

## F-GHG Emissions Reduction Efforts: Flat Panel Display Supplier Profiles

### Introduction

U.S. Environmental Protection Agency  
Office of Air and Radiation  
May 2013

Fluorinated greenhouse gases (F-GHGs) are among the most potent and persistent greenhouse gases (GHGs) contributing to global climate change. These gases play a vital role in the manufacture of flat panel displays--most commonly liquid crystal display (LCD) panels-- that go into televisions, computer monitors, and many other display products. The overall climate impact of the millions of display products Americans use can be greatly reduced if suppliers of these components take steps to mitigate releases of these F-GHGs to the atmosphere.

Over the last decade, many key flat panel display manufacturers have undertaken commendable voluntary efforts to reduce their F-GHG emissions. In the interest of encouraging further emissions reductions, the U.S. Environmental Protection Agency (EPA) is profiling efforts by flat panel display suppliers to reduce their F-GHG emissions, consistent with its purpose of sharing industry best practices and emerging efforts to reduce corporate GHG emissions through its Center for Corporate Climate Leadership.

EPA assembled the information presented in each profile from publicly available sources, including suppliers' corporate sustainability reports and their responses to the Carbon Disclosure Project's Investor or Supply Chain questionnaire, and from information provided by the suppliers themselves or by trade associations representing the flat panel display industry. Where information on suppliers' F-GHG emissions reduction efforts was assembled, suppliers then had the opportunity to review their draft profiles and provide feedback before profiles were completed. EPA intends to update the following profiles from all flat panel suppliers on an as-needed basis when new information or updates to existing information become available.

To better understand the information presented, below are some key points to consider.

#### **Definitions:**

- Flat Panel Displays: Today flat panel displays that use F-GHGs during manufacturing are mostly liquid crystal display (LCD) panels. Some suppliers refer specifically to LCD manufacturing when describing their efforts to reduce F-GHG use in production. For purposes of capturing future products or other displays that may use F-GHGs in production, EPA has opted to use the broader term of 'flat panel displays' instead of 'LCDs.' To EPA's knowledge, production of OLEDs uses F-GHGS but production of plasma displays does not use them.

- F-GHGs and PFCs: The F-GHG emissions of primary concern are from perfluorocarbons (PFCs), trifluoromethane (CHF<sub>3</sub> or HFCs), nitrogen trifluoride (NF<sub>3</sub>), and sulfur hexafluoride (SF<sub>6</sub>); these are sometimes collectively called perfluorocompounds (also termed PFCs). In some publicly available information, suppliers use the term 'PFCs' instead of 'F-GHGs' to refer to all of their F-GHGs used. EPA has chosen to use the term 'F-GHGs' instead of 'PFCs' (for perfluorocompounds) to address all known F-GHGs used in flat panel display manufacturing.
- Fab: Fabrication facility for panel production.

### **F-GHGs in the Context of Corporate GHG Inventories and Reporting:**

Many flat panel display suppliers have implemented corporate-wide GHG emissions reduction goals and developed GHG inventories, encompassing both Scope 1 emissions, namely those from on-site combustion and processes, and Scope 2 emissions, those from purchased electricity and/or steam. The F-GHG emissions used in flat panel manufacturing reflect a subset of suppliers' Scope 1 emissions and are usually referenced in terms of CO<sub>2</sub> equivalent (CO<sub>2</sub>e).

### **Key Manufacturing Processes to Consider**

Panel etching and CVD chamber cleaning are the key processes that use F-GHGs in manufacturing flat panel displays.

Fluorinated heat transfer fluids (HTFs) are often used to cool equipment, resulting in emissions due to evaporative losses. Some manufacturers indicate that they do not use such fluorinated HTFs, or that emissions from fluorinated HTFs are minimal compared to those from etching and chamber cleaning processes. EPA is interested in understanding the extent to which such HTFs are used, how their potential emissions compare to those resulting from other key processes, and options for reducing F-GHG emissions from their use. EPA has also learned that N<sub>2</sub>O (not an F-GHG, but another GHG which has a GWP of 300) is also used in flat panel display manufacturing, both in the CVD process and in combustion. EPA is also interested in understanding the role of N<sub>2</sub>O in flat panel display manufacturing and current and emerging opportunities to reduce N<sub>2</sub>O emissions from manufacturing, alongside reducing F-GHG emissions.

### **Reducing F-GHG Emissions**

Over the last decade, electronics manufacturers have made significant progress in identifying effective technological solutions to reducing F-GHG emissions. The following approaches to reducing F-GHG emissions from the manufacture of flat panels are in use today or are being explored:

1. **Process improvements/source reduction:** Manufacturers optimize their processes to use F-GHGs more efficiently, especially in CVD clean processes, resulting in smaller amounts of gas that are unreacted and emitted.
2. **Alternative chemicals:** Manufacturers use alternative gases that are more efficient (more of the applied gas served its intended purpose versus being left unreacted) with a lower global warming potential (GWP) to accomplish the same result. For example, many manufacturers have modified certain key processes to use  $\text{NF}_3$  instead of  $\text{SF}_6$ ;  $\text{NF}_3$  is a replacement gas for in-situ use for CVD and is also used in CVD remote plasma chamber cleaning. Though  $\text{NF}_3$  still has very high GWP of 17,200, it is lower than that of  $\text{SF}_6$  (which has a GWP of nearly 23,000) and is used more efficiently. Some companies are piloting the use of  $\text{F}_2$  to replace  $\text{NF}_3$  in the remote plasma chamber cleaning process and are seeking to surmount some of challenges associated with transport, storage and use of  $\text{F}_2$ .
3. **Capture and beneficial reuse:** Manufacturers capture F-GHGs and process them to remove impurities and refine them for reuse. Some suppliers are evaluating the opportunities; however, reuse/recycling has so far not been implemented widely due to limitations on the effectiveness and cost of available recycling technologies.
4. **Abatement via gas destruction technologies:** Both *point-of-use abatement*, where the abatement system is attached to a process tool(s), and *centralized abatement systems*, where gases are sent to, and destroyed in, a centralized system, are being used by major panel suppliers. Abatement remains one of the most effective ways to reduce the majority of F-GHG emissions. There are many different types of destruction technologies that are used to abate F-GHGs, however, most abatement systems today use combustion.

#### **Measuring Emissions and Monitoring Abatement Systems:**

Measuring the efficiency of an installed abatement system to destroy or remove gases such as F-GHGs--known as the destruction or removal efficiency (DRE)-- directly relates to how suppliers can account for their annual F-GHG emissions and subsequent reductions. Most suppliers today use default factors from the 2006 IPCC Guidelines to account for the DRE of abatement systems. However, suppliers may also directly measure DREs using measurement guidelines or protocols. An example of such a protocol is EPA's "Protocol for Measuring Destruction or Removal Efficiency (DRE) of Fluorinated Greenhouse Gas Abatement Equipment in Electronics Manufacturing" (EPA's DRE Protocol). Published in 2010 and internationally peer-reviewed, EPA's DRE Protocol provides a reliable method for measuring DRE's of point-of-use abatement systems for F-GHGs used during the manufacture of electronics. In other cases, for both point of use and centralized abatement systems, suppliers may monitor their systems on an ongoing basis, especially in the case of Clean Development Mechanism (CDM) projects, to acquire on-site real-time data. Suppliers may also test their abatement systems by monitoring specific

parameters such as temperature, process gas and exhaust gas flow rate. Going forward, EPA anticipates that this effort will enable sharing of best practices regarding measurement and move the industry to produce reliable estimates of abatement systems' DREs.

