

# F-GHG Emissions Reduction Efforts: FY2015 Supplier Profiles

U.S. Environmental Protection Agency  
Office of Air and Radiation  
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The Supplier Profiles outlined in this document detail the efforts of large-area flat panel suppliers to reduce their F-GHG emissions in manufacturing facilities that make today's large-area panels used for products such as TVs and computer monitors.

## Summary of Supplier Profiles

The table below summarizes which panel suppliers publicly report their F-GHG emissions, their most recent F-GHG emissions, and, where available, their F-GHG emissions intensity based on panel production. It also includes information on suppliers' broader GHG emissions reduction goals, since F-GHGs comprise a significant portion of on-site Scope 1 GHG emissions, as well as the regulatory and/or voluntary efforts by which suppliers are reducing their F-GHG emissions.

Most importantly, the table highlights which suppliers have fully implemented F-GHG emissions reduction measures across their older and newer manufacturing, or fabrication, facilities, also referred to as 'fabs.' For panel suppliers that have not fully implemented F-GHG reduction measures, whereby approximately 90 percent of annual F-GHG emissions are avoided or removed, further opportunities for improvement exist.

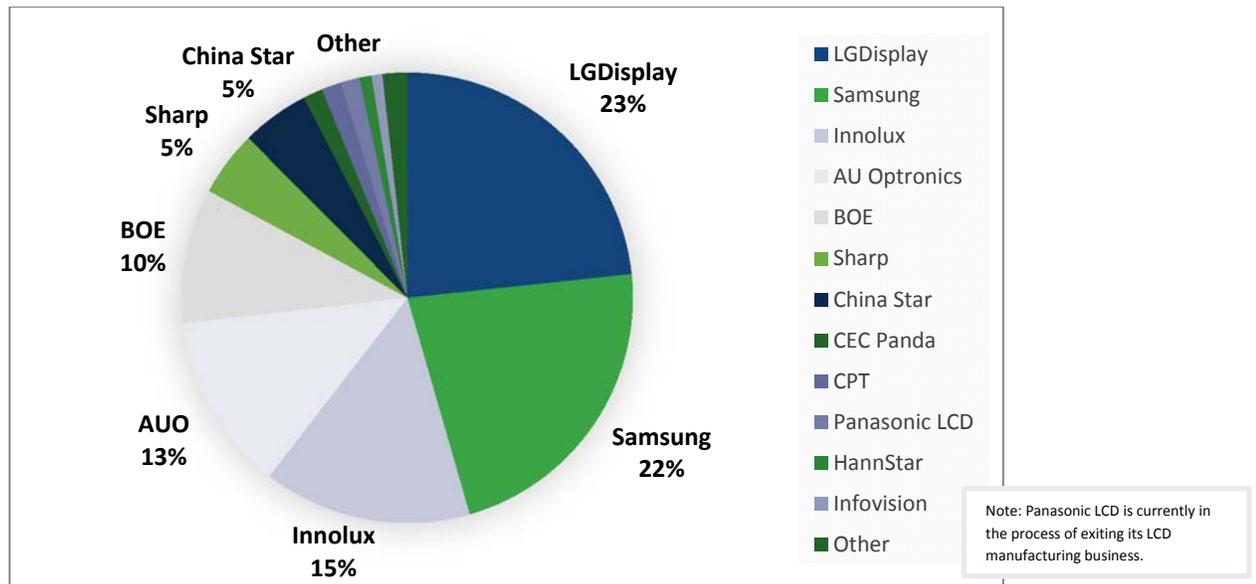
The summary table and charts reflect data, assembled from public sources and the suppliers themselves, on F-GHG emissions for calendar year or fiscal year 2015, depending on the supplier's reporting cycle. Public sources of information include suppliers' responses to the annual CDP Investor Questionnaire and each supplier's annual sustainability reports.

Following the summary information, individual profiles provide more information on specific methods, such as abatement, process optimization and use of alternatives that suppliers are using to reduce their F-GHG emissions.

## Supplier Market Share

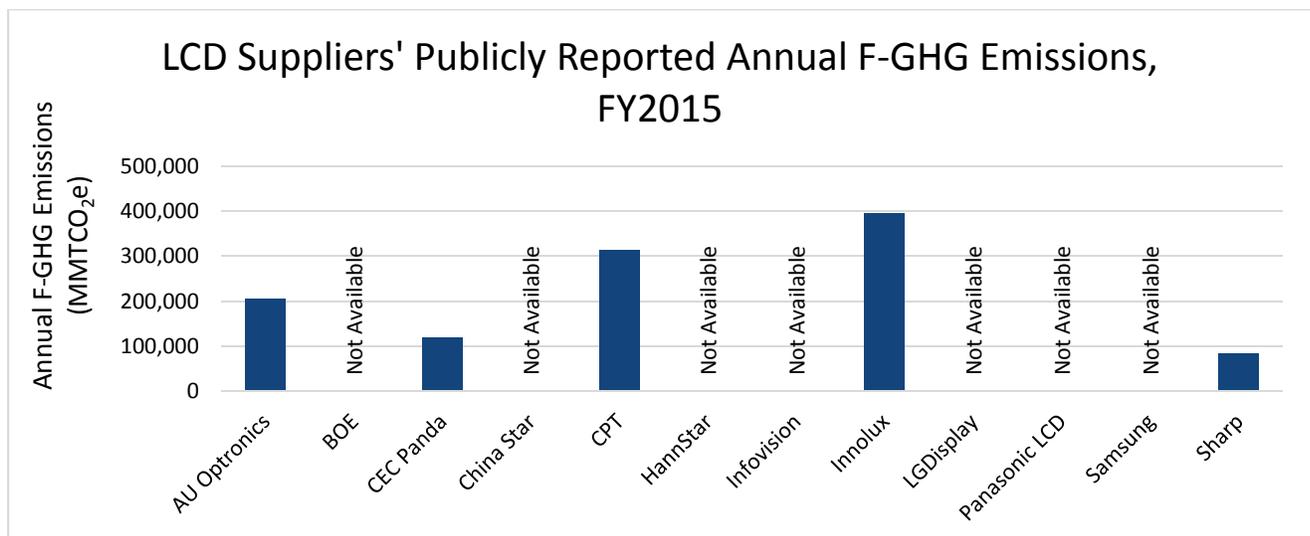
The twelve global suppliers named among the profiles produce 98% of all large-area flat panel displays sold globally, as shown in the chart below. Large area panels are defined as being 9.1 inches or larger.

## FY2015 Global Market Share of Large Area Panels Production for Featured Suppliers



## Key Findings Based on 2015 Data

- Greater transparency is needed on all LCD panel suppliers' F-GHG emissions to better understand overall trends in F-GHG emissions.
- An improved understanding is needed on the extent to which F-GHG emission reductions result from both the use of F-GHG reduction technologies and the use of alternative F-GHGs in key processes to better equip brands to understand all of the methods their suppliers are implementing to reduce F-GHG emissions.
- An optimal F-GHG emissions intensity based on full abatement and/or the fullest use of alternative gases could serve as an indicator for brands and other interested stakeholders on whether emissions reduction efforts have been implemented to the fullest extent possible.



Company	Market Share of FPD Production	Publicly Reported FY2015 F-GHGs	FY2015 F-GHG Emissions (MMTCO <sub>2</sub> e)	% Reduction from FY2014	FY2015 F-GHG Intensity (MMTCO <sub>2</sub> e/m <sup>2</sup> of panel produced)	GHG Reduction Goals <sup>1</sup>	National Regulations on F-GHGs/Carbon Trading	Participation in Voluntary National/International (i.e., WDICC) F-GHG Efforts?	F-GHGs Targeted by Emission Reduction Efforts				Processes Targeted by Emission Reduction Efforts			Reduction Approach(es) Used				Full F-GHG Emission Reduction Measures Implemented at each fab (resulting in overall ~90% F-GHG emission reductions across all fabs)	
									SF <sub>6</sub>	PFCs	HFCs	NF <sub>3</sub>	Etch	Clean	Cool	Abatement	Process Improvements	CVD Remote Plasma	Other		
LG Display	23%		Not Available	NA	Not Available	12.6% by 2020	✓	✓	✓	✓	not used	✓	✓	✓	F-GHGs not used	✓	✓	✓			
Samsung	22%		<i>2015 F-GHG emissions data is not publicly available, however data for 2011 and part of 2012 are available in previous profiles.</i>																		
Innolux	15%	✓	394,223	15%	Not Available	No	✓	✓	✓	✓	✓	✓	✓	✓	not inventoried	✓	✓			✓	✓
AU Optronics	13%	✓	205,046	14%	0.039	25% by 2015	✓	✓	✓	CF <sub>4</sub>	✓	✓	✓	✓	deemed too minor	✓	✓			✓	✓
BOE	10%		<i>2015 F-GHG emissions data is not publicly available, however information on general GHG emissions management efforts is publicly available.</i>																		
Sharp	5%	✓	85,000	6%	Not Available	No		✓	✓	CF <sub>4</sub> C <sub>2</sub> F <sub>6</sub> C <sub>4</sub> F <sub>8</sub>	CHF <sub>3</sub>	✓	✓	✓	no info available	✓	✓		✓	✓	
China Star	5%		<i>2015 F-GHG emissions data is not publicly available.</i>																		
CEC Panda	1%	✓	119,287	NA	Not Available	No		Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Panasonic LCD	1%		<i>2015 F-GHG emissions data is not publicly available, as Panasonic LCD is ending its business of manufacturing panels for consumer televisions.</i>																		
CPT	1%	✓	313,000	NA	Not Available	280,000 MtCO <sub>2</sub> e by 2016		✓	✓	✓	✓	✓	✓	✓	no info available	✓	✓			✓	
HannStar	1%		Not Available	NA	Not Available	No	✓	✓	✓			✓	✓	✓	F-GHGs not used	✓	✓			✓	
Infovision	1%		<i>2015 F-GHG emissions data is not publicly available.</i>																		

<sup>1</sup> For more information on GHG emission reduction goals, including the base year and scope of included emissions, see the individual Supplier Profiles.

