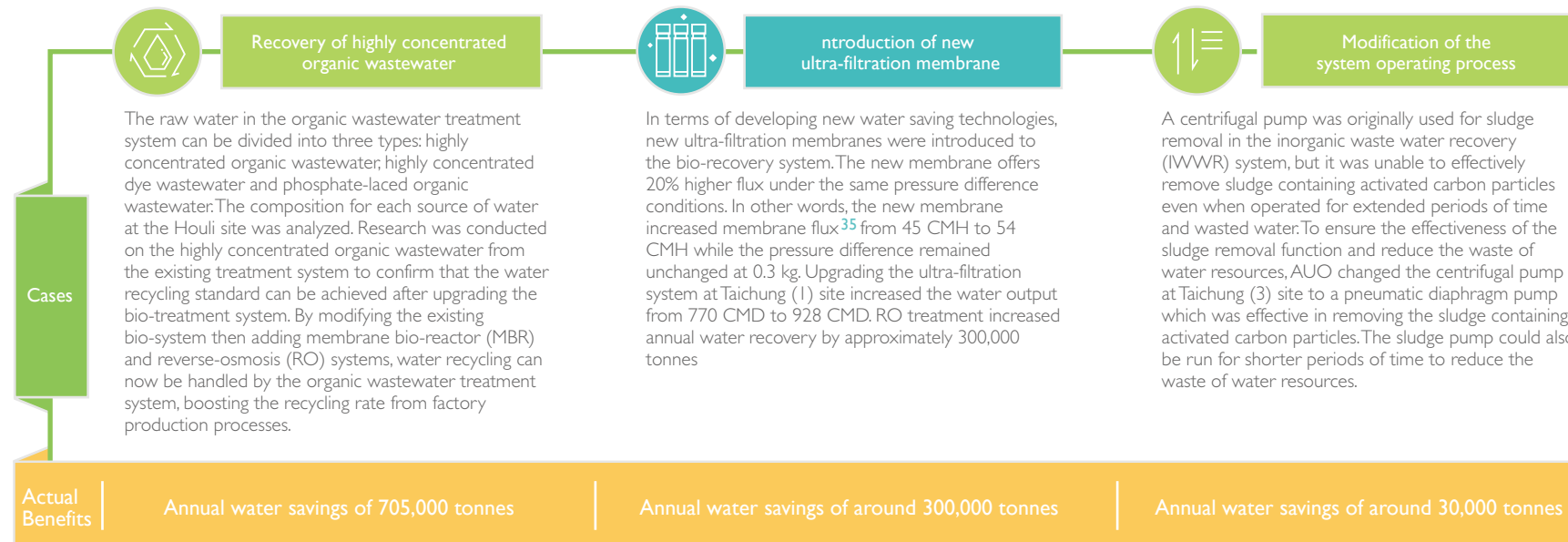
### Improvement techniques

- Recovery of run-off from cleaner machine
- Backwash from purified water filtered through activated carbon/sand is reclaimed directly through the industrial tank instead of being discharged into the recovery system
- Low-concentration reclaimed water is discharged into the middle section of the recovery system
- Eliminate small amounts of chromium-laced water and reclaimed water with large variations in conductivity

- Run-off from regeneration of resin column is drained into the industrial tank for re-use instead
- Resin columns reduced from 3 sets to 2 and operating time was extended



In terms of improvements to water saving technology, the organic wastewater treatment system was analyzed to examine its sources and analyze their water composition. An assessment was undertaken to see if the water recycling standard can be met under the existing system structure in order to increase the overall amount of water recycled throughout the site and reduce the dependence on tap water.

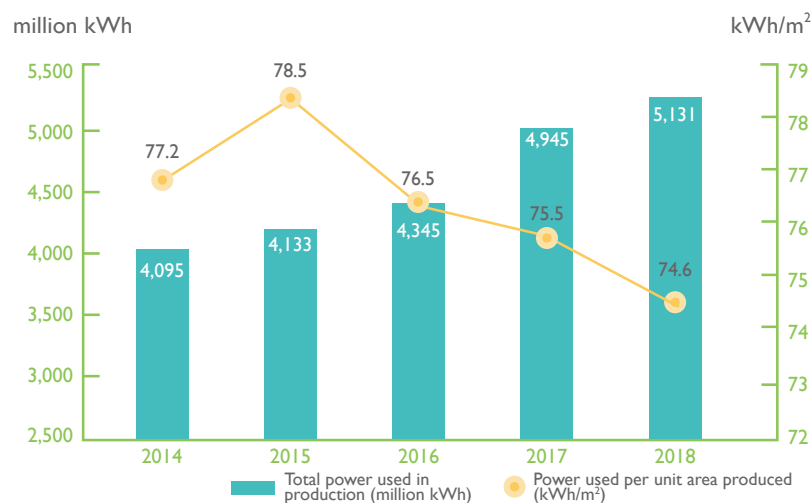


35. Membrane flux is the key parameter for membrane separation units. It is defined as the flow divided by the membrane area over a unit of time.

## 4.3 Green Production

### 4.3.1 Energy Efficient Production

In 2018, AUO production processes worldwide used around 5.13 billion kWh of electricity. This was higher than 2017 due to an increase in production capacity. To make continued improvements, the cross-unit Carbon-Energy Working Group was set up by AUO to look for energy-saving measures. An incentive scheme was introduced to encourage employees to make suggestions on how to save energy.