### **Voluntary F-GHG reduction efforts:**

Flat panel display suppliers are to be commended for undertaking F-GHG reductions voluntarily, as many companies have been implementing F-GHG emissions reductions for over a decade. Most suppliers represented in the following profiles have been participating, through their respective trade associations, in the World LCD Industry Cooperation Committee (WLICC), which agreed to voluntary reduction activities in 2001-2010 that would reduce 2000 baseline levels by approximately 90 percent down to 0.82 MMTCE<sup>1</sup>. To meet the reduction goal, many suppliers in participating countries implemented strategies to address their emissions including installing abatement technologies on production lines in their newer generation fabs, namely those built within the last decade. As a result, F-GHG emissions were reduced by 10.1 MMTCE, to where aggregate emissions totaled 1.75 MMTCE. Though these reductions demonstrated significant accomplishments, the WLICC fell short of its goal due to a rise in emissions resulting from a rapid increase in production for LCD panels that were integrated into products such as televisions faster than initially anticipated<sup>2</sup>.

Since the WLICC set its goals, newer suppliers with growing market share—those who have not participated in the WLICC's F-GHG reduction efforts to date-- have also emerged and information on their F-GHG emissions reductions efforts is currently unknown. In addition, it appears that some key suppliers, are still in varying stages of implementing comprehensive F-GHG emission reductions efforts across their fabs. As worldwide demand for flat panels continue to increase, F-GHG emissions are also projected to rise. To mitigate those emissions, it is important that reduction efforts across all major panel suppliers are implemented.

### **Suppliers:**

Currently, twelve suppliers (listed below) are the major producers of large-area flat panel displays used to make TVs and display products. The profiles that follow highlight efforts of these suppliers to reduce their F-GHG emissions in flat panel manufacturing across key areas covering mitigation measures and goals, the extent of their reduction efforts (whether they include all processes and gases used), the extent to which

<sup>1</sup> Sources: Nishida, et al. *PFC Emission Reduction Strategy for the LCD Industry*. Journal of the SID 13/10. 2005 and *WLICC Working Group 1 Activity Report on the 2012 FCs Reduction*. World LCD Industry Cooperation Committee. November 10, 2011, Tokyo [http://home.jeita.or.jp/device/committee/kankyoku/pdf/20111110WLICC\\_e.pdf](http://home.jeita.or.jp/device/committee/kankyoku/pdf/20111110WLICC_e.pdf).

<sup>2</sup> Source: *WLICC Working Group 1 Activity Report on the 2012 FCs Reduction*. World LCD Industry Cooperation Committee. November 10, 2011, Tokyo [http://home.jeita.or.jp/device/committee/kankyoku/pdf/20111110WLICC\\_e.pdf](http://home.jeita.or.jp/device/committee/kankyoku/pdf/20111110WLICC_e.pdf).

abatement technologies are installed on newer fabs, and public disclosure of F-GHG emissions and/or emissions reductions. Profiles were only developed for suppliers where information on their F-GHG emissions reduction efforts in flat panel manufacturing was publicly available.

AU Optronics (AUO)

BOE Technology

CEC-Panda

ChinaStar

Chunghwa Picture Tubes (CPT)

HannStar

Infovision

INX (Innolux, formerly CMI)

LG Display

Panasonic

Samsung Display

Sharp

## AUO (AU Optronics)

### Overview

Specific F-GHG emissions reduction efforts and/or goals

AUO reduced manufacturing emissions, namely F-GHGs, by 6.94 million metric tons of CO<sub>2</sub>e from 2003-2011. AUO considers itself a pioneer of F-GHG abatement in Taiwan. Since 2003, AUO voluntarily installed IPCC-recognized F-GHG abatement devices with destruction removal efficiencies (DRE) over 90 percent in dry etching and chemical vapor deposition (CVD) processes for all newly built fabs to reduce emissions from gases such as SF<sub>6</sub> and NF<sub>3</sub>.

In 2011, AUO planned to begin installing abatement systems for fabs constructed prior to 2003. AUO is now the only member in WLICC that invested abatement system in all small to medium-sized LCD fab ranging from G3.5 to G5.

Sources:

*AUO 2011 Corporate Social Responsibility Report.*

*([http://auo.com/upload/download/1/AUO\\_2011\\_CSR\\_EN\\_CH2\\_v1.pdf](http://auo.com/upload/download/1/AUO_2011_CSR_EN_CH2_v1.pdf)).*

*AUO 2010 Corporate Social Responsibility Report.*

*([http://auo.com/upload/download/1/AUO\\_2010\\_CSR\\_EN\\_CH2\\_v0.pdf](http://auo.com/upload/download/1/AUO_2010_CSR_EN_CH2_v0.pdf)).*

*AUO's responses to the 2012 Carbon Disclosure Project Investor Questionnaire.*

+ F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHGs

Etch and Clean processes.

On fluorinated heat transfer fluids (HTFs): AUO follows the "Guidance for Greenhouse Gas Accounting and Reporting for GHG inventory" published by Taiwan's Environmental Protection Administration. In the guidance, HTFs are listed as emission sources for semiconductor industry, but not for optoelectronics industry, meaning that emissions from HTFs are too minor in AUO's process.

Sources:

*AUO*

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

+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted

SF<sub>6</sub>, PFCs, HFCs, NF<sub>3</sub>.

Source: *AUO's responses to the 2012 Carbon Disclosure Project Investor Questionnaire.*

Participation in national and/or international mandatory and/or voluntary efforts to reduce F-GHG emissions from flat panel display manufacturing

AUO is a member of Taiwan’s TFT-LCD Association (TTLA). TTLA participates on behalf of Taiwan’s LCD suppliers in the World LCD Industry Cooperation Committee (WLICC), an international industry initiative that previously set goals to reduce F-GHG emissions.

In 2004, TTLA and Taiwan’s Environmental Protection Administration signed an MOU where TTLA agreed to choose 2002 as the base year for reducing F-GHG emissions and to reduce F-GHG emissions intensity to 0.0335 tons of CO<sub>2</sub>e/m<sup>2</sup> of glass substrate area by 2010 (this target is TTLA’s collective goal and does not necessarily reflect each individual supplier’s goal).

Recently, the TTLA and Taiwan’s Industrial Development Bureau, Ministry of Economic Affairs signed a “Voluntary GHG Reduction Agreement,” for 2011-2015, which aims to achieve additional GHG reductions by 12 million metric tons of CO<sub>2</sub>e within 5 years. In Taiwan, F-GHG emission reductions by flat panel display manufacturers are still voluntary. However, as of 2012, Taiwan’s EPA listed PFCs, HFCs, and SF<sub>6</sub> (including non-F-GHG CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O) as air pollutants and has indicated that it will implement emissions control measures under the Air Pollution Control Act in the future.