# Flat Panel Display Supplier Profiles

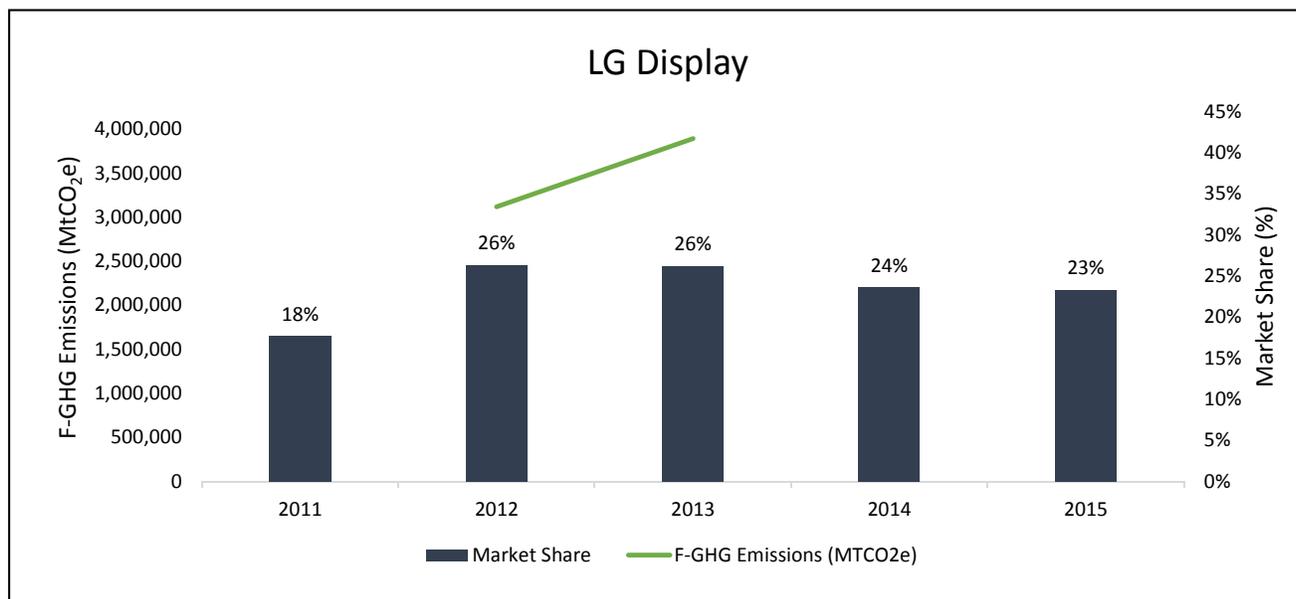
Flat panel display suppliers are presented in descending order of market share.

<b>LG Display</b> .....	<b>5</b>
<b>Innolux Corporation</b> .....	<b>8</b>
<b>AUO (AU Optronics)</b> .....	<b>11</b>
<b>Sharp</b> .....	<b>16</b>
<b>CEC Panda</b> .....	<b>19</b>
<b>Chunghwa Picture Tubes (CPT)</b> .....	<b>21</b>
<b>HannStar</b> .....	<b>27</b>
<b>Suppliers Without Public Data</b> .....	<b>30</b>
Samsung.....	30
BOE .....	30
China Star.....	31
Infovision .....	31

# LG Display FY2015 Data

23% Market Share

## Emissions Over Time



The chart above shows the following separate but related metrics:

- **Market share** over time shows the size of the Supplier relative to all suppliers in the industry based on area of panels produced.
- **Total emissions** over time show total F-GHG emitted by the supplier each year. Supplier emissions can change due to the implementation of emissions reduction efforts, an increase or decrease in panel production, and/or LCD technology advancements.
- **Emission intensity**, where available, is a measure of the amount of F-GHG emissions per unit of production. Trends in emission intensity show whether the Supplier's rate of emissions is increasing or decreasing over time and can indicate whether the supplier is implementing emission reduction efforts. LG Display does not publicly report F-GHG emission intensity.

F-GHG emissions are publicly reported by Suppliers through the CDP (formerly "Carbon Disclosure Project") and/or corporate sustainability reports. In this graph, market share is calculated based on production data from IHS Technology.

## F-GHG Emission Reduction Activities

### Overview

- There is no publicly available information on LG Display's F-GHG emissions for the most recent calendar year, however additional information for earlier years can be found in LG Display's [previous profiles](#).

## Gases Targeted

- SF<sub>6</sub>
- PFCs
- NF<sub>3</sub>

## Processes Targeted

- Etching
- Cleaning

## Approaches Used

### Abatement

- **Abatement Systems:** LG Display has installed F-GHG abatement systems on all lines of cleaning tools and on two lines of etching tools. Electrically heated point-of-use systems are installed for NF<sub>3</sub> in cleaning tools and combustion-type centralized systems are installed for SF<sub>6</sub> and PFCs in etch tools.

### Process Improvements

- LG Display has applied end-point detection and revised processes to optimize the use of F-GHGs.

### Alternative Chemicals

- **SF<sub>6</sub> Replacement:** In 2014, LG Display developed a gas application technology as an alternative to using SF<sub>6</sub> and has started implementing the use of the alternative.
- **Remote Plasma Source Chamber Clean:** LG Display has applied NF<sub>3</sub> remote plasma source chamber clean (RPSC) to all manufacturing lines. RPSC's utilization rate is 97% compared to 70% for an ordinary chamber.
- **NF<sub>3</sub> Replacement:** LG Display has replaced NF<sub>3</sub> with F<sub>2</sub> in chamber cleaning on one of its manufacturing lines. LG Display continues to research alternative lower GWP etching gases than SF<sub>6</sub> for the dry etching process.

## Emissions Measurement Approaches and Verification

- LG Display uses national GHG emission estimation guidelines issued by the South Korean Ministry of Environment and estimates NF<sub>3</sub> emissions by using the 2006 IPCC Tier 2b guidelines.
- LG Display's GHG emissions are assured by a third party in accordance with South Korean government regulations. NF<sub>3</sub> emissions estimated by the 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions are not assured by a third party, but cross-checked by WDICC members.

## Emission Reduction Goals and Progress

- LG Display set a corporate-wide GHG reduction goal to reduce its GHG emissions intensity by 29% from 2009 to 2020.
- LG Display set a target to reduce Scope 1 and Scope 2 GHG emissions 12.6% by 2020 and 54.6% by 2040, relative to 2014 levels. Scope 1 emissions include F-GHGs.
- LG Display's F-GHG emissions reduction efforts are part of its broader goals to reduce corporate-wide GHG emissions.

- LG Display has been participating in GHG emissions trading since January 2015.
- In 2015, LG Display implemented its Carbon Footprint Calculator to respond to government GHG regulations and respond to customer preference for environmentally friendly products.
- LG Display is a member of the [Korea Display Industry Association \(KDIA\)](http://www.kdia.org/new/eng/), where it participates in an environmental working group that promotes information exchange on GHG emissions reduction technologies and initiatives. KDIA represents Korea's flat panel display suppliers in the World Display device Industry Cooperation Committee (WDICC).

## Sources

*Korea Display Industry Association.* See <http://www.kdia.org/new/eng/>.

*LG Display 2015-2016 Sustainability Report.* Available at <http://www.lgdisplay.com/eng/sustainability/report>.