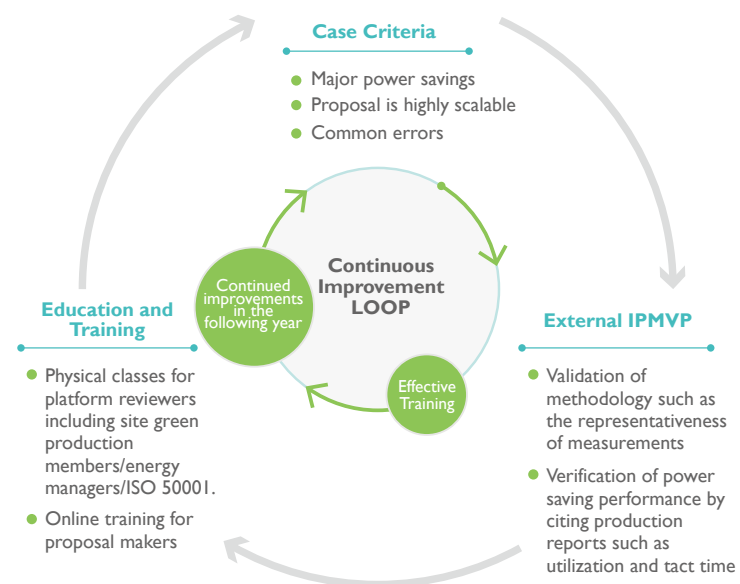


AUO introduced the ISO 50001 energy management system in 2011, and external verification for the Taiwan and Singapore sites were completed in 2018. The Suzhou site in China passed the equivalent GB/T 2331-2009 national standard. In addition to the ISO 50001 energy standards, AUO also used external audits to examine the effectiveness of improvement proposals using the International Performance Measurement and Verification Protocol (IPMVP).<sup>36</sup>

36. International Performance Measurement and Verification Protocol, IPMVP

### Introduction of External Projects

To verify the performance of improvement proposals under the ISO 50001 management system, respond to the Bureau of Energy's requirements for proposal reviews and give employees a better understanding of the proposals, in 2018 AUO adopt external Energy Service Companies (ESCO) to apply the IPMVP along with third-party verification for a 3-year period to improve the materiality of the internal energy-saving proposals. This program is divided into three parts. The first step was to screen the best proposals during the year with an emphasis on major power-saving projects that are highly scalable and most prone to mistakes. The next step is the verification of actual performance. This included validation of the power-saving methodology in phase 1 and verification of performance data in phase 2. Finally, errors identified during the validation of methodology are used to conduct seminars for Energy Management System (EnMS) reviewers such as green production members, energy managers and ISO 50001 contact windows. This also includes online training courses for all contact windows authorized to make EnMS proposals. The implementation of this accountability system will hopefully make reviewers more accountable when it comes to validation and verification.



In 2018, 30 cases underwent external audits. In addition to large systems where intelligent manufacturing has already been introduced, more than half of all energy-efficiency improvement proposals for production processes were verified to have achieved power savings of up to 25.06 million kWh, or 26% of all power savings. Education and training, group discussion of case studies and online training courses were also used to help proposal makers and reviewers understand the crux of the proposals. Nearly 700 people were trained through online training and testing was used as the condition for activating EnMS system privileges. The introduction of the IPMVP program not only significantly increased the quality of improvement proposals at AUO sites but also fostered a more supportive environment for employees making proposals.

#### Topical workshop

- Help reviewers use IPMVP to master the representativeness of measurements
- And cite production data to calculate power savings

#### Group discussion of case studies

- Measurement techniques and their representativeness
- Consistency of comparison conditions before and after improvement
- Cite and trace production report data

#### Online training course

- Help all proposal makers master the crux of the proposals

### Validity of Performance Data on EnMS Platform

Mandatory energy savings of more than 1% are now required by law. Energy saving performance and actions must also be registered with the competent authority's reporting platform. AUO however set its internal target as 1.5% due to energy conservation, carbon reduction and transformation to intelligent manufacturing. Hundreds of energy-saving proposals are registered and managed with the EnMS platform every year. The reams of data are organized through the database for proposal review, compilation of statistical data, and generation of reports and graphs. In 2018, there were nearly 700 proposals for green manufacturing and energy-saving solutions; the total power saved for the year came to 96.45 million kWh with an annual energy conservation rate of 1.94%. 54% of the savings came from improvements to management processes; 46% came from budgeted improvements. In terms of measurement and verification, up to 53% were measured power savings with just 47% being estimate.

### Improving the Quality of Internal Proposals through Incentivized Competitions

AUO has continued to invest large amounts of resources into energy conservation, water conservation, environmental indicators and materials reduction since 2008 to boost environmental awareness and support among employees. Proposal competitions are used to recognize the efforts made by each site and encourage employees to keep coming up with new ideas through tangible rewards. Voting by all employees provide outstanding proposals with more exposure as well.





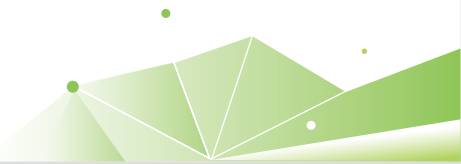


IPMVP training course



Award Presentation for Green Manufacturing and Energy Conservation Proposal Competition

## Case Highlight

Method	 Introduction of High-performance Equipment	 Optimized Formula	 Introduction of New Technology
Case	<ul style="list-style-type: none"> <li>● <b>High-efficiency water pump</b></li> </ul> <p>High-efficiency vertical centrifugal pump was introduced at the Taichung (2) site for the high-pressure purified water RO system to improve energy efficiency. The less efficient canned pump was replaced by a high-efficiency vertical centrifugal pump that delivers the same flow and output while using less energy.</p> 	<ul style="list-style-type: none"> <li>● <b>Optimization of air compressor</b></li> </ul> <p>Increased production at the Longtan site led to an increase in demand for compressed air as well, but running the four existing high-power air compressors wasted energy due to over-production. Compressor configuration was therefore optimized to be 3 high-power and 1 medium-power high-efficiency air compressors. Matching the equipment to actual demand helped to avoid waste.</p>	<ul style="list-style-type: none"> <li>● <b>AI energy efficiency management</b></li> </ul> <p>In 2018, the Longke plant introduced energy-efficiency optimization for "air compressors" that consumed a great amount of power. The collection and analysis of big data together with AI learning and prediction were used to realize real-time energy-efficiency management by adjusting the air compressor load based on demand.</p> 
	Actual Benefits	Annual power savings of 5.65 million kWh for an energy conservation rate of 52%	Annual power savings of 4.289 million kWh for an energy conservation rate of 9.8%

## 4.3.2 Wastewater Management

AUO sets strict, internal requirements that exceed those required by law and has continued to invest in improvements to protect the environment. With regards to the treatment of hazardous substances, the company conducts random inspections and has automatic monitoring to ensure that wastewater standards are met. With regards to the disclosure of certain substances, an on-site risk assessment mechanism has been set up for source chemicals and raw materials. In addition to active efforts to improve energy and resource efficiency, regulations have been devised governing the disposal of harmful liquid wastes (Cu, HF), chemical oxygen demand (COD), ammonia (NH<sub>4</sub><sup>+</sup>-N) and sludge reduction. Monthly reviews are conducted to identify more environment friendly treatment technologies.