Sources:

*AUO’s responses to the 2012 Carbon Disclosure Project Investor Questionnaire.*

*“SF<sub>6</sub> Abatement Strategy in Taiwan”. Presentation by Taiwan’s Industrial Technology Research Institute (ITRI). ([www.epa.gov/electricpower-sf6/documents/conf04\\_lu.pdf](http://www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf)).*

TTLA

Corporate-wide GHG emissions reduction goals and reduction initiatives

AUO set an intensity goal to reduce its Scope 1 and Scope 2 GHG emissions in all its fabs worldwide by 25 percent from 2010 to 2015, where its most recent base year GHG emissions, based on the 2010 national electricity emission factor, were reported as 69 kg CO<sub>2</sub>e/m<sup>2</sup>. AUO updates its GHG inventory based on the latest national electricity factors published by the Bureau of Energy.

AUO’s “Green Solutions” initiative addresses emissions reductions from all of its manufacturing and other operations, from within its supply chain, and via improved product design to create lower-carbon products. In 2011, AUO began implementing an energy management platform at one LCD panel manufacturing fab, obtaining the ISO 50001 certification, and plans to implement energy efficiency measures in all fabs. In 2010, AUO issued a “Carbon Footprint Reduction Statement,” setting a separate goal to reduce its products’ carbon footprint by 30 percent from 2009 to 2012. AUO has also increased its outreach to its suppliers to encourage them to reduce their own GHG emissions. Since 2007, AUO has been participating in, and publicly reporting on its GHG management efforts to, the Carbon Disclosure Project.

Sources:

*AUO 2011 CSR Corporate Social Responsibility Report, website on AUO’s corporate-wide GHG reduction efforts. ([http://auo.com/upload/download/1/AUO\\_2011\\_CSR\\_EN\\_CH2\\_v1.pdf](http://auo.com/upload/download/1/AUO_2011_CSR_EN_CH2_v1.pdf)).*

*AUO’s responses to the 2012 Carbon Disclosure Project Investor Questionnaire.*

F-GHG Reduction Efforts

Process optimization

AUO’s process experts worked with its SF<sub>6</sub> supplier to investigate ways to reduce the quantity of SF<sub>6</sub> used in dry etching manufacturing processes for manufacture of its TFT-LCD panels. AUO found that by adjusting process parameters, SF<sub>6</sub> consumption could be considerably reduced. For example, at its G6 fab in Taichung, Taiwan, if the fab is in full production capacity, by adjusting relevant process parameters, the amount of SF<sub>6</sub> gas can be reduced by 720 kgs per year, equal to reducing 32,000 metric tons of CO<sub>2</sub> emissions annually. AUO plans to expand this SF<sub>6</sub> reduction scheme across all its fabs, including those located in other regions. In addition, AUO installed flow meters and mass flow controllers at the front of reaction chambers, enabling on-site engineers to reduce unnecessary gas waste in chambers, and improve gas utilization efficiencies.

Source: AUO 2011 Corporate Social Responsibility Report.

Use of alternatives

Though it is more expensive, AUO uses NF<sub>3</sub>, which has a lower global warming potential, instead of SF<sub>6</sub> in clean vapor deposition (CVD) chambers. AUO also started using NF<sub>3</sub> when fabs were newly built. 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.

Source: AUO

Capture and recycling

One fab uses recycling technologies and AUO is currently testing the recycling efficiency at this location. The utilization efficiency of the recycling system is measured directly by monitoring the recycled gas flow.

Source: AUO

Abatement

- + Full or partial installation of abatement systems across all new generation fabs

AUO has installed abatement systems in all newer generation fabs. CVD processes in all fabs are equipped with abatement systems. For dry etching processes, abatement systems have been gradually installed since 2003 on new production lines. Types of abatement technologies being employed include combustion (for CVD, dry etching) and membrane separation technology (for dry etching and is regarded as a recycling technology). AUO uses localized, point of use (POU) abatement systems.

Sources:  
AUO

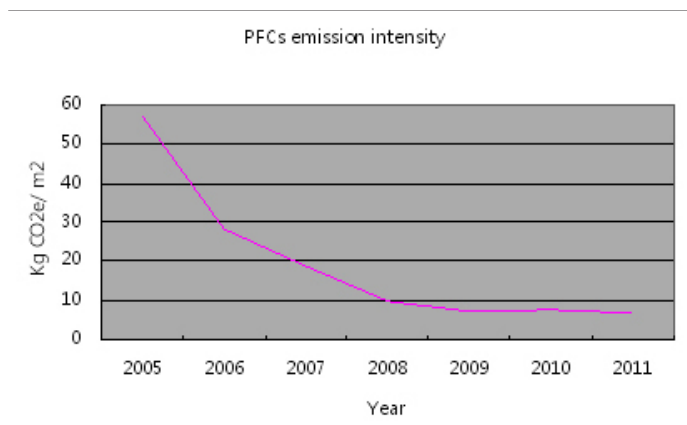
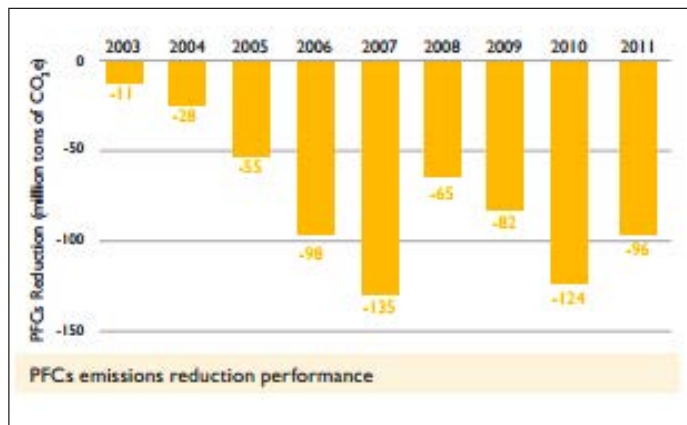
Taiwan Environmental Protection Administration. “The Initiative and Efforts from Electronic Corporations in Taiwan-Semiconductor and TFT-LCD.”  
([http://unfccc.epa.gov.tw/unfccc/english/\\_uploads/downloads/05\\_The\\_Initiative\\_and\\_Efforts\\_form\\_Electronic\\_Industry\\_in\\_Taiwan.pdf](http://unfccc.epa.gov.tw/unfccc/english/_uploads/downloads/05_The_Initiative_and_Efforts_form_Electronic_Industry_in_Taiwan.pdf)).

TTLA presentation at APEC meeting, August 2012, Taiwan.