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*LG Display's responses to the 2014 Carbon Disclosure Project Investor Questionnaire.*

*LG Display's responses to the 2016 Carbon Disclosure Project Investor Questionnaire*

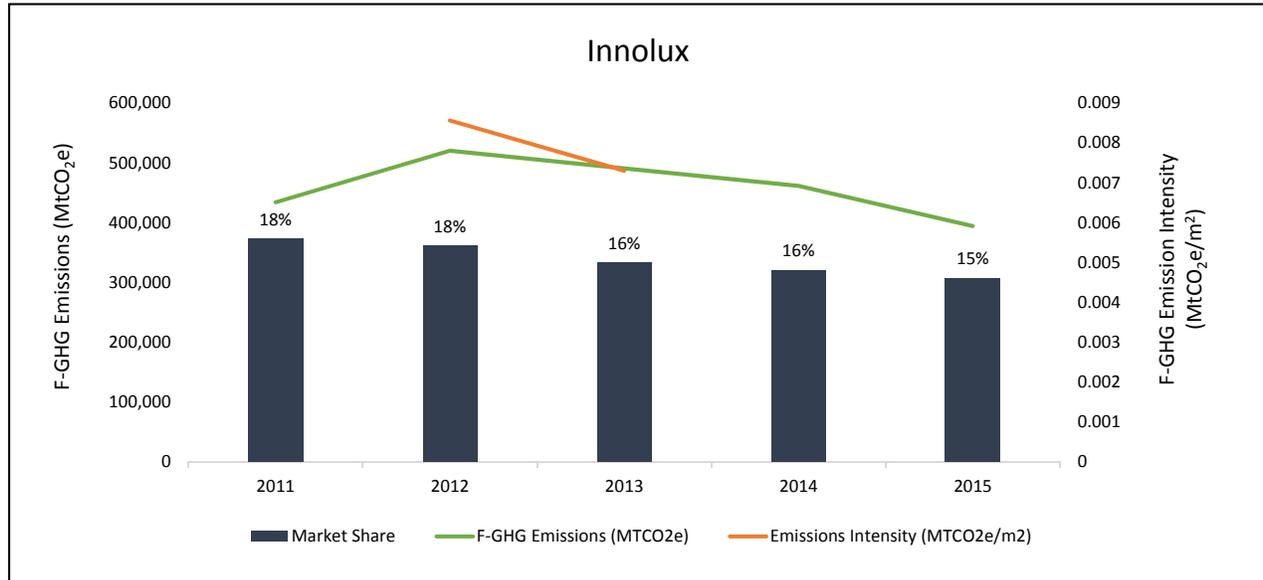
*"Point of Use Abatement Device to Reduce SF<sub>6</sub> emissions in LCD Manufacturing Operation in the Republic of Korea (South Korea)." LG Display's SF<sub>6</sub> Abatement Project. Clean Development Mechanism Project: 3440.* Available at <https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view>.

*LG Display (response in 2014 regarding 2012/2013 data).*

# Innolux Corporation FY2015 Data

## 15% Market Share

### Emissions Over Time



The chart above shows the following separate but related metrics:

- **Market share** over time shows the size of the Supplier relative to all suppliers in the industry based on area of panels produced.
- **Total emissions** over time show total F-GHGs emitted by the supplier each year. Supplier emissions can change due to the implementation of emissions reduction efforts, an increase or decrease in panel production, and/or LCD technology advancements.
- **Emission intensity**, where available, is a measure of the amount of F-GHG emissions per unit of production. Trends in emission intensity show whether the Supplier's rate of emissions is increasing or decreasing over time and can indicate whether the supplier is implementing emission reduction efforts.

F-GHG emissions are publicly reported by Suppliers through the CDP (formerly "Carbon Disclosure Project") and/or corporate sustainability reports. In this graph, market share is calculated based on production data from IHS Technology.

## F-GHG Emission Reduction Activities

### Overview

- In 2015, Innolux emitted approximately 394,000 MtCO<sub>2</sub>e of F-GHGs, as follows:  
 HFCs: 13,143.78  
 PFCs: 23,081.92  
 SF<sub>6</sub>: 357,997.05
- Innolux reported a 15.4% reduction in total F-GHG emissions compared to 2014.

- Innolux reduced its F-GHG emission intensity from 0.0094 MtCO<sub>2</sub>e/m<sup>2</sup> in 2010 to 0.0086 MtCO<sub>2</sub>e/m<sup>2</sup> in 2012, and in 2013 it dropped to 0.0073 MtCO<sub>2</sub>e/m<sup>2</sup>.
- In 2015, Innolux reported that removal equipment reduced total annual F-GHG emissions by 2,139,043 tons of CO<sub>2</sub>e, compared to 2,465,694 tons of CO<sub>2</sub>e reduced in 2014, and 2,622,000 tons of CO<sub>2</sub>e reduced in 2013.
- In 2015, F-GHGs represented 3.8 percent of Innolux's total GHG emissions compared to 14 percent of total emissions in 2014.

### Gases Targeted

- SF<sub>6</sub>
- PFCs
- HFCs
- NF<sub>3</sub>

### Processes Targeted

- Cleaning
- Etching
- *Innolux uses a small amount of fluorinated heat transfer fluids, but has not inventoried them.*

### Approaches Used

#### Abatement

- **Abatement Systems:** Innolux has installed abatement systems in all newer generation fabrication facilities (fabs) and has installed burn type point-of-use abatements systems in all fabs constructed prior to 2003.
- **Local Scrubbers:** Innolux installed combustion local scrubbers between 2011 and 2015, collectively eliminating 1,200 million tons of F-GHGs. More local scrubbers are scheduled for installation in 2016.

#### Process Improvements

- Innolux is optimizing the use of F-GHGs in the process chambers. Additional details not available.

#### Recycling/Reuse

- **Recovery System:** Innolux is working with the Industrial Technology Research Institute of Taiwan to test an SF<sub>6</sub> liquefaction recovery system. If it works, Innolux will expand the system across applicable fabs.

#### Alternative Chemicals

- Innolux is using lower GWP gases, where possible. Additional details not available.

## Emissions Measurement Approaches and Verification

- Innolux estimates F-GHG emissions based on the Tier 2b method for electronics industry emissions provided in the [2006 IPCC Guidelines for National Greenhouse Gas Inventories](#).
- Innolux received third party verification for its 2014 GHG inventory, which was verified in accordance with the [ISO-14064-3](#) standard.

## Emission Reduction Goals and Progress

- In 2013, Innolux released its Product Carbon Footprint (PCF) system to help streamline calculations of emissions on a per product basis.
- In 2015, Innolux audited the carbon emissions of 69 suppliers and 132 materials.
- Innolux plans to continue monitoring carbon emissions to establish a comprehensive database.
- Innolux applied for early carbon credits for its carbon reduction efforts between 2005 and 2011, receiving 16 million tons in credits in 2015 for Taiwan's cap and trade program.

## Participation in Broader F-GHG Reduction Efforts

- Innolux is a member of Taiwan's [TFT-LCD Association \(TTLA\)](#). The TTLA participates on behalf of Taiwan's LCD suppliers in the World Display device Industry Cooperation (WDICC), whose members have agreed to 30% F-GHG emission reductions by 2020 relative to 2010 levels.

## Sources

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2015 INNOLUX CSR Report. Available at [http://www.innolux.com/Files/CWSFiles/csr/CSR2015-en\\_0630f.pdf](http://www.innolux.com/Files/CWSFiles/csr/CSR2015-en_0630f.pdf) (see page 47).

SF<sub>6</sub> Abatement Strategy in Taiwan". Presentation by Taiwan's Industrial Technology Research Institute (ITRI), 2004. Available at [www.epa.gov/electricpower-sf6/documents/conf04\\_lu.pdf](http://www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf).

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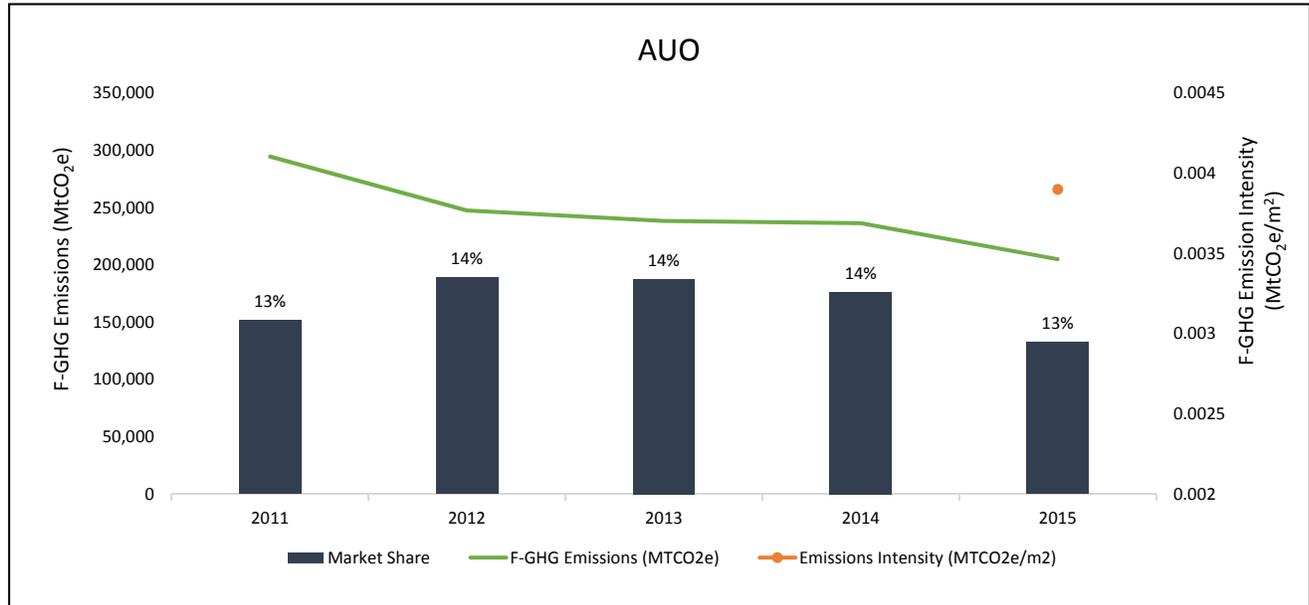
[http://unfccc.epa.gov.tw/unfccc/english/uploads/downloads/05\\_The\\_Initiative\\_and\\_Efforts\\_form\\_Electronic\\_Industry\\_in\\_Taiwan.pdf](http://unfccc.epa.gov.tw/unfccc/english/uploads/downloads/05_The_Initiative_and_Efforts_form_Electronic_Industry_in_Taiwan.pdf).