### Timely Response to Regulatory Impact

The Water Pollution Prevention and Control Act in Taiwan underwent a major revision in 2017. Further amendments were made to the law before it took effect in 2018. Self-assessments are conducted by AUO when each piece of legislation is still being drafted. For example, wastewater separation measures were already put into place when the requirement for separation, collection and treatment of production wastewater was issued. Wastewater can then be processed separately depending on their nature. For sites that discharge their wastewater, the regular quarterly testing of discharge water quality is also supplemented by internal testing that is stricter than those required by law. This ensures that all readings comply with wastewater discharge standards and greatly reduce the risk of abnormal discharge.

### 4.3.3 Air Pollution Management

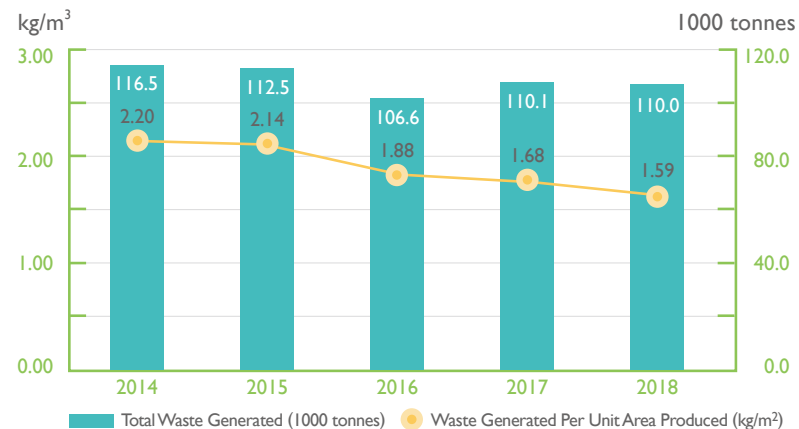
In addition to routine maintenance and upgrading of monitoring and control equipment, a push for reduction of VOCs was made to realize the source reduction indicator.

The "AUO AI Air Quality Monitoring Network" developed by the Taichung site combined a self-developed environmental monitoring network with the Internet, geography, time, wind speed, wind direction and other meteorological data. AI computing technology was also incorporated to convert data and text from single points into a three-dimensional visualized display that simulates potential air-quality hot spots around the site. The time axis can also be rapidly changed to enhance visual traceability and improve the quality of site emission management.

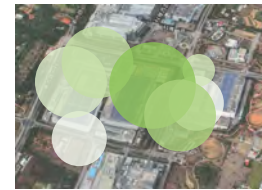
### 4.3.4 Reuse of Waste

110,000 tonnes of waste was produced in 2018, down 5.6% from 2014. Waste per unit area produced decreased by 27.7% as well. To realize the sustainable re-use of resources, waste is re-used by production processes if possible to reduce the amount of raw materials required. Recycling and re-using are the next options, while incineration and landfills are only used if there is no other choice. With liquid waste for example, the possibility of re-use in the production process is assessed first to turn waste into resource and conserve raw materials. If it cannot be re-used by the process then it is passed to contractors for re-processing into industrial-grade water materials. Only waste solvents, acids and alkaline of no further value are incinerated.

#### Changes in Production Waste



#### Changes in environmental concentrations around Taichung site over time



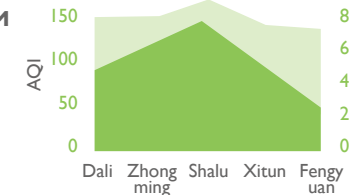
#### Changes in wind direction over time Risk blocks



#### Risk blocks



#### AQI and PM 2.5 from nearby monitoring stations



Visualization of monitoring data for rapid identification of environmental anomalies

Link observation stations to big data database for overall assessment of high-risk areas

Set up environmental background database for rapid cross-referencing with historical data

In addition, Taiwan generates 17,167 tonnes of hazardous waste every year. An extremely tiny amount of 0.1% comes from nickel cadmium and lithium batteries. These substances are shipped to developed countries for recycling treatment in keeping with the spirit of the Basel Convention.

#### 2018 Waste Output

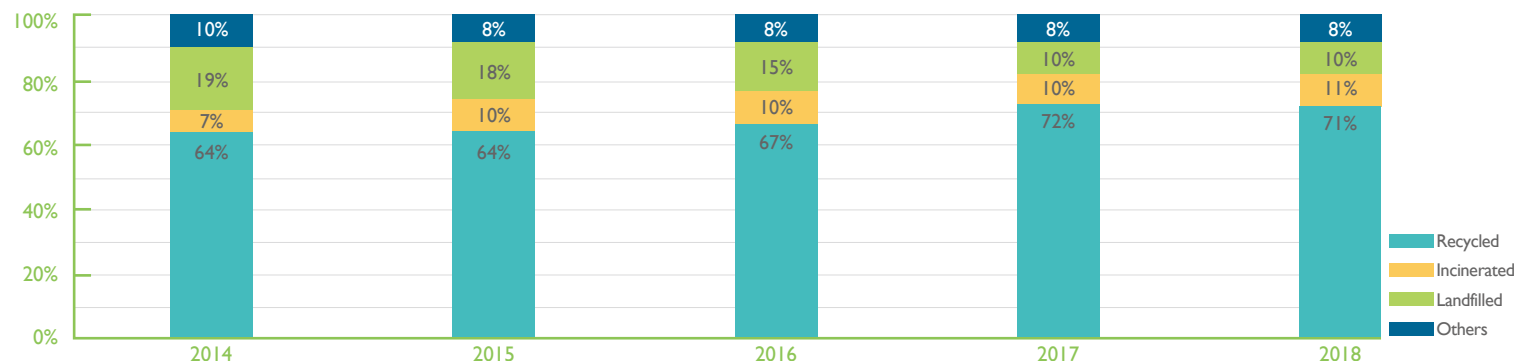
Unit: tonnes

	Recycled	Incinerated	Landfill	Others <sup>37</sup>	Total
Hazardous	16,596.72	3,267.25	2,081.27	8,678.16	30,623.4
Non-hazardous <sup>38</sup>	61,318.77	8,374.21	9,202.88	453.61	79,349.47
Total	77,915.49	11,641.46	11,284.15	9,131.77	109,972.87