F-GHG Reduction Efforts	+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	For abatement systems, the destruction or removal efficiency was checked once first installed.  <i>Source: AUO</i>
	+ Indicate whether default factors or actual measurements were used to estimate the DRE  Reported destruction or removal efficiency (DRE)	Default factors used.  AUO applies the 90 percent default DRE value for SF <sub>6</sub> , HFCs and PFCs abatement technologies and the 95 percent default DRE value for NF <sub>3</sub> abatement technologies, taken from the 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions.  <i>Source: AUO</i>
	+ Practices for monitoring abatement systems	When abatement systems were first installed, AUO randomly selected devices from each machine type per site, and measured their utilization efficiencies and DRE using Fourier Transform Infra Red (FTIR). To ensure the effectiveness of the CVD and dry etching abatement systems, both systems were measured even if they were located in the same site. The outcomes of the FTIR measurements were verified by a third party, the Industrial Technology Research Institute of Taiwan (ITRI). However, due to the high cost of FTIR testing, AUO uses an operation recipe instead as a method to monitor abatement devices after installation. Engineers check and record the operation recipe. Parameters include temperature, process gas, and exhaust gas flow rate. By types of devices, different parameters are monitored. For most devices, AUO found that air fuel ratio is a key indicator to determine if more fuel is needed. If the abatement system does not have a thermometer, then the volume of gas flow will become an important indicator.  <i>Source: AUO</i>
F-GHG Emissions Measurements	Total annual F-GHG emissions in CO <sub>2</sub> e, emitted across all flat panel display manufacturing fabs  Include year	The total amount of F-GHG emissions attributed to panel manufacturing is not publicly available.  As part of its <b>2012</b> disclosure to the Carbon Disclosure Project, which discloses GHG emissions from <b>Jan 1, 2011–Dec 31, 2011</b> , AUO lists its total Scope 1 emissions. These Scope 1 emissions represent its organizational boundary, using an operational control approach that includes facilities within Taiwan and in other countries. Its F-GHG emissions, as reported, are as follows, in metric tons of CO <sub>2</sub> e: HFCs emissions: 5,916.42 PFCs emissions: 71,191.19 SF <sub>6</sub> emissions: 217,523.75  <b>Important:</b> The emissions listed cannot be compared to the emissions from other suppliers because they may use different estimation methods and monitoring practices to calculate their emissions. These process emissions may also reflect manufacturing processes that create additional products other than large-area flat panel displays.  <i>Source: AUO's responses to the 2012 Carbon Disclosure Project Investor Questionnaire.</i>

Total annual F-GHG emissions reductions and/or rate of emissions reductions



AUO also estimated that it lowered SF<sub>6</sub> usage per substrate size by approximately 6.65 percent in 2011 compared with 2010.


Sources:  
 AUO 2011 Corporate Social Responsibility Report.  
 AUO's responses to the 2012 Carbon Disclosure Project Investor Questionnaire.

Methodology used to estimate F-GHG emissions

AUO 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.

Source: AUO

AUO's raw data is verified by a third party each year. The page below is part of AUO's "Verification Statement of Greenhouse Gas Assertions" for 2011.



**VERIFICATION STATEMENT OF GREENHOUSE GAS ASSERTIONS**  
 Supplement to Statement No. 00007-2012-AG-TWN  
 Page 3 of 3

**Process and Methodology**  
*The reviews of the Inventory Report and relevant documents, and the subsequent follow-up interviews have provided DNV with sufficient evidence to determine the fulfilment of stated criteria.*

**Quantification of Greenhouse Gas Emission**  
*The Inventory Report covering the period Jan. 1, 2011 to Dec. 31, 2011, it is DNV'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>  
 Total Direct Emissions: 372,887.24 Tonnes CO<sub>2</sub>-e  
 Total Indirect Emissions: 2,603,789.05 Tonnes CO<sub>2</sub>-e

*The fluorinated compounds ("FCs" defined by 2006 IPCC Guidelines) emissions in year 2011 without and with installing abatement equipment were calculated as 1,248,415.02 and 288,714.94 CO<sub>2</sub>e tonnages, respectively, according to a self-declared Tier 2b method referred to 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 3 Industrial Processes and Product Use, Chapter 6 Electronics Industry Emissions.*

*The Global Warming Potential (GWP) defined in IPCC FAR (2007) has been chosen and correctly referred by the Organization.*

**Verification Opinion**  
 Verified without Qualification  
 Unable to Verify

This Verification Opinion is based on the information made available to us and the engagement conditions detailed above. Hence, DNV can not guarantee the accuracy or correctness of the information. DNV can not be held liable by any party relying or acting upon this Verification Opinion.

立思威國際驗證股份有限公司, 新北市 220 板橋區文化路 2 段 293 號 29 樓 TEL: +886 2 82537800

Source: AUO's responses to the 2012 Carbon Disclosure Project Investor Questionnaire.

## BOE Technology Group Co., Ltd.

### Overview

Specific F-GHG emissions reduction efforts and/or goals

Information not available.

+ F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHGs

Information not available.

+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted

Information not available.

Participation in national and/or international mandatory and/or voluntary efforts to reduce F-GHG emissions from flat panel display manufacturing

Information not available.

Corporate-wide GHG emissions reduction goals and reduction initiatives

BOE Technology participates in the Carbon Disclosure Project and most recently publicly reported on its GHG management efforts in 2011 for its 2010 calendar year, which is also the base year for its corporate GHG inventory. BOE developed an energy plan in 2010 and reported having made reductions in energy consumption.

*Source: BOE Technology Group Co., Ltd.'s responses to the 2011 Carbon Disclosure Project Investor Questionnaire.*

**F-GHG Reduction Efforts**

Process optimization	Information not available.
Use of alternatives	Information not available.
Capture and recycling	Information not available.
<b>Abatement</b>	
+ Full or partial installation of abatement systems across all new generation fabs	Information not available.
+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	Information not available.
+ Indicate whether default factors or actual measurements were used to estimate the DRE  Reported destruction or removal efficiency (DRE)	Information not available.
+ Practices for monitoring abatement systems	Information not available.

**F-GHG Emissions Measurements**

Total annual F-GHG emissions in CO<sub>2</sub>e, emitted across all flat panel display manufacturing fabs

Include year

The total amount of F-GHG emissions attributed to panel manufacturing is not publicly available.

As part of its **2011** responses to the Carbon Disclosure Project, which discloses its corporate GHG emissions from **January 1, 2010–December 31, 2010**, BOE Technology lists its total Scope 1 emissions. These Scope 1 emissions represent its organizational boundary, using an equity share approach that includes facilities within China. BOE Technology also disclosed its Scope 1 GHG emissions, using an operational control approach, for **January 1, 2009–December 31, 2009**, in response to the Carbon Disclosure Project’s 2010 Supply Chain questionnaire. However, in neither disclosure report, does BOE list its Scope 1 process emissions by gas, so it is difficult to identify how much of its Scope 1 emissions include F-GHGs.

Sources:

*BOE Technology Group, Co., Ltd.’s responses to the 2011 Carbon Disclosure Project Investor Questionnaire.*

*BOE Technology Group, Co., Ltd.’s responses to the 2010 Carbon Disclosure Project Supply Chain Questionnaire.*

Total annual F-GHG emissions reductions and/or rate of emissions reductions

Information not available.

Methodology used to estimate F-GHG emissions

In BOE Technology’s responses to the Carbon Disclosure Projects’ 2010 Supply Chain questionnaire for its 2009 calendar year, it lists the “2006 edition of Guidelines for National Greenhouse Gas Inventories published by the IPCC” as one of the methodologies used to estimate its Scope 1 and 2 emissions. Further details on the extent to which the guidelines were used to estimate F-GHG emissions specifically in 2009 or in 2010 are not available.

Source:

*BOE Technology Group, Co., Ltd.’s responses to the 2010 Carbon Disclosure Project Supply Chain Questionnaire.*

Third party assurance for F-GHG emissions estimates

Information not available.

## Chunghwa Picture Tubes (CPT)

### Overview

Specific F-GHG emissions reduction efforts and/or goals

As part of the memorandum of understanding (MOU) in 2004 with the Taiwan TFT-LCD Association (TTLA) and Taiwan's Environmental Protection Administration, CPT promised to install abatement equipment with over 90 percent destruction and removal efficiency (DRE) in all new fabs designed after 2003 and to reduce F-GHG emissions intensity to 0.0335 tons of CO<sub>2</sub>e/m<sup>2</sup> of glass substrate area by 2010.