TTLA presentation at APEC meeting, August 2012, Taiwan.

# AUO (AU Optronics) FY2015 Data

13% Market Share

## Emissions Over Time



The chart above shows the following separate but related metrics:

- **Market share** over time shows the size of the Supplier relative to all suppliers in the industry based on area of panels produced.
- **Total emissions** over time show total F-GHGs emitted by the supplier each year. Supplier emissions can change due to the implementation of emissions reduction efforts, an increase or decrease in panel production, and/or LCD technology advancements.
- **Emission intensity**, where available, is a measure of the amount of F-GHG emissions per unit of production. Trends in emission intensity show whether the Supplier's rate of emissions is increasing or decreasing over time and can indicate whether the supplier is implementing emission reduction efforts.

F-GHG emissions are publicly reported by Suppliers through the CDP (formerly "Carbon Disclosure Project") and/or corporate sustainability reports. In this graph, market share is calculated based on production data from IHS Technology.

## F-GHG Emission Reduction Activities

### Overview

- In 2015, AUO emitted approximately 205,000 MtCO<sub>2</sub>e of F-GHGs, as follows:
  - HFCs: 6,437.57
  - PFCs (includes NF<sub>3</sub>): 21,585.75
  - SF<sub>6</sub>: 177,022.64

- From 2010 to 2015, AUO reduced its GHG emissions intensity, which includes both Scope 1 and Scope 2 emissions, by 20%, from 58.5 kg CO<sub>2</sub>e/m<sup>2</sup> (0.059 MtCO<sub>2</sub>e/m<sup>2</sup>) to 46.8 kg CO<sub>2</sub>e/m<sup>2</sup> (0.047 MtCO<sub>2</sub>e/m<sup>2</sup>). AUO has pledged to continue its efforts to achieve an additional 5% reduction in emissions intensity by 2020 to attain their 25% GHG reduction goal. Specifically, from 2008 to 2015, AUO reported a 61% reduction in F-GHG emissions per unit of production, from 9.96 kg CO<sub>2</sub>e/m<sup>2</sup> (0.010 MtCO<sub>2</sub>e/m<sup>2</sup>) to 3.91 kg CO<sub>2</sub>e/m<sup>2</sup> (0.0039 MtCO<sub>2</sub>e/m<sup>2</sup>).
- From 2003 to 2015, AUO reduced F-GHG emissions by 120.16 million metric tons CO<sub>2</sub>e. This is equivalent to taking 25 million cars off the road for one year.<sup>2</sup>

## Gases Targeted

- SF<sub>6</sub>
- PFCs (specifically CF<sub>4</sub>)
- HFCs
- NF<sub>3</sub>

## Processes Targeted

- Etching
- Cleaning
- Cooling: *Per the "Guidance for Greenhouse Gas Accounting and Reporting for GHG inventory" published by the Taiwanese EPA, emissions from fluorinated heat transfer fluids are too minor in AUO's process to account for.*

## Approaches Used

### Abatement

- **Localized Abatement Systems:** As of 2015, AUO has installed localized, point-of-use abatement systems in all fabrication facilities (fabs).
- **Abatement for Cleaning:** AUO uses combustion abatement systems for cleaning processes in all fabs.
- **Abatement for Etching:** AUO uses combustion abatement systems or membrane separation technology for dry etching processes on all new production lines (built after 2003).

### Process Improvements

- **Reduced SF<sub>6</sub> Consumption:** AUO's process experts worked with its SF<sub>6</sub> supplier to implement ways to reduce the quantity of SF<sub>6</sub> used in etching across all fabs. At one of its fabs, at full production capacity, adjusting relevant SF<sub>6</sub> process parameters can result in reducing the equivalent of 32,000 metric tons of CO<sub>2</sub> annually, which is equal to 18% of AUO's reported SF<sub>6</sub> emissions in 2015.
- **Reduced Gas Waste and Improved Utilization Efficiencies:** By installing flow meters and mass flow controllers at the front of tool chambers, on-site engineers have been able to reduce unnecessary gas waste and improve gas utilization efficiencies.

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<sup>2</sup> Calculated using EPA's Greenhouse Gas Equivalencies Calculator, which is available at <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

## Alternative Chemicals

- **NF<sub>3</sub> Substitution:** AUO uses NF<sub>3</sub> instead of SF<sub>6</sub> in cleaning, since NF<sub>3</sub> has a lower global warming potential (GWP) and it is used more efficiently.
- **Ongoing Research:** AUO continues to research the possibilities of using alternative gases with lower or no GWP in conjunction with optimizing process efficiencies and implementing abatement systems.

## Recycling/Reuse

- **Recycling Test:** In 2012, AUO tested gas recycling technologies and recycling efficiency at one fab.
- **Reuse Pilot:** In 2013, AUO's Longtan site introduced a membrane separation method that purifies SF<sub>6</sub> so that it can be re-used in the manufacturing process. However, due to a higher maintenance demand and lower efficiency, the recycling system has been replaced by an abatement system.

## Emissions Measurement Approaches and Verification

- AUO estimates F-GHG emissions based on the Tier 2b method for electronics industry emissions provided in the [2006 IPCC Guidelines for National Greenhouse Gas Inventories](#), including use of default destruction or removal efficiency (DRE) values for abatement.
- A third party verifies AUO's raw data according to the [ISO 14064-1](#) guidance (verification document included below).

## Emission Reduction Goals and Progress

- AUO set a goal to reduce Scope 1 and 2 GHG emission intensity in all fabs globally by 25% from 2010 to 2015. F-GHGs are included as part of Scope 1 emissions.
- AUO has a "Green Solutions" initiative that addresses emissions reductions through operations, supply chain improvements, and product design.

## Participation in Broader F-GHG Reduction Efforts

- AUO is a member of Taiwan's [TFT-LCD Association \(TTLA\)](#). The TTLA participates on behalf of Taiwan's LCD suppliers in the World Display device Industry Cooperation (WDICC), whose members have agreed to 30% F-GHG emission reductions by 2020 relative to 2010 levels.
- AUO participates in the Product Attribute to Impact Algorithm (PAIA) Project to develop lifecycle impact calculation tools for LCDs, capturing F-GHG emissions information.
- AUO has engaged in developing the SF<sub>6</sub> abatement verification methodology for LCD industries in Taiwan.
- AUO received 9.41 million tons of tradeable carbon credits by the Taiwan EPA for its early action on PFC reductions and third party verification of its F-GHG abatement.

# VERIFICATION STATEMENT OF GREENHOUSE GAS ASSERTIONS

Statement No.:  
00012-2016-AG-TWN-Rev.1

Issued date:  
5 May, 2016

Page 1 of 4

This is to verify initiate reporting of Greenhouse Gas Inventory Management Report (2015) of

## AU Optronics Corporation

### Scope of Verification

DNV GL Business Assurance (DNV GL) has been commissioned by AU Optronics Corporation to perform a verification of the greenhouse gas assertion of Greenhouse Gas Inventory Management Report (2015) (hereafter the "Inventory Report") with respect to the sites listed in Appendix.

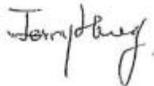
### Verification Criteria and GHG Programme

The verification was performed on the basis of ISO 14064-1:2006 and CNS 14064-1:2006 as well as criteria given to provide for consistent GHG emission identification, calculation, monitoring and reporting.

### Verification Statement

It is DNV GL's opinion that with reasonable assurance the greenhouse gas assertion of the Inventory Report of 4th March, 2016 is free from material discrepancies in accordance with ISO 14064-1:2006 and CNS 14064-1:2006. DNV GL thus requests the registration of the Inventory Report as a GHG inventory demonstration project.

Chien Yi Jerry Huang  
GHG Verifier



Place and date:  
Taipei, 5 May, 2016

For the Issuing office:  
DNV GL Business Assurance Co., Ltd.  
29Fl., No. 293, Sec. 2, Wenhua Rd.,  
Banqiao District, New Taipei City 220,  
Taiwan



Management Representative

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AUO 2013 Corporate Social Responsibility Report (Section 4.2.1, page 61) Available at [http://www.auo.com/upload/download/1/AUO\\_2013\\_CSR\\_EN\\_All.pdf](http://www.auo.com/upload/download/1/AUO_2013_CSR_EN_All.pdf).