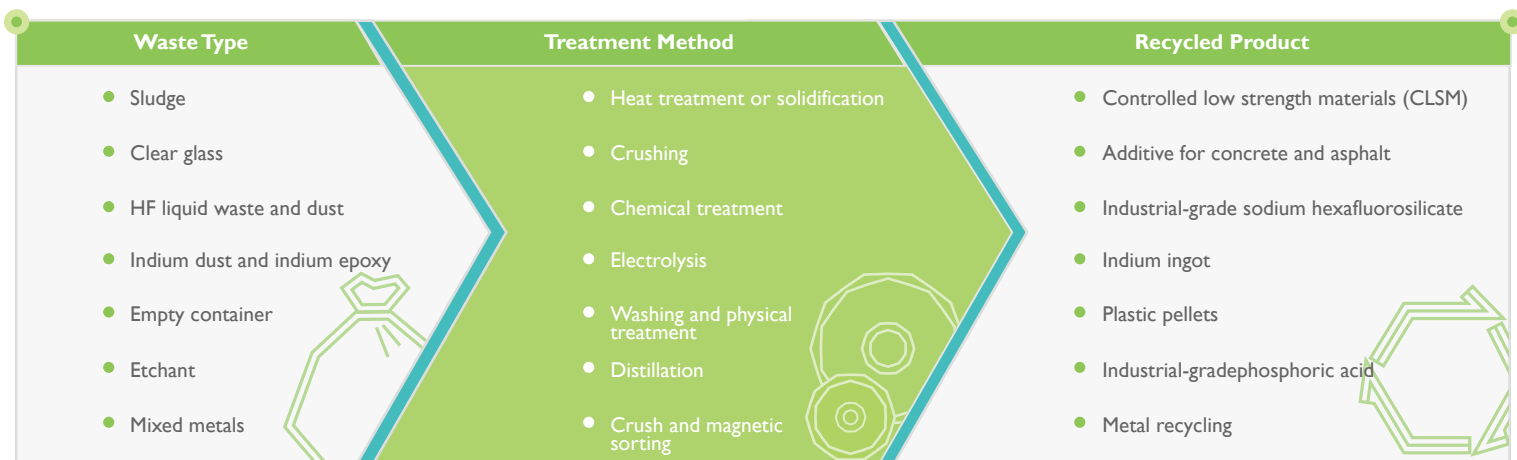
37. Other: Hazardous wastewater is produced by the Singapore site while non-hazardous waste is produced by chemical treatments in Taiwan sites.

38. Domestic waste in non-hazardous waste – Waste from the Suzhou and Xiamen sites is estimated based on the number of collections and average weight of each load. (2) Domestic wastes from the Hsinchu site are not included. (3) Manure and feces from sites in Hsinchu, Suzhou, Songjiang, Xiamen, Czech Republic and Slovakia are not included.

### Percentage of Waste Treatment by Disposal

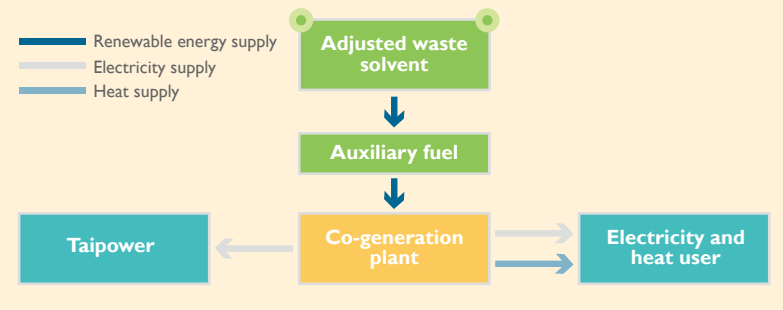


### Waste Recycling Types and Processes at Taiwan Sites



### Reuse of Waste Solvents

A co-generation waste disposal contractor was introduced in 2018. Waste solvents that used to be incinerated are now recovered for recycling. The contractor takes advantage of the waste solvent's high specific heat content by burning it to produce steam. Electricity produced by the co-generation unit is provided to suppliers to be sold back to Taipower. Steam can also be supplied to nearby companies through the ductwork. The recycling and reuse of waste stream not only reduces the environmental impact but also greatly reduces the cost of incineration.