Sources:

CPT Website: *Social Responsibility–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)).

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

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

+ F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHG

Etch and Clean processes.  
Information on fluorinated heat transfer fluids not available.

Sources:

CPT Website: *Social Responsibility–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)).

TTLA presentation at APEC meeting, August 2012, Taiwan.

+ F-GHG emissions reduction efforts/goals target the following F-GHG emitted

SF<sub>6</sub>, PFCs, HFCs, NF<sub>3</sub>.

Sources:

CPT Website: *Social Responsibility–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)).

TTLA presentation at APEC meeting, August 2012, Taiwan.

Participation in national and/or international mandatory and/or voluntary efforts to reduce F-GHG emissions from flat panel display manufacturing

CPT is a member of the Taiwan TFT-LCD Association (TTLA). TTLA participates on behalf of Taiwan's LCD suppliers in the World LCD Industry Cooperation Committee (WLICC), an international industry initiative that previously set goals to reduce F-GHG emissions.

In 2004, TTLA and Taiwan's Environmental Protection Administration signed an MOU where TTLA agreed to choose 2002 as the base year for reducing F-GHG emissions and to reduce F-GHG emissions intensity to 0.0335 tons of CO<sub>2</sub>e/m<sup>2</sup> of glass substrate area by 2010 (this target is TTLA's collective goal and does not necessarily reflect each individual supplier's goal).

Overview		<p>Recently, the TTLA and Taiwan’s Industrial Development Bureau, Ministry of Economic Affairs signed a “Voluntary GHG Reduction Agreement,” for 2011-2015, which aims to achieve additional GHG reductions by 12 million metric tons of CO<sub>2</sub>e within 5 years. In Taiwan, F-GHG emission reductions by flat panel display manufacturers are still voluntary. However, as of 2012, Taiwan’s EPA listed PFCs, HFCs, and SF<sub>6</sub> (including non-F-GHGs CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O) as air pollutants and has indicated that it will implement emissions control measures under the Air Pollution Control Act in the future.</p> <p>According to CPT’s website, the company “actively discloses its greenhouse gas management information to external observers, and hopes to gather relevant opinions for continuous improvements. CPT is a member of the Taiwan TFT LCD Association (TTLA), which holds regular annual review meetings for greenhouse gas emissions. Other than disclosing our own emissions over the national greenhouse gas registration platforms, we also use the association to explain our carbon management and reduction methods to domestic government agencies and international WLICC members... We continue to absorb new knowledge and review our performance, and we also share our reduction experience with all enterprises in the industry as part of our collective effort to address climate change...CPT will also work with TTLA to provide regular emission information of fluorinated compounds, and engage in reductions of fluorinated compounds.”</p> <p>Sources:  CPT Website: <i>Social Responsibility–Environmental Management</i>.  (<a href="http://www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180">www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180</a>).</p> <p>“SF<sub>6</sub> Abatement Strategy in Taiwan”. Presentation by Taiwan’s Industrial Technology Research Institute (ITRI), 2004.  (<a href="http://www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf">www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf</a>).</p> <p>TTLA</p>
	Corporate-wide GHG emissions reduction goals and reduction initiatives	<p>Since CPT’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 efforts on reducing energy use and F-GHG emissions. According to CPT, it reduced its carbon emissions by 22 percent from 2008-2012.</p> <p>Source:  CPT Website: <i>Social Responsibility–Environmental Management</i>.  (<a href="http://www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180">www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180</a>).</p>
F-GHG Reduction Efforts	Process optimization	<p>According to CPT, “Reconstruction of the chemical vapor deposition (CVD) process in the Taoyuan and Longtan plants have been completed, which results in a 38 percent emission reduction of fluorinated compounds from 2010 levels, equal to approximately 170,000 tons of carbon dioxide... Emissions produced by manufacturing processes that use fluorocarbons (FCs), is a major source of greenhouse gas emission during the production process of thin membrane liquid crystal display devices. Currently, processes for end gases from machines include increasing production usage rate and adding local scrubbers (LS).”</p> <p>Source:  CPT Website: <i>Social Responsibility–Environmental Management</i>.  (<a href="http://www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180">www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180</a>).</p>



<p>Use of alternatives</p>	<p>CPT is using lower GWP gases, where possible. Additional details not available.</p> <p>Sources: CPT TTLA presentation at APEC meeting, August 2012, Taiwan.</p>
<p>Capture and recycling</p>	<p>Information not available.</p>
<p>Abatement</p>	
<p>+ Full or partial installation of abatement systems across all new generation fabs</p>	<p>CPT has installed abatement systems in all newer generation fabs. CPT committed to install abatement systems in all fabs established after 2003 to reduce more than 90 percent of its F-GHG emissions.</p> <p>According to CPT, its "Taoyuan and Lungtan plants' TFT manufacturing process involve membrane molding and dry etching procedures that use SF<sub>6</sub> and NF<sub>3</sub> gases for the manufacturing process. Therefore, fluoride gases that have not reacted completely would be emitted from the end gas emissions. Because SF<sub>6</sub> and NF<sub>3</sub> are greenhouse gases with high global warming potential (GWP), CPT uses high temperature burning to break down the gases' molecules, augmented by particle accumulation filter bags to capture the secondary solid pollutant that result from the burning process – silicon dioxide. Lastly, the cleaning tower is used to clean out special gas molecules in the waste gas. Currently, efficiency is at 90 percent or above."</p> <p>"Due to adding new manufacturing processes required for touch sensor panels (TSP) in 2010, the Longtan plant added a dry etching manufacturing machine. This machine uses fluorinated gases. In order to achieve our reduction targets, we have procured end gas incineration equipment, which can achieve an emission elimination rate of up to 90 percent."</p> <p>Sources: CPT Website: <i>Social Responsibility–Environmental Management</i>. (<a href="http://www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180">www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180</a>).</p> <p>CPT's responses to the 2009 Carbon Disclosure Project Supply Chain Questionnaire.</p> <p>Taiwan Environmental Protection Administration. "The Initiative and Efforts from Electronic Corporations in Taiwan-Semiconductor and TFT-LCD." (<a href="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</a>).</p> <p>TTLA presentation at APEC meeting, August 2012, Taiwan.</p>
<p>+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications</p>	<p>Upon installation at the facility and before CPT begins operating the abatement system, the abatement equipment manufacturer verifies that the system can meet the default DRE.</p> <p>Sources: CPT TTLA</p>