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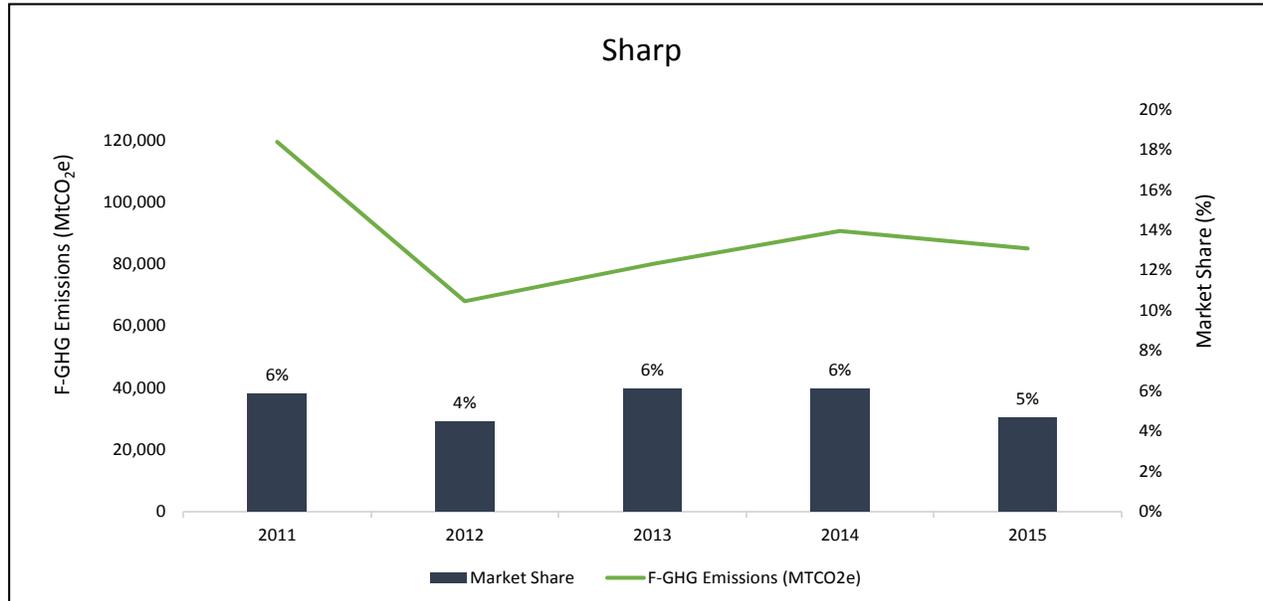
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# Sharp FY2015 Data

5% Market Share

## Emissions Over Time



The chart above shows the following separate but related metrics:

- **Market share** over time shows the size of the Supplier relative to all suppliers in the industry based on area of panels produced.
- **Total emissions** over time show total F-GHGs emitted by the supplier each year. Supplier emissions can change due to the implementation of emissions reduction efforts, an increase or decrease in panel production, and/or LCD technology advancements.
- **Emission intensity**, where available, is a measure of the amount of F-GHG emissions per unit of production. Trends in emission intensity show whether the Supplier's rate of emissions is increasing or decreasing over time and can indicate whether the supplier is implementing emission reduction efforts. Sharp does not publicly report F-GHG emission intensity.

F-GHG emissions are publicly reported by Suppliers through the CDP (formerly "Carbon Disclosure Project") and/or corporate sustainability reports. In this graph market share is calculated based on production data from IHS Technology.

## F-GHG Emissions Reduction Activities

### Overview

- In 2015, Sharp emitted a total of approximately 85,000 MtCO<sub>2</sub>e of F-GHGs, as follows:
  - HFCs: 5,000
  - PFCs: 34,000
  - SF<sub>6</sub>: 37,000

- NF<sub>3</sub>: 9,000 MtCO<sub>2</sub>e

## Gases Targeted

- SF<sub>6</sub>
- PFCs (CF<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, C<sub>4</sub>F<sub>8</sub>)
- HFCs (CHF<sub>3</sub>)
- NF<sub>3</sub>

## Processes Targeted

- Etching
- Cleaning

## Approaches Used

### Abatement

- **Abatement Systems:** Sharp has installed abatement systems on all etching and cleaning process equipment.

### Process Improvements

- **Researching Process Optimization:** Sharp has been researching ways to improve process optimization and manufacturing process conditions at the time that manufacturing equipment is first installed and in daily operations.

### Alternative Chemicals

- **Researching Lower GWP gases:** Sharp has been collecting the latest information from relevant sources and researching the possibility of using lower GWP alternative gases.

### Recycling/Reuse

- Sharp implements the recycling of F-GHGs in some manufacturing processes.

## Emissions Measurement Approaches and Verification

- Sharp estimates F-GHG emissions based on the Tier 2b method for electronics industry emissions provided in the [2006 IPCC Guidelines for National Greenhouse Gas Inventories](#).
- Sharp's Sustainability Report is audited by a third-party organization.

## Emission Reduction Goals and Progress

- Sharp works to reduce F-GHG emissions in accordance with the targets of [Ministry of Economy, Trade and Industry](#); the [Japan Electronics and Information Technology Industries Association \(JEITA\)](#); and other industrial associations.
- Sharp set a goal to reduce annual GHG emissions to below FY2007 baseline emissions levels for ten manufacturing fabrication facilities (fabs) by 2011.
- Sharp set a goal to reduce GHG emissions intensity per adjusted production unit (tons of CO<sub>2</sub>e/100 million yen) by 35% across the ten fabs by 2012. By end of fiscal year 2011, Sharp met both of its goals and reduced total emissions by 40% and emissions intensity by 42%.

- In fiscal year 2015, the Sharp Group's GHG emissions decreased by 15% compared to the previous fiscal year.

## Participation in Broader F-GHG Reduction Efforts

- Sharp is a member of the [Japan Electronics and Information Technology Industries Association \(JEITA\)](#), which participates on behalf of Japan's LCD suppliers in the World Display device Industry Cooperation Committee (WDICC).

## Sources

*Japan Electronics and Information Technology Industries Association (JEITA). See*

<http://www.jeita.or.jp/english/>.

*Nishida, et al. PFC Emission Reduction Strategy for the LCD Industry. Journal of the SID 13/10. 2005*

*Sharp (Sharp Corporation).*

*Sustainability Report 2016 by the Sharp Corporation, page 21. Available at: [\[world.com/corporate/eco/report/ssr/pdf/ssr2016e.pdf\]\(http://www.sharp-world.com/corporate/eco/report/ssr/pdf/ssr2016e.pdf\).](http://www.sharp-</a></i></p></div><div data-bbox=)*

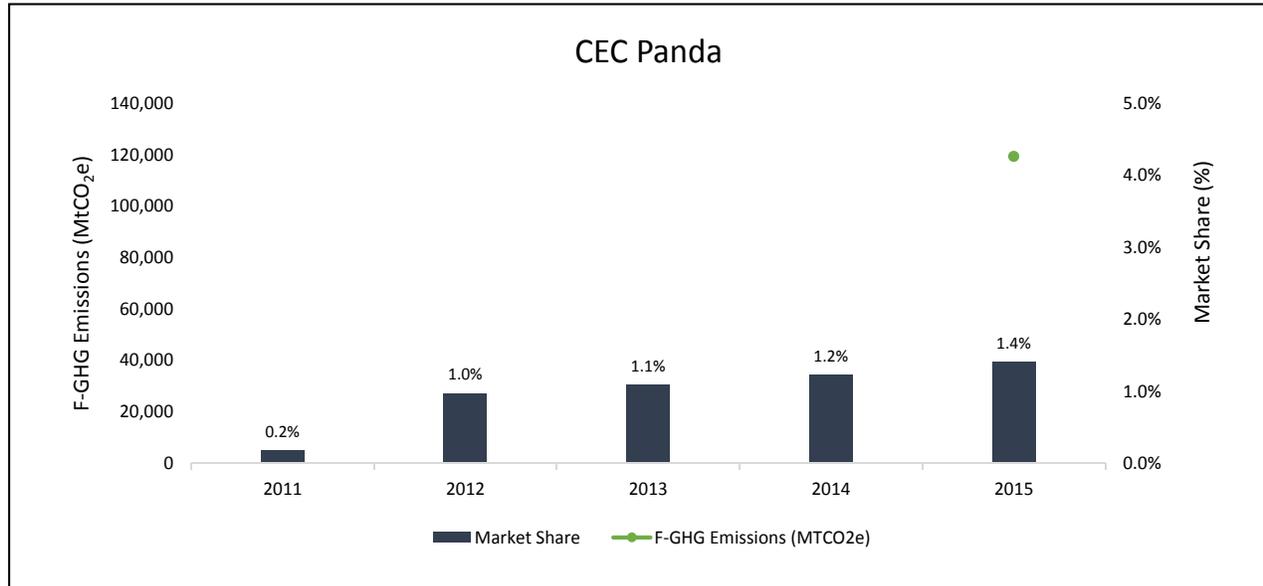
*Sustainability Report 2016 by the Sharp Corporation. Available at:*

<http://www.sharp.co.jp/corporate/eco/report/ssr/index.html>.