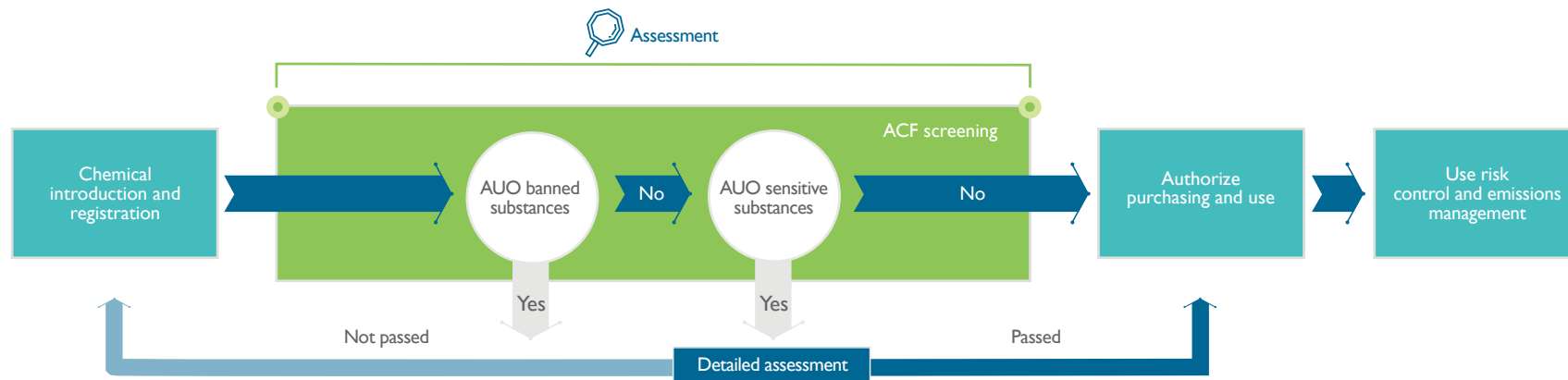


### Management of the Waste Service Providers

Waste service providers for Taiwan sites undergo regular audits every year. In 2018, AUO conducted a total of 49 regular audits targeting the back-end product flow. At the same time, the company has been communicating with service providers regarding issues that they might have encountered during the process of disposal to work together on overcoming specific challenges to facilitate a smooth waste disposal process. Safety-related regulations were also strengthened for 16 tanker operation companies when removing waste from the site. These included checking the chemical tanker before filling, personal safety protection and confirming that chemical tankers have been filled.

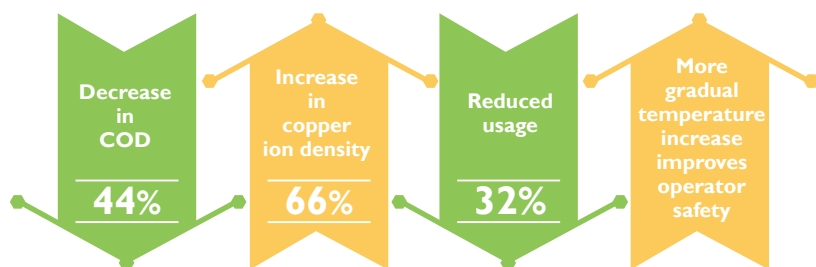
### 4.3.5 Reduction of Process Chemicals

Work began on the development of a chemical management system in 2005. Internationally recognized databases and international conventions were used as a reference for developing a list of controlled chemicals, identifying prohibited substances and for promoting/implementing chemical source management. All chemicals must first be compared against the ACF to ensure that they are not prohibited before introduction. Registration with the AUO chemical management system and a thorough review must be undertaken before chemicals can be introduced and requisitioned.



## Reduction in Chemical for Copper Processing

2nd generation liquid copper was introduced at the Longtan plant as a continuation of the liquid copper waste reduction initiative for the copper process from 2017. This continued to decrease the use of chemicals and discharge of chemical liquid waste. The amount of 2nd generation liquid



## 4.4 Product Innovation

### 4.4.1 Green Design

AUO products are designed from the start to use MFCA (Material Flow Cost Accounting) to reduce unnecessary waste. The sharing model of the circular economy is incorporated into the production process. Priority is given to commonality of use during product manufacturing to minimize the resources consumed by each product. The goals of carbon reduction and environmental protection can then be indirectly achieved in this manner.

### High-Quality Medical Displays

Medical technology now expects displays to be more precise than ever. Doctors often use photos on medical displays to make their diagnoses and decisions. To prevent misjudgments caused by poor display quality, there must be no question about the quality of the displays that they use. The medical displays that AUO supplies to customers offer high-color, high-definition, high gray scale, high contrast, large viewing angle, low ghosting, high consistency, long service life, dust-proofing and high quality. Apart from providing high-quality products for customers to pick from, this also makes a contribution to modern medicine.

copper was reduced to suit the new production process. A new solution with a high concentration of copper ions can be used for a longer period of time, improving the product output and realizing the goal of reducing usage by 20~30%. Compared to the 1st generation liquid copper waste, the new solution's COD is approximately 44% lower for the same volume of wastewater, reducing its environmental impact and treatment costs.

### Introduction of Water-Soluble Stripper

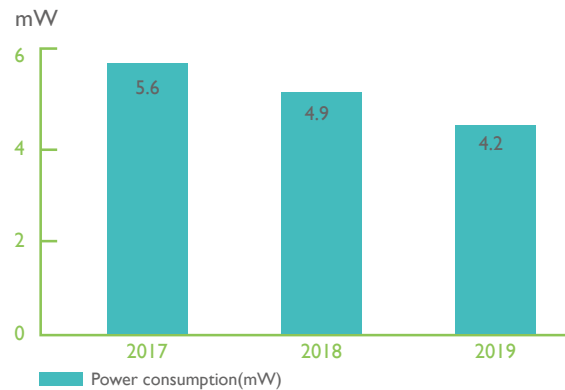
The solvent-based stripper used in the existing production process contains large amounts of chemical solvents that have an impact on the environment. AUO introduced water-soluble strippers that replace the solvent with 30% water content. COD is also 27% lower than solvent-based strippers, making it a significantly better choice for waste liquid treatment. The process temperature can also be reduced which means less energy consumption by the machine. The technology is now undergoing pilot testing at AUO's 6th generation site and is expected to begin mass production in 2020.

### Ultra-Low Power AMOLED Wearable Panel

Organic Light-Emitting Diodes (OLED) have now become the display technology of choice for wearable devices due to properties such as self-illumination, wide viewing angle, high contrast, and fast response. Their use in wearable products emphasize the performance of OLED displays. AUO has been developing AMOLED technology for many years and the focus in recent years has been ultra-low power, ultra-narrow bezel and slim designs for the best product application and experience.

The length of smart watches' standby time is closely linked to charging frequency. Extensive work was undertaken by AUO to reduce power consumption and provide customers with the best user experience, including the development of high-efficiency OLED components, optimization of the display driver architecture and reducing the number of peripheral components in panels. Standby power consumption was successfully reduced from 5.6 mW in 2017 to 4.9 mW in 2018 then to 4.2 mW in 2019. The magnitude of decreases were 12.5% and 25%, respectively.