F-GHG Reduction Efforts	+ Indicate whether default factors or actual measurements were used to estimate the DRE  Reported destruction or removal efficiency (DRE)	<p>Default factors used.</p> <p>CPT applies the 90 percent default DRE value for SF<sub>6</sub>, HFCs and PFCs abatement technologies and the 95 percent default DRE value for NF<sub>3</sub> abatement technologies, taken from the 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions.</p> <p>CPT reports the DRE of its abatement systems at 90 percent or higher.</p> <p>Sources: CPT</p> <p>CPT Website: <i>Social Responsibility–Environmental Management.</i> (<a href="http://www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180">www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180</a>).</p>
	+ Practices for monitoring abatement systems	Information not available.
F-GHG Emissions Measurements	Total annual F-GHG emissions in CO <sub>2</sub> e, emitted across all flat panel display manufacturing fabs  Include year	<p>In 2011, CPT’s F-GHG emissions accounted for 24 percent of the company’s total GHG emissions.</p> <p><b>Important:</b> The emissions cannot be compared to the emissions from other suppliers because they may use different estimation methods and monitoring practices to calculate their emissions. These process emissions may also reflect manufacturing processes that create additional products other than large-area flat panel displays.</p> <p>Source: CPT Website: <i>Social Responsibility–Environmental Management.</i> (<a href="http://www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180">www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180</a>).</p>
	Total annual F-GHG emissions reductions and/or rate of emissions reductions	<p>CPT estimates reducing F-GHG emissions by approximately 24 million tons of CO<sub>2</sub>e between 2002 and 2011.</p> <p>Source: CPT Website: <i>Social Responsibility–Environmental Management.</i> (<a href="http://www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180">www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180</a>).</p>
	Methodology used to estimate F-GHG emissions	<p>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.</p> <p>Source: CPT</p>
	Third party assurance for F-GHG emissions estimates	<p>CPT’s annual total GHG inventory undergoes third party verification.</p> <p>Source: CPT Website: <i>Social Responsibility–Environmental Management.</i> (<a href="http://www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180">www.cptt.com.tw/index.php?option=com_content&amp;task=view&amp;id=447&amp;Itemid=180</a>).</p>

## HannStar

### Overview

Specific F-GHG emissions reduction efforts and/or goals

As part of the memorandum of understanding (MOU) in 2004 with the Taiwan TFT-LCD Association (TTLA) and Taiwan's Environmental Protection Administration, HannStar promised to install abatement equipment with over 90 percent destruction and removal efficiency (DRE) in all new fabs designed after 2003. HannStar reduced approximately 1.23 million tons of F-GHG emissions in CO<sub>2</sub>e from 2005-2011.

Sources:

*HannStar 2011 Corporate Social Responsibility Report. (www.hannstar.com/Hannstar\_2011CSR\_en.pdf).*

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

+ F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHGs

Etch and Clean processes.  
HannStar does not use fluorinated heat transfer fluids.

Sources:

*HannStar (HannStar's website will be updated in the future to refer to etch and clean processes for the status of its F-GHG usage).*

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

+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted

SF<sub>6</sub>, PFCs, HFCs, NF<sub>3</sub>.

Sources:

*HannStar 2011 Corporate Social Responsibility Report. (www.hannstar.com/Hannstar\_2011CSR\_en.pdf).*

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

Participation in national and/or international mandatory and/or voluntary efforts to reduce F-GHG emissions from flat panel display manufacturing

HannStar is a member of the Taiwan TFT-LCD Association (TTLA). TTLA participates on behalf of Taiwan's LCD suppliers in the World LCD Industry Cooperation Committee (WLICC), an international industry initiative that previously set goals to reduce F-GHG emissions.

In 2004, TTLA and Taiwan's Environmental Protection Administration signed an MOU where TTLA agreed to choose 2002 as the base year for reducing F-GHG emissions and to reduce F-GHGs emissions intensity to 0.0335 tons of CO<sub>2</sub>e/m<sup>2</sup> of glass substrate area by 2010 (this target is TTLA's collective goal and does not necessarily reflect each individual supplier's goal).

Overview		<p>Recently, the TTLA and Taiwan’s Industrial Development Bureau, Ministry of Economic Affairs signed a “Voluntary GHG Reduction Agreement,” for 2011-2015, which aims to achieve additional GHG reductions by 12 million metric tons of CO<sub>2</sub>e within 5 years. In Taiwan, F-GHG emission reductions by flat panel display manufacturers are still voluntary. However, as of 2012, Taiwan’s EPA listed PFCs, HFCs, and SF<sub>6</sub> (including non-F-GHGs CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O) as air pollutants and has indicated that it will implement emissions control measures under the Air Pollution Control Act in the future.</p> <p>Sources:  <i>“SF<sub>6</sub> Abatement Strategy in Taiwan”</i>. Presentation by Taiwan’s Industrial Technology Research Institute (ITRI), 2004. (<a href="http://www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf">www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf</a>).</p> <p>TTLA</p>
	Corporate-wide GHG emissions reduction goals and reduction initiatives	<p>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 efforts on reducing energy use and F-GHG emissions. HannStar lowered its overall GHG emissions intensity by 59 percent from 2005 to 2011 down to 0.072 tons of CO<sub>2</sub>e/m<sup>2</sup> of glass input.</p> <p>In addition, “HannStar has proceeded ISO 14064-1 inventory and external verification since 2005 and reduces GHG voluntarily.”</p> <p>Source: <i>HannStar 2011 Corporate Social Responsibility Report</i>. (<a href="http://www.hannstar.com/Hannstar_2011CSR_en.pdf">www.hannstar.com/Hannstar_2011CSR_en.pdf</a>).</p>
F-GHG Reduction Efforts	Process optimization	<p>HannStar is optimizing the use of F-GHGs in the process chambers. Additional details not available.</p> <p>Sources:  <i>HannStar</i>  <i>TTLA presentation at APEC meeting, August 2012, Taiwan.</i></p>
	Use of alternatives	<p>HannStar is using lower GWP gases, where possible. Additional details not available.</p> <p>Sources:  <i>HannStar</i>  <i>TTLA presentation at APEC meeting, August 2012, Taiwan.</i></p>
	Capture and recycling	Information not available.

**Abatement**

<p>+ Full or partial installation of abatement systems across all new generation fabs</p>	<p>HannStar has installed abatement systems in all newer generation fabs. HannStar promised to install abatement equipment in all fabs established after 2003 to reduce more than 90 percent of F-GHG emissions.</p> <p>Additional details not available.</p> <p>Sources:  <i>HannStar 2011 Corporate Social Responsibility Report. (www.hannstar.com/Hannstar_2011CSR_en.pdf).</i></p> <p><i>Taiwan Environmental Protection Administration. "The Initiative and Efforts from Electronic Corporations in Taiwan-Semiconductor and TFT-LCD."</i>  <i>(http://unfccc.epa.gov.tw/unfccc/english/_uploads/downloads/05_The_Initiative_and_Efforts_form_Electronic_Industry_in_Taiwan.pdf).</i></p> <p><i>TTLA presentation at APEC meeting, August 2012, Taiwan</i></p>
<p>+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications</p>	<p>Upon installation at the facility and before HannStar begins operating the abatement system, the abatement equipment manufacturer verifies that the system can meet the default DRE.</p> <p>Sources:  <i>HannStar</i>  <i>TTLA</i></p>
<p>+ Indicate whether default factors or actual measurements were used to estimate the DRE</p> <p>Reported destruction or removal efficiency (DRE)</p>	<p>Default factors used.</p> <p>HannStar applies the 90 percent default DRE value for SF<sub>6</sub>, HFCs and PFCs abatement technologies and the 95 percent default DRE value for NF<sub>3</sub> abatement technologies, taken from the 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions.</p> <p>Source: <i>HannStar</i></p>
<p>+ Practices for monitoring abatement systems</p>	<p>Information not available.</p>

Total annual F-GHG emissions in CO<sub>2</sub>e, emitted across all flat panel display manufacturing fabs

Include year

The total amount of F-GHG emissions attributed to panel manufacturing is not publicly available.