# CEC Panda FY2015 Data

1% Market Share

## Emissions Over Time



The chart above shows the following separate but related metrics:

- **Market share** over time shows the size of the Supplier relative to all suppliers in the industry based on area of panels produced.
- **Total emissions** over time show total F-GHG emissions by the supplier each year. Supplier emissions can change due to the implementation of emissions reduction efforts, an increase or decrease in panel production, and/or LCD technology advancements.
- **Emission intensity**, where available, is a measure of the amount of F-GHG emissions per unit of production. Trends in emission intensity show whether the Supplier's rate of emissions is increasing or decreasing over time and can indicate whether the supplier is implementing emission reduction efforts. CEC Panda does not publicly report F-GHG emission intensity.

F-GHG emissions are publicly reported by Suppliers through the CDP (formerly "Carbon Disclosure Project") and/or corporate sustainability reports. In this graph, market share is calculated based on production data from IHS Technology.

## F-GHG Emission Reduction Activities

### Overview

- 2015 is the first year that CEC Panda has reported F-GHG emissions to the CDP.
- In 2015, CEC Panda emitted a total of approximately 119,287 MtCO<sub>2</sub>e of F-GHG emissions, as follows:
  - HFCs: 58,381
  - PFCs: 8,758

SF<sub>6</sub>: 13,002  
NF<sub>3</sub>: 39,146

### Gases Targeted

*No information is available on gases targeted by CEC Panda's F-GHG emission reduction activities.*

### Processes Targeted

*No information is available on processes targeted by CEC Panda's F-GHG emission reduction activities.*

### Approaches Used

*No information is available on approaches used by CEC Panda to reduce F-GHG emissions.*

## Emissions Measurement Approaches and Verification

- CEC PANDA estimates its F-GHG emissions based on the Tier 2b method provided by the [2006 IPCC Guidelines for National Greenhouse Gas Inventories](#) for electronics industry emissions.
- CEC PANDA has not undergone third party verification or assurance for its reported Scope 1 emissions, which include F-GHG emissions, for its calendar year 2015 GHG inventory data.

## Emission Reduction Goals and Progress

*CEC Panda does not have or disclose GHG reduction goals and activities.*

## Participation in Broader F-GHG Reduction Efforts

*No information is available on CEC Panda's participation in broader F-GHG reduction efforts.*

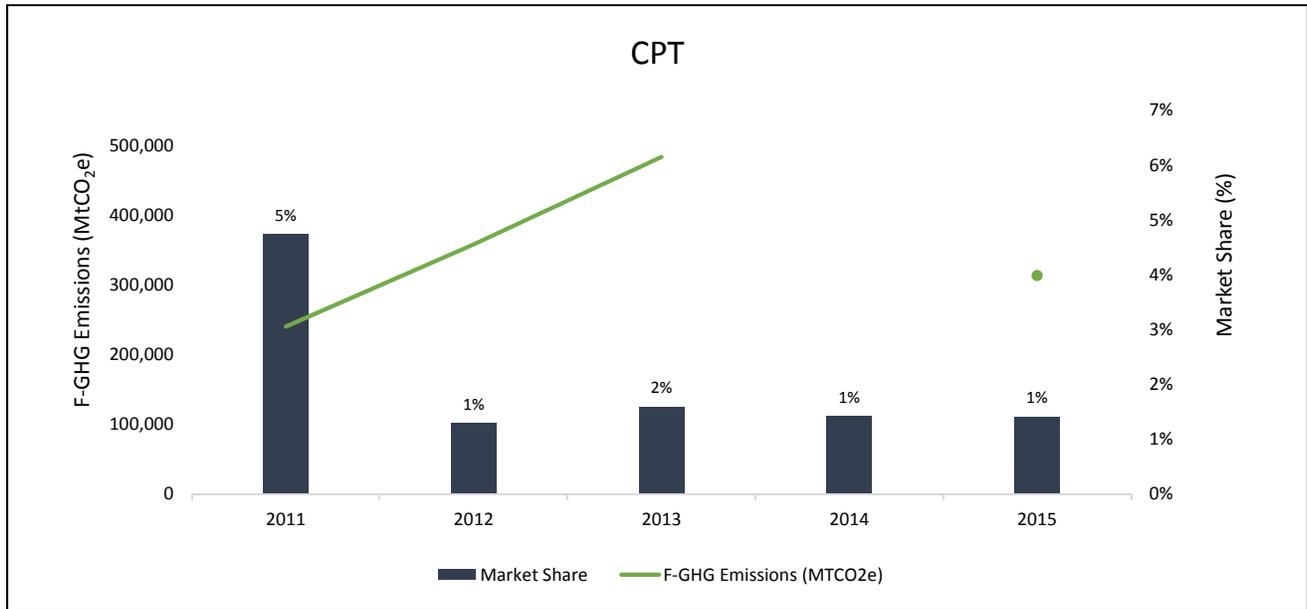
## Sources

*CEC PANDA's responses to the 2016 CDP Investor Questionnaire*

# Chunghwa Picture Tubes (CPT) FY2015 Data

1% Market Share

## Emissions Over Time



The chart above shows the following separate but related metrics:

- **Market share** over time shows the size of the Supplier relative to all suppliers in the industry based on area of panels produced.
- **Total emissions** over time show total F-GHGs emitted by the supplier each year. Supplier emissions can change due to the implementation of emissions reduction efforts, an increase or decrease in panel production, and/or LCD technology advancements.
- **Emission intensity**, where available, is a measure of the amount of F-GHG emissions per unit of production. Trends in emission intensity show whether the Supplier’s rate of emissions is increasing or decreasing over time and can indicate whether the supplier is implementing emission reduction efforts. CPT does not publicly report F-GHG emission intensity.

F-GHG emissions are publicly reported by Suppliers through the CDP (formerly “Carbon Disclosure Project”) and/or corporate sustainability reports. In this graph, market share is calculated based on production data from IHS Technology.

## F-GHG Emission Reduction Activities

### Overview

- In 2015, CPT emitted approximately 313,000 MtCO<sub>2</sub>e of F-GHGs, a 62% reduction from 2008, but an increase from 2014.

- CPT reduced F-GHG emissions by approximately 30 million MtCO<sub>2</sub>e between 2002 and 2014. This is equivalent to removing 6.3 million vehicles from the road for one year.<sup>3</sup>

## Gases Targeted

- SF<sub>6</sub>
- PFCs
- HFCs
- NF<sub>3</sub>

## Processes Targeted

- Etching
- Cleaning

## Approaches Used

### Abatement

- **Abatement Systems:** CPT has installed abatement systems in all newer generation fabrication facilities (fabs).

### Process Improvements

- **PFC Reduction:** In 2014, CPT implemented PFC reduction methods and evaluated process equipment, targeting its 4.5 generation fabs, an earlier generation of fabs built prior to 2004.
- **Cleaning Process:** CPT completed reconstruction of the cleaning process in their Taoyuan and Longtan plants, resulting in a 38% emission reduction of fluorinated compounds in 2014 from 2010 levels, equal to approximately 170,000 MtCO<sub>2</sub>e of carbon dioxide.

### Alternative Chemicals

- **SF<sub>6</sub> Replacement:** CPT is using lower GWP gases, where possible. For example, CPT continues to implement carbon reduction activities by replacing SF<sub>6</sub> with NF<sub>3</sub> in cleaning processes.

## Emissions Measurement Approaches and Verification

- CPT estimates its F-GHG emissions based on the Tier 2b method provided by the [2006 IPCC Guidelines for National Greenhouse Gas Inventories](#) for electronics industry emissions.
- CPT's annual GHG inventory undergoes third party verification (verification document included below).

## Emission Reduction Goals and Progress

- CPT set a goal to reduce GHG emissions by 280,000 MtCO<sub>2</sub>e from 2013 to 2016 through process optimization, adoption of dry etch machinery, and installation of tail gas incinerator facilities.
- In 2015, CPT's GHG emissions were 1,127,003 MtCO<sub>2</sub>e, representing a decrease of approximately 354,000 MtCO<sub>2</sub>e or 23.9% compared to 2008 emissions. The majority of CPT's GHG emissions are from F-GHG process emissions and electricity use.

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<sup>3</sup> Calculated using EPA's Greenhouse Gas Equivalencies Calculator, which is available at <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

## Participation in Broader F-GHG Reduction Efforts

- CPT is a member of the Taiwan's [TFT-LCD Association \(TTLA\)](#). The TTLA participates on behalf of Taiwan's LCD suppliers in the World Display device Industry Cooperation (WDICC), whose members have agreed to 30% F-GHG emission reductions by 2020 relative to 2010 levels. CPT will work with TTLA to provide regular emission information of fluorinated compounds, and engage in reductions of fluorinated compounds.