### Trends in the Power Consumption Specifications of the 1.2" AMOLED Wearable Panel



AMOLED Wearable Display

### Development of Metal Oxide Panel Technology

Metal oxide's<sup>39</sup> advantages over conventional a-Si (amorphous silicon) LCD technology is a higher electron mobility rate and lower power consumption that translates into significantly increased product endurance. When used on medium and large panels, ghosting is reduced for dynamic imagery, providing the end-user with better dynamic visuals. Metal Oxide also offers better consistency and lower costs compared to LTPS. It can therefore be applied to medium- and large-sized panels. High-definition designs can also be realized at a more affordable price while providing superior image quality. A 12.3" metal oxide panel lit with AUO's novel OLED display technology was successfully developed by AUO in 2018. We are now planning to introduce this for our medium- and large-sized fabs.

### Development of Wrap-able Panels

The commercialization of thin, wrappable display products based on polymer substrates such as e-Paper and OLED led the focus of display technology to gradually shift towards moldable, thin, lightweight, impact-resistant and wrap-able displays. The increased attention paid to flexible displays has led to a clearer industry definition of "flexible." Flexible displays are now further categorized as curved displays, bendable displays or roll-able displays, depending on their level of flexibility. Different levels of flexibility translates to different applications and technical thresholds. A flexible display basically replaced the conventional glass substrate with a "flexible substrate." It is then combined with other flexible critical components to create a wrappable display structure. By drawing upon its extensive technical expertise, AUO was able to focus its internal resources and R&D talents to develop a bendable display in partnership with a customer in 2018. The bendable display will hopefully drive the next step in the evolution of mobile phones in 2019.

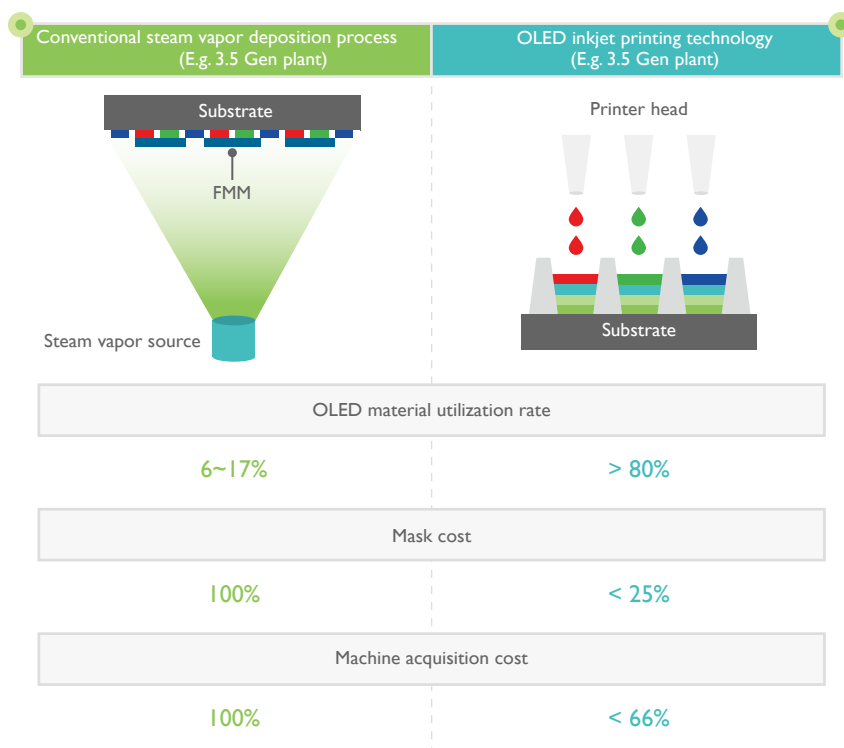
	a-Si	Oxide	LTPS
Mobility	×	○	◎
Consistency	◎	◎	×
Large size	◎	◎	×
Energy	×	◎	◎
Efficiency	◎	◎	×

×: Poor ○: Good ◎: Excellent

<sup>39</sup> Metal Oxide Semiconductor

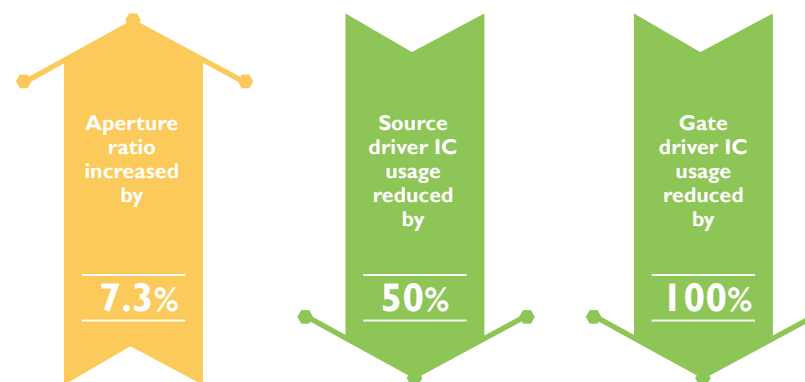
## Development of OLED Inkjet Printing Technology

AMOLED<sup>40</sup> advantages include its simple structure and self-illumination with no need for a backlight module. Its display applications have therefore drawn increasing interest in recent years. However, AMOLED materials are relatively expensive. The material utilization rate of the conventional steam deposition process is also quite low, and high-precision metal masks are required to define the size and location of each pixel. Photo masks are not cheap either, so AMOLED panels tend to cost more. The inkjet printing technology now under development at AUO will not only greatly boost the material utilization but also define pixels using inkjet printing technology instead of metal masks.



## Convert All Products to GOA

The growing market demand for high-definition TVs will bring about an exponential growth in the number of driver ICs that they require. UHD for example doubles the number of source<sup>41</sup> and gate driver ICs<sup>42</sup>. The jump in amount of driver ICs used means longer production times when driver ICs and panels are laminated together. AUO began applying Gate on Array (GOA) technology to the UHD TV displays over 65" in size in 2015. Continued improvements were made to the GOA circuit design and panel wiring layout while innovative display technologies were also introduced. Mass production of 85" UHD and 8K products in 2018 meant that the entire product series is now GOA-based. A comparison of the 1st generation 85" UHD model and the 2nd generation 85" UHD model put into mass production in 2018 showed that optimization of panel pixels increased their aperture ratio and energy efficiency. The GOA design greatly reduces the number of driver ICs needed to realize the goal of materials reduction.