As part of its **2009 CSR Report**, HannStar lists its F-GHG emissions **for its Tainan Plant only**. Its F-GHG emissions (HFCs, PFCs and SF<sub>6</sub>), as reported, are as follows, in tons of CO<sub>2</sub>e:

GHG	Emissions (t-CO <sub>2</sub> -e)	Ratio to total emissions (%)
CO <sub>2</sub>	207367.0	69.4
CH <sub>4</sub>	94.8	0.0
N <sub>2</sub> O	1.5	0.0
HFC	2586.1	0.9
PFCs	1072.7	0.4
SF <sub>6</sub>	87779.8	29.4
<b>TOTAL</b>	<b>298901.9</b>	<b>100.0</b>

Note: Only the data for Tainan Plant is included

**Important:** The emissions listed cannot be compared to the emissions from other suppliers because they may use different estimation methods and monitoring practices to calculate their emissions. These process emissions may also reflect manufacturing processes that create additional products other than large-area flat panel displays.

Source: HannStar 2009 Corporate Social Responsibility Report. ([www.hannstar.com/Hannstar\\_2009CSR\\_en.pdf](http://www.hannstar.com/Hannstar_2009CSR_en.pdf)).

Total annual F-GHG emissions reductions and/or rate of emissions reductions

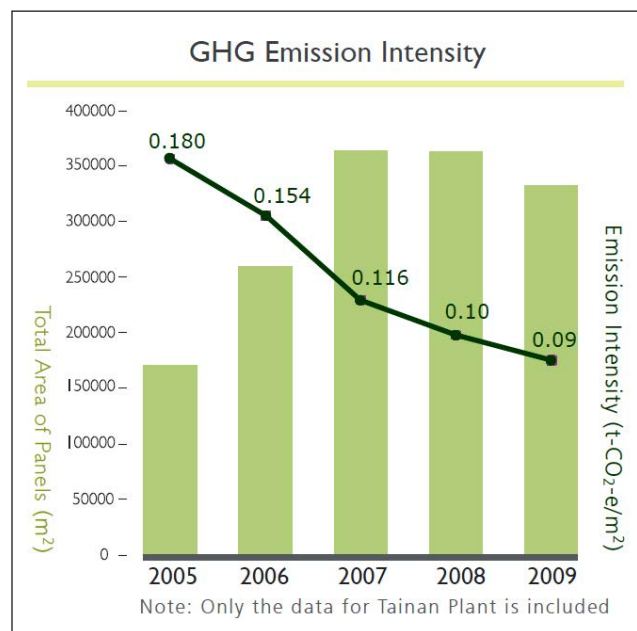
With regard to F-GHG emissions, HannStar reduced approximately 1.23 million tons of CO<sub>2</sub>e from 2005-2011.

F-GHG emissions reductions (in kg) for Tainan plant only in 2009:

Performance of PFC Emission Reduction				
	PFC Production	PFCs Emission Reduction	PFC Emission	Ratio of PFC Emission Reduction
2007	404,142	225,724	178,418	56%
2008	455,236	332,039	123,197	73%
2009	224,860	135,987	88,872	60%

Note: PFC emissions in unit of kg. Only the data for Tainan Plant is included.

F-GHG emissions intensity in tons of CO<sub>2</sub>e/m<sup>2</sup> of glass input for Tainan plant only in 2009:



Sources:

HannStar 2011 Corporate Social Responsibility Report. ([www.hannstar.com/Hannstar\\_2011CSR\\_en.pdf](http://www.hannstar.com/Hannstar_2011CSR_en.pdf)).

HannStar 2009 Corporate Social Responsibility Report. ([www.hannstar.com/Hannstar\\_2009CSR\\_en.pdf](http://www.hannstar.com/Hannstar_2009CSR_en.pdf)).

**F-GHG Emissions Measurements**

Methodology used to estimate F-GHG emissions

HannStar 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.

Source: *HannStar*

Third party assurance for F-GHG emissions estimates

"HannStar has proceeded ISO 14064-1 inventory and external verification since 2005 and reduces GHG voluntarily."

Source: *HannStar 2011 Corporate Social Responsibility Report. (www.hannstar.com/Hannstar\_2011CSR\_en.pdf).*



## INX (Innolux, formerly Chimei Innolux (CMI))

### Overview

#### Specific F-GHG emissions reduction efforts and/or goals

As of 2010, INX had met, and exceeded, its reduction goal and its emissions amounted to 0.0094 tons of CO<sub>2</sub>e/m<sup>2</sup> of glass substrate. INX further reduced its F-GHG emissions intensity in tons of CO<sub>2</sub>e/m<sup>2</sup> of glass input by 13 percent from 2010 to 2011 (the emissions intensity dropped from 0.0094 tons of CO<sub>2</sub>e/m<sup>2</sup> of glass input in 2010 down to 0.0082 tons of CO<sub>2</sub>e/m<sup>2</sup> in 2011).

Sources:  
INX

INX 2011 Corporate Social Responsibility Report.  
([www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?\\_\\_locale=en](http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?__locale=en)).

INX's responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).

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

#### + F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHGs

Etch and Clean processes.  
INX uses a small amount of fluorinated heat transfer fluids, but has not inventoried them.

Sources:  
INX  
TTLA presentation at APEC meeting, August 2012, Taiwan.

#### + F-GHG emissions reduction efforts/goals target the following F-GHGs emitted

SF<sub>6</sub>, PFCs, HFCs, NF<sub>3</sub>.

Sources:  
INX's responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).  
TTLA presentation at APEC meeting, August 2012, Taiwan.

#### Participation in national and/or international mandatory and/or voluntary efforts to reduce F-GHG emissions from flat panel display manufacturing

INX is a member of Taiwan's TFT-LCD Association (TTLA). TTLA participates on behalf of Taiwan's LCD suppliers in the World LCD Industry Cooperation Committee (WLICC), an international industry initiative that previously set goals to reduce F-GHG emissions.

In 2004, TTLA and Taiwan's Environmental Protection Administration signed an MOU where TTLA agreed to choose 2002 as the base year for reducing F-GHG emissions and to reduce F-GHG emissions intensity to 0.0335 tons of CO<sub>2</sub>e/m<sup>2</sup> of glass substrate area by 2010 (this target is TTLA's collective goal and does not necessarily reflect each individual supplier's goal).

Corporate-wide GHG emissions reduction goals and reduction initiatives

Recently, the TTLA and Taiwan’s Industrial Development Bureau, Ministry of Economic Affairs signed a “Voluntary GHG Reduction Agreement,” for 2011-2015, which aims to achieve additional GHG reductions by 12 million metric tons of CO<sub>2</sub>e within 5 years. In Taiwan, F-GHG emission reductions by flat panel display manufacturers are still voluntary. However, as of 2012, Taiwan’s EPA listed PFCs, HFCs, and SF<sub>6</sub> (including non-F-GHG CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O) as air pollutants and has indicated that it will implement emissions control measures under the Air Pollution Control Act in the future.