# VERIFICATION STATEMENT OF GREENHOUSE GAS ASSERTIONS

Statement No.:  
00006-2016-AG-TWN-Rev.1

Issued date:  
30 December, 2016

Page 1 of 2

This is to verify initiate reporting of Greenhouse Gas Inventory Management Report (2015) of

## CHUNGHWA PICTURE TUBES LTD.

### Scope of Verification

DNV GL Business Assurance (DNV GL) has been commissioned by CHUNGHWA PICTURE TUBES LTD. to perform a verification of the greenhouse gas assertion of Greenhouse Gas Inventory Management Report (2015) (hereafter the "Inventory Report") with respect to the following area:

Taoyuan: No.1127, Heping Rd., Bade Dist., Taoyuan City, Taiwan, R.O.C.  
Lungtan: No.1, Huaying Rd., Longtan Dist., Taoyuan City, Taiwan, R.O.C.  
Yangmei: No.80, Xingshan Rd., Yangmei Dist., Taoyuan City, Taiwan, R.O.C.  
Wujiang (CPTW) :No. 88 Jiang Xing East RD., Wujiang Economic Technology Development Zone,jiangsu Province,China, P.R.C.  
Fujian (FDT) : No. 6 Rujiang West Road,Mawei Hi-tech Development Zone, Fuzhou,China, P.R.C.  
CPTF: No. 1 Xing Ye Road Mawei Hi-tech Development Zone, Fuzhou,China, P.R.C.  
FVD: No. 1 Xing Ye Road Mawei Hi-tech Development Zone, Fuzhou,China, P.R.C.  
CTOC: Shangzheng,Yuanhong Road,Fuqing City, Fujian Province,China, P.R.C.

### Verification Criteria and GHG Programme

The verification was performed on the basis of ISO 14064-1:2006 and CNS 14064-1:2006 as well as criteria given to provide for consistent GHG emission identification, calculation, monitoring and reporting.

### Verification Statement

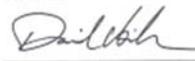
It is DNV GL's opinion that with reasonable assurance the greenhouse gas assertion of the Inventory Report of July 22, 2016 is free from material discrepancies in accordance with ISO 14064-1:2006 and CNS 14064-1:2006. DNV GL thus requests the registration of the Inventory Report as a GHG inventory demonstration project.

Jerry Huang  
GHG Verifier



Place and date:  
Taipei, 30 December, 2016

For the issuing office:  
DNV GL Business Assurance Co., Ltd.  
29Fl, No. 293, Sec. 2, Wenhua Rd.,  
Banqiao District, New Taipei City 220,  
Taiwan



Management Representative

## Supplement to Statement

### Process and Methodology

The reviews of the Inventory Report and the subsequent follow-up interviews have provided DNV GL with sufficient evidence to determine the fulfilment of stated criteria. The Inventory Report correctly complies with the requirement of ISO 14064-1:2006 and CNS 14064-1:2006.

### Quantification of Greenhouse Gas Emission

The Inventory Report covering the period 1<sup>st</sup> January, 2015 to 31<sup>st</sup> December, 2015 it is DNV GL's opinion that the Inventory Report results in quantification of GHG emissions that are real, transparent and measurable.

### Organizational Boundary of Verification

Financial Management Control  Operational Management Control  Equity Share

### GHGs Verified

CO<sub>2</sub>  CH<sub>4</sub>  N<sub>2</sub>O  HFCs  PFCs  SF<sub>6</sub>  NF<sub>3</sub>

Total Direct Emissions: 562,044.68 Tonnes CO<sub>2</sub>-e

Total Energy Indirect Emissions: 564,958.60 Tonnes CO<sub>2</sub>-e

The Indirect Emissions was calculated based on 2014 electricity emission factor of 0.528 kg CO<sub>2</sub>-e/kwh, which was announced on 17<sup>th</sup> June, 2016 by Bureau of Energy, Ministry of Economic Affairs. The Global Warming Potential (GWP) defined in IPCC AR4 (2007) has been chosen and correctly referred by the Organization.

### Verification Opinion

Verified without Qualification  
 Unable to Verify

## Sources

CPT 2014 Corporate Sustainability Report (page 28)

[http://www.cptt.com.tw/cptt/english/html/2014\\_ebook\\_CSR\\_EN/index.html#p=32](http://www.cptt.com.tw/cptt/english/html/2014_ebook_CSR_EN/index.html#p=32).

CPT 2015 Corporate Sustainability Report (page 42)

[http://www.cptt.com.tw/cptt/english/html/2015\\_ebook\\_CSR\\_EN/index.html#p=42](http://www.cptt.com.tw/cptt/english/html/2015_ebook_CSR_EN/index.html#p=42).

CPT direct communications.

CPT's responses to the 2009 Carbon Disclosure Project Supply Chain Questionnaire.

CPT's Responses to the 2015 CDP Investor Questionnaire. Available at

<https://www.cdp.net/sites/2015/45/22645/Climate%20Change%202015/Pages/DisclosureView.aspx>.

CPT Website : [http://www.cptt.com.tw/cptt/english/images/stories/08\\_CSR/CSR\\_07/GHG.pdf](http://www.cptt.com.tw/cptt/english/images/stories/08_CSR/CSR_07/GHG.pdf).

CPT Website: Environmental Management:

[www.cptt.com.tw/index.php?option=com\\_content&task=view&id=447&Itemid=180](http://www.cptt.com.tw/index.php?option=com_content&task=view&id=447&Itemid=180).

EPA's Greenhouse Gas Equivalencies Calculator. Available at <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>.

"SF<sub>6</sub> Abatement Strategy in Taiwan". Presentation by Taiwan's Industrial Technology Research Institute (ITRI), 2004. Available at [www.epa.gov/electricpower-sf6/documents/conf04\\_lu.pdf](http://www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf).

TTLA presentation at APEC meeting, August 2012, Taiwan.

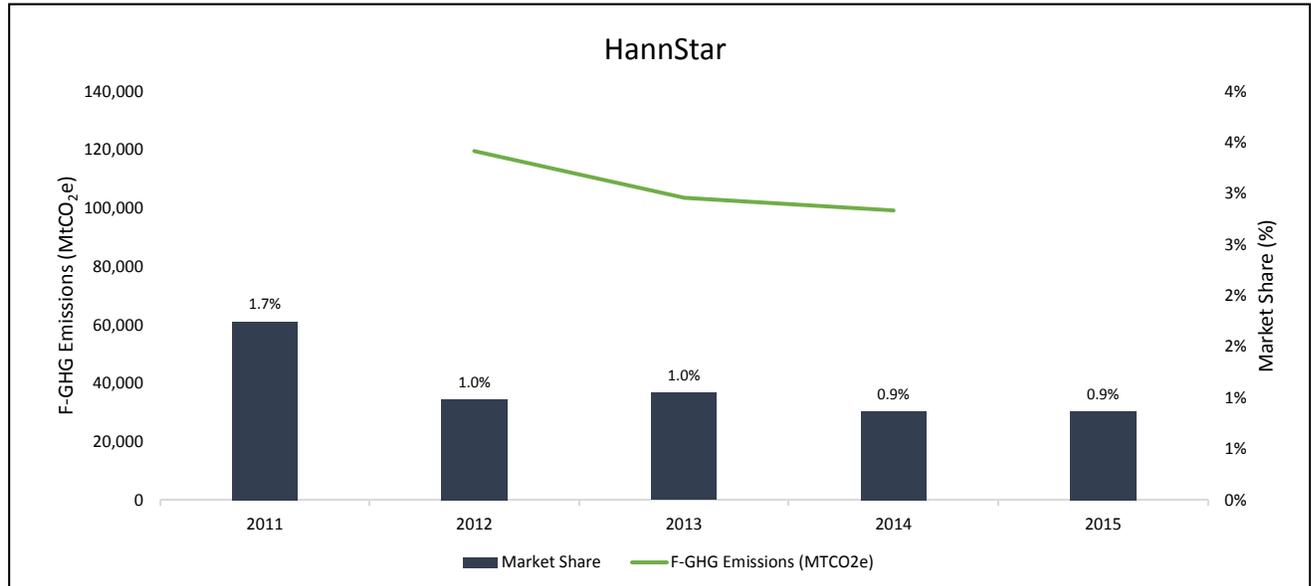
World Display device Industry Cooperation Committee Environmental Report. Available at

[http://home.jeita.or.jp/device/committee/pdf/Environmental%20Report\\_ENG\\_161110.pdf](http://home.jeita.or.jp/device/committee/pdf/Environmental%20Report_ENG_161110.pdf).

# HannStar FY2015 Data

1% Market Share

## Emissions Over Time



The chart above shows the following separate but related metrics:

- **Market share** over time shows the size of the Supplier relative to all suppliers in the industry based on area of panels produced.
- **Total emissions** over time show total F-GHGs emitted by the supplier each year. Supplier emissions can change due to the implementation of emissions reduction efforts, an increase or decrease in panel production, and/or LCD technology advancements.
- **Emission intensity**, where available, is a measure of the amount of F-GHG emissions per unit of production. Trends in emission intensity show whether the Supplier's rate of emissions is increasing or decreasing over time and can indicate whether the supplier is implementing emission reduction efforts. HannStar does not publicly report F-GHG emissions.