40. Active-matrix organic light-emitting diode (AMOLED)

41. Source driver IC is used for data input. It is characterized by its high-frequency and display function.

42. Gate driver IC determines the orientation and speed of liquid crystal molecules.

Penetration Improvement Technology

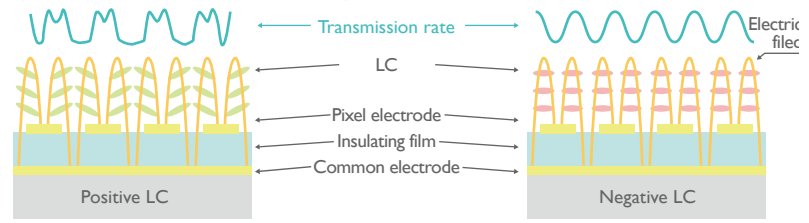
Low-power Backlight Module for Auto LCD

After many years of developments in the automotive display products sector, AUO is continuing to refine its display technology by developing color filters with high transmission. The increase of LCD panel's overall transmission to 27.4% greatly improves the efficiency of the backlight module. Product power consumption, is significantly reduced by 21.5% while maintaining the same basic level of brightness (1000 cd/m<sup>2</sup>).

	Color filter transmission rate	Display power consumption at 1000 cd/m <sup>2</sup>
Original design	22.6%	6.89 W
Energy-saving design	28.8%	5.41 W
Energy efficiency	Transmission increased by 27.4%	Power consumption reduced by 21.5%

Increasing Transmission with Negative Liquid Crystals

The increasing popularity of mobile devices means that users now pay more attention to screen resolution and energy efficiency. The top priority now is to improve panel transmission in order to reduce the power consumption of the backlighting. Liquid crystal (LC) materials come in two types. Positive LC aligns with the electric field in parallel, while negative LC aligns perpendicular to the electric field. Negative LCD has been introduced in AUO products to exploit their alignment characteristics and solve the problem of positive LC molecules not lining up properly on the edge of pixel electrodes. The improvement in LCD efficiency helps increase panel transmission. For a panel with 224 PPI, replacing the positive LC with negative LC increases the LC efficiency by 12%. Optimizations to the corresponding pixel design increases the overall panel transmission to 20%. Power consumption can therefore be reduced by 20% for the same level of brightness.



Using Algorithms to Achieve Wide Viewing Angle and Low Power Consumption

LCDs offering higher 8K4K resolutions were released to provide greater realism and immersive experience for the viewer. However, the higher resolution lowers the light emission of LCD panel and increases power consumption. To provide a good viewing angle, the pixel design of the vertically aligned LCDs usually adopts an 8-domain structure (two 4-domains each with different driving voltages). This reduces the aperture ratio of the pixel while also reducing the light emission of the LCD panel. A color-tuning algorithm for suppressing all the color shift between front and side viewing angles was developed for this project that gives the viewing angle performance of the 4-domain pixel design panels approaching that of 8-domain. 8K4K panels can therefore offer a wide viewing angle as well as energy-efficiency at the same time. On identical 75" 8K displays, the transmission of 4-domain (~3.7%) increases the light emission of LCD panel by 48% compared to 8-Domain (~2.5%), so there is more energy saving.

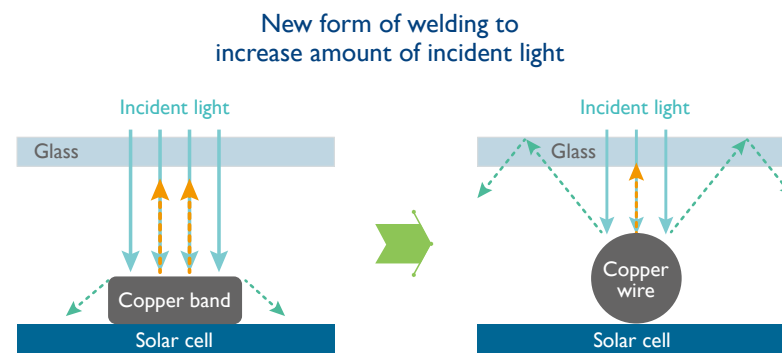
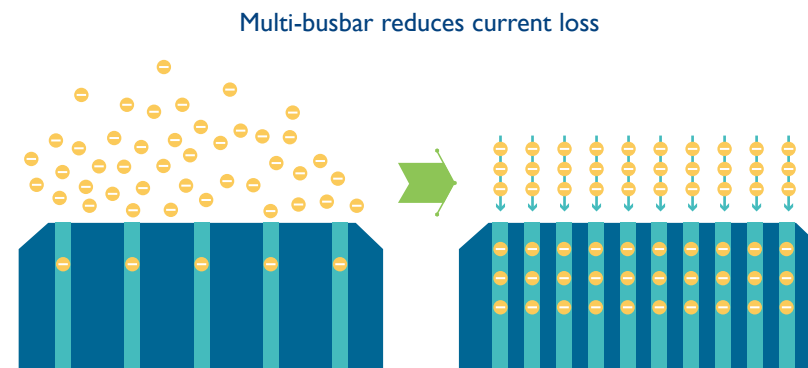
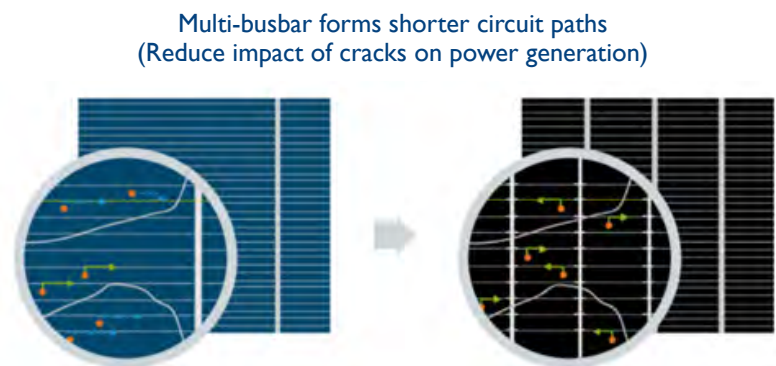
Comparison of design differences and benefits

	Conventional technology	New technology
Diagram of pixels and driving signals	<p>8-Domain</p>	<p>4-Domain</p>
Transmission difference	Base (~2.5%)	Base+48 (~3.7%)

## Advanced and Highly Efficient Solar Modules

As a leader in the green industry, AUO focuses on the development of advanced, high-efficiency solar module products. Continued improvements to the opto-electric conversion efficiency of solar modules help drive the adoption of PV applications and realize AUO's commitment to green energy.

Multi-busbar solar modules have an optimized solar cell structure with multiple copper wires placed on the cell to form shorter current paths that improve current collection efficiency. The rounded copper wire increases the amount of light reaching the cell compared to the conventional ribbon type and gives another boost to the module's generating efficiency. A multi-busbar structure effectively reduces the impact of external forces on the cell, limits the extent of micro-cracks and prevents the further degradation of the current distribution paths. This next-generation technology ensures that the solar module can maintain a stable output over long periods of time while also improving generation efficiency and reliability.

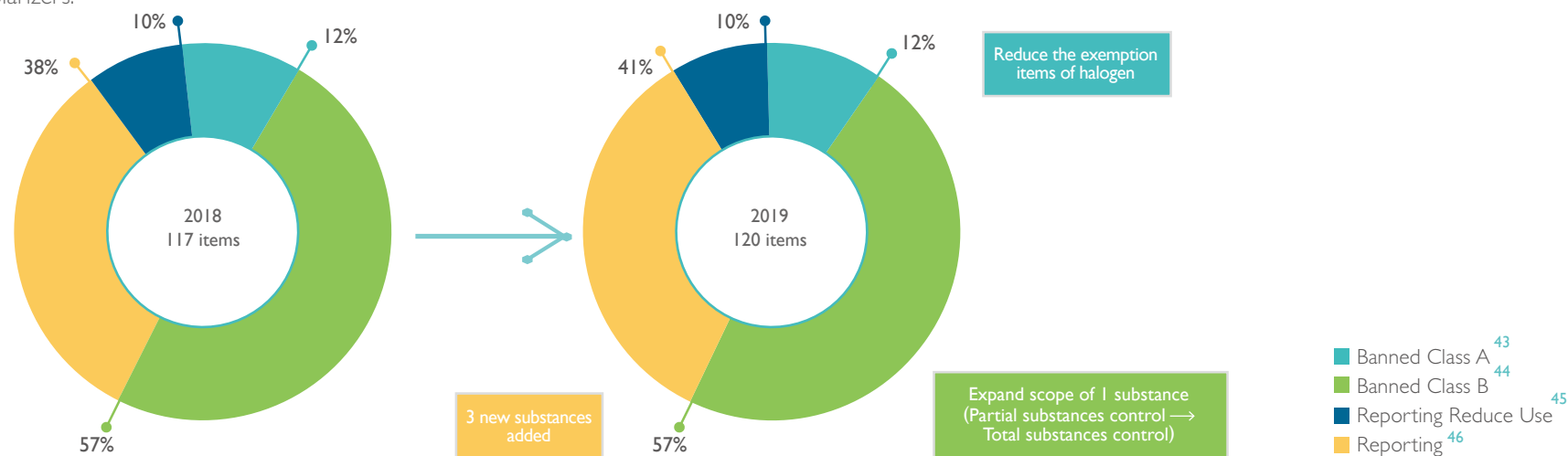


### 4.4.2 Control of Hazardous Substances

To effectively manage hazardous substances in all display products, AUO introduced and passed the certification of IECQ QC 080000 international standard for hazardous substance management systems from 2007 to now. A clear, systematic and complete "process-oriented" management process for hazardous substances was put into place from stakeholder requirements and expectations, product design/development, materials input and product output, and to the final satisfaction. The hazardous substance process management system standard (IECQ QC 080000) was formally revised in 2017 to increase the applicable regulations of hazardous substance, strengthen documentation requirements, and emphasize management risks and opportunities. In response to the standard revisions, AUO immediately strengthened our management process and successfully passed the conversion certification for the management system in 2018 to continue providing high-quality green products and services.

## Product Hazardous Substance Management

To reduce our environmental and ecological impact, fulfill our corporate responsibility for environmental sustainability as well as continue to comply with the international regulations and the expectations of all stakeholders, AUO regularly reviewed and revised the policy of hazardous substances management every year based on international regulations, customer requirements and environmental protection trends. In 2018, the reduction plan for exemption of halogen was launched in AUO, and to consider the supply chain technologies and customer requirements. AUO had the 17th revision for the policy of hazardous substances, it had been take effect in 2019. controlled substances are expected to increase to 120 types of chemicals and the change of this revision including adding 3 reporting substances, expanding to ban all of Persistent Organic Pollutants (POPs), and revising the exemption items of halogen to be in the color resists of color filters and polarizers.



## Low-Cadmium Quantum Dot Optical Film

Continued advances in display resolutions and specifications have led to customer requirements for color-gamut being raised to Adobe RGB 99% and Rec. 2020 90%. Quantum dot displays use blue light LED to illuminate red and green quantum dots of different diameters, and generate high-purity red and green light. This provides the three primary colors of red, green and blue light needed for high-color displays. The CdSe content of the current quantum dot optical film exceeds the RoHS restrictions on the cadmium content. AUO therefore partnered with vendors to develop a quantum dot optical film with 50% less cadmium content that satisfies the RoHS requirement of < 100 ppm. This can be used with the color filter and color resist materials to satisfy the Rec. 2020 90% color-gamut specifications. The technology has now been introduced to the new models developed for 2018. Further work will be undertaken with the goal of developing a cadmium-free quantum dot optical film.

<sup>43</sup>. Banned Class A: Absence of the banned substance must be evidenced with a test report for

<sup>44</sup>. Banned Class B: Absence of the banned substance can be declared by the supplier

<sup>45</sup>. Reporting Reduce Use: Controlled substances that suppliers must reduce use of or find alternatives for

<sup>46</sup>. Reporting: Controlled substances that suppliers must make detailed disclosures with regards to the content and concentration