F-GHG emissions are publicly reported by Suppliers through the CDP (formerly "Carbon Disclosure Project") and/or corporate sustainability reports. In this graph, market share is calculated based on production data from IHS Technology.

## F-GHG Emission Reduction Activities

### Overview

- HannStar reduced approximately 1.55 MtCO<sub>2</sub>e of F-GHG emissions from 2007-2015.
- HannStar's total GHG emission intensity from flat panel manufacturing processes remained mostly unchanged from 0.069 in 2014 to 0.070 MtCO<sub>2</sub>e/m<sup>2</sup> in 2015.

## Gases Targeted

- SF<sub>6</sub>
- NF<sub>3</sub>

## Processes Targeted

- Etching
- Cleaning

## Approaches Used

### Abatement

- **Local Scrubber:** HannStar has installed a high efficiency local scrubber to reduce emissions of SF<sub>6</sub>, NF<sub>3</sub> and other PFCs.
- **Abatement Systems:** HannStar has installed abatement systems in all newer generation fabrication facilities (fabs).

### Process Improvements

- Hannstar is optimizing the use of F-GHGs in the process chambers. Additional details not available.

### Alternative Chemicals

- HannStar is using lower GWP gases, where possible. Additional details not available.

## Emissions Measurement Approaches and Verification

- HannStar estimates F-GHG emissions based on the Tier 2b method for electronics industry emissions provided in the [2006 IPCC Guidelines for National Greenhouse Gas Inventories](#).
- HannStar's plants in Taiwan have been developing GHG inventories and implementing third party verification with reference to [ISO 14064-1](#) since 2005.
- HannStar's plants in China have been developing GHG inventories since 2012, but have not had these inventories verified by a third party.

## Emission Reduction Goals and Progress

- Since HannStar's GHG emissions are mostly due to electricity consumption and the use of F-GHGs in flat panel display manufacturing, the company has focused its GHG reduction efforts on these two areas.
- HannStar applied for GHG early action offset credits based on the Taiwan EPA's Principles for Promoting Greenhouse Gas Pilot and Offset Projects and the Announced GHG Emission Intensity for TFT-LCD Industry.
- In 2015, Taiwan's EPA awarded Hannstar 3.78 million tons of carbon credits for their early action in voluntary GHG reductions.

## Participation in Broader F-GHG Reduction Efforts

- HannStar is a member of Taiwan's [TFT-LCD Association \(TTLA\)](#). The TTLA participates on behalf of Taiwan's LCD suppliers in the World Display device Industry Cooperation (WDICC), whose members have agreed to 30% F-GHG emission reductions by 2020 relative to 2010 levels.

## Sources

*HannStar "SF<sub>6</sub> Abatement Strategy in Taiwan". Presentation by Taiwan's Industrial Technology Research Institute (ITRI), 2004. Available at: [www.epa.gov/electricpower-sf6/documents/conf04\\_lu.pdf](http://www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf).*

*TTLA presentation at APEC meeting, August 2012, Taiwan.*

*HannStar World Display device Industry Cooperation Committee Environmental Report. Available at [http://home.jeita.or.jp/device/committee/pdf/Environmental%20Report\\_ENG\\_161110.pdf](http://home.jeita.or.jp/device/committee/pdf/Environmental%20Report_ENG_161110.pdf).*

# Suppliers Without Public Data in 2015

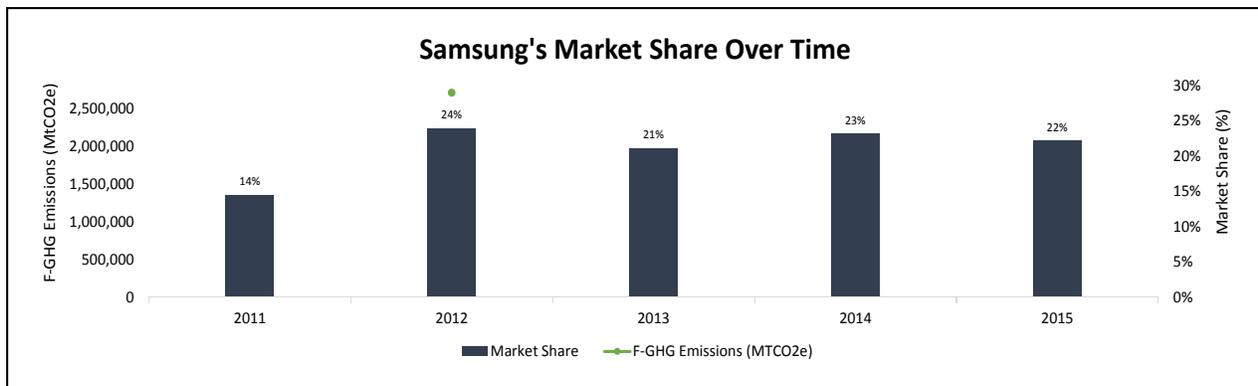
Samsung, BOE, China Star, and Inovision did not report public data in 2015. As a result:

- No information is available these suppliers' F-GHG emission reduction activities, including on gases targeted, processes targeted, or approaches used.
- These suppliers do not publicly measure or verify F-GHG emissions.
- These suppliers do not have or disclose emission reduction goals and progress.
- No information is available on these suppliers' participation in broader F-GHG reduction efforts, except for Samsung, which is subject to Korea's regulatory requirements to reduce GHG emissions.

Below, the suppliers are listed based on their 2015 market share:

## Samsung

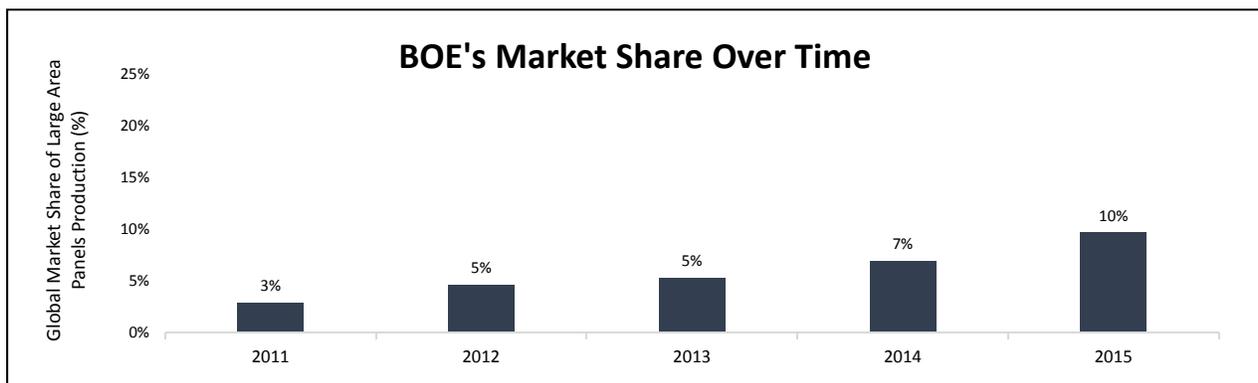
*22% Market Share in 2015*



Information for calendar year 2012 can be found in a [previous profile](#), hence the inclusion of emissions data information for Samsung here.

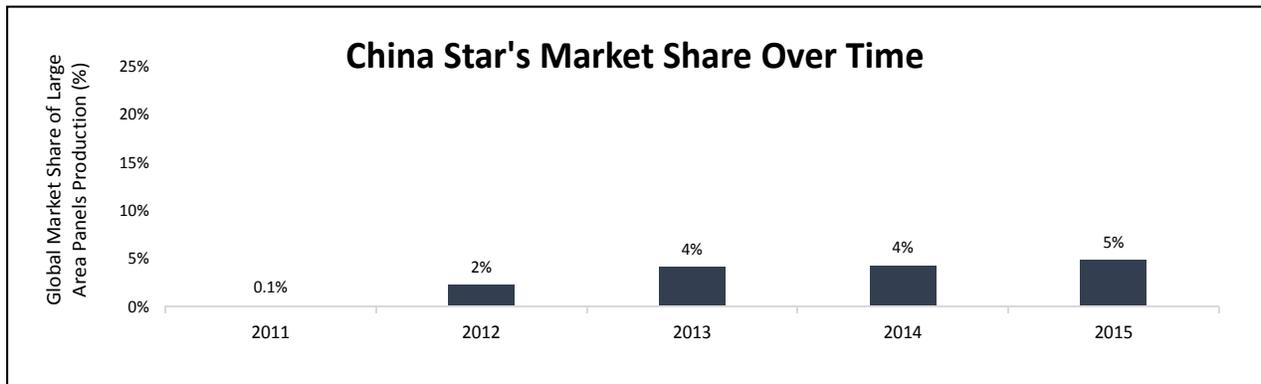
## BOE

*10% Market Share in 2015*



# China Star

5% Market Share in 2015



# Infovision

1% Market Share in 2015