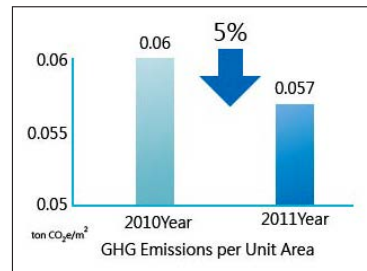
Sources:

INX’s responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).

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

TTLA

INX set a goal to reduce its absolute Scope 1 emissions by 3 percent from 2010 to 2012, where its most recent base year GHG emissions were reported as 457,752 metric tons of CO<sub>2</sub>e. INX aims to achieve its target mostly by reducing F-GHG emissions from flat panel display manufacturing. In addition, INX also set a goal to reduce GHG emissions intensity per square meter of glass input substrate by 10 percent from 2010 to 2012. Thus far, the total amount of GHG emissions intensity, which includes both Scope 1 and Scope 2 emissions, decreased by 5 percent from 2010 to 2011 to 0.057 metric tons of CO<sub>2</sub>e per area of input glass. INX attributes these reductions to installing more efficient F-GHG abatement equipment and promoting energy saving projects.



INX also set a goal to increase the energy efficiency of its TFT-LCD products by improving the energy efficiency of its computer monitor panels by 40 percent and TV panels by 50 percent from 2009 to 2012. INX met its goal for TV panels by improving efficiency by 50.5 percent and approached its goal for monitor panels by improving efficiency by 33.7 percent. INX is working with its suppliers to improve GHG reporting within its supply chain and participates in.

INX most recently publicly reported on its GHG management efforts to the Carbon Disclosure Project in 2012 for its 2011 calendar year.

Sources:

INX 2011 CSR Report. ([http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?\\_\\_locale=en](http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?__locale=en) and [http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenValueChain/LowCarbonGreenProductDesign.html?\\_\\_locale=en](http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenValueChain/LowCarbonGreenProductDesign.html?__locale=en)).

INX’s responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).

F-GHG Reduction Efforts

<p><b>Process optimization</b></p>	<p>INX is optimizing the use of F-GHGs in the process chambers. Additional details not available.</p> <p>Sources:            INX            TTLA presentation at APEC meeting, August 2012, Taiwan.</p>
<p><b>Use of alternatives</b></p>	<p>INX is using lower GWP gases, where possible. Additional details not available.</p> <p>Sources:            INX            TTLA presentation at APEC meeting, August 2012, Taiwan.</p>
<p><b>Capture and recycling</b></p>	<p>INX considered using recycling technologies, yet stopped its efforts due to safety issues.</p> <p>Source: INX</p>
<p><b>Abatement</b></p>	
<p>+ Full or partial installation of abatement systems across all new generation fabs</p>	<p>INX has installed abatement systems in all newer generation fabs. For process emissions that use F-GHGs, INX has installed point of use (POU) abatement systems, namely combustion-type local scrubbers fitted to the back end of production machinery and some thermal-type local scrubbers on select equipment. F-GHGs emissions undergo special combustion treatment before being neutralized by central scrubbers to further reduce emissions.</p> <p>Sources:            INX 2011 Corporate Social Responsibility Report.            (<a href="http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?__locale=en">http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?__locale=en</a>).</p> <p>Taiwan Environmental Protection Administration. "The Initiative and Efforts from Electronic Corporations in Taiwan-Semiconductor and TFT-LCD."            (<a href="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</a>).</p> <p>TTLA presentation at APEC meeting, August 2012, Taiwan.</p>
<p>+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications</p>	<p>Upon installation at the facility and before INX begins operating the abatement system, the abatement equipment manufacturer verifies that the system can meet the default DRE.</p> <p>Sources:            INX            TTLA</p>

<b>F-GHG Reduction Efforts</b>	+ Indicate whether default factors or actual measurements were used to estimate the DRE  Reported destruction or removal efficiency (DRE)	<p>Default factors used.</p> <p>INX applies the 90 percent default DRE value for SF<sub>6</sub>, HFCs and PFCs abatement technologies and the 95 percent default DRE value for NF<sub>3</sub> abatement technologies, taken from the 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions.</p> <p><i>Source: INX's responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).</i></p>
	+ Practices for monitoring abatement systems	<p>"INX controls all processes to follow the standard in the whole process." Additional details not available.</p> <p><i>Source: INX</i></p>
<b>F-GHG Emissions Measurements</b>	<b>Total annual F-GHG emissions in CO<sub>2</sub>e, emitted across all flat panel display manufacturing fabs</b>  Include year	<p>F-GHG emissions represented approximately 11 percent of INX's 2011 total GHG emissions inventory (Scope 1 and 2 emissions).</p> <p>As part of its <b>2012</b> responses to the Carbon Disclosure Project, which discloses its GHG emissions from <b>Jan 1, 2011–Dec 31, 2011</b>, INX lists its total Scope 1 emissions. These Scope 1 emissions represent its organizational boundary, using an operational control approach that includes facilities within Taiwan and in other countries. Its F-GHG emissions, as reported, are as follows, in metric tons of CO<sub>2</sub>e:</p> <p>HFCs emissions: 2,685          PFCs emissions: 14,687          SF<sub>6</sub> emissions: 416,533</p> <p><b>Important:</b> The emissions listed cannot be compared to the emissions from other suppliers because they may use different estimation methods and monitoring practices to calculate their emissions. These process emissions may also reflect manufacturing processes that create additional products other than large-area flat panel displays.</p> <p><i>Sources:</i>          2011 INX CSR Report          INX's responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).</p>
	<b>Total annual F-GHG emissions reductions and/or rate of emissions reductions</b>	<p>INX reduced its F-GHGs emissions intensity in tons of CO<sub>2</sub>e/m<sup>2</sup> of glass input by 13 percent from 2010 to 2011. The emissions intensity decreased from 0.0094 tons of CO<sub>2</sub>e/m<sup>2</sup> of glass input in 2010 to 0.0082 tons of CO<sub>2</sub>e/m<sup>2</sup> in 2011.</p> <p><i>Sources:</i>          INX</p> <p><i>INX 2011 CSR Report (to be updated). (<a href="http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?__locale=en">http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?__locale=en</a>).</i></p> <p><i>INX's responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).</i></p>

**F-GHG Emissions Measurements**

Methodology used to estimate F-GHG emissions

INX 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.

*Source: INX's responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).*

Third party assurance for F-GHG emissions estimates

INX most recently received third party verification for its 2011 GHG inventory in May 2012, which was verified in accordance with the ISO-14064-1 standard. INX is to have finished its most recent inventory of GHG emissions at the end of April 2013.

Sources:  
INX

*INX's website at [http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?\\_\\_locale=en](http://www.chimei-innolux.com/opencms/cmo/csr/LOVE/GreenOperations/ClimateChangeRisksAndOpportunities.html?__locale=en).*

## LG Display

Specific F-GHG emissions reduction efforts and/or goals

LG Display's F-GHG emissions reduction efforts are part of its broader goals to reduce corporate-wide GHG emissions. LG Display has installed F-GHG abatement systems to reduce  $\text{NF}_3$  emissions from all of its flat panel display (LCD, OLED) manufacturing fabs, and  $\text{SF}_6$  emissions from two of its flat panel display (LCD) manufacturing fabs.

Sources:  
LG Display

*LG Display's responses to the 2011 Carbon Disclosure Project Investor Questionnaire.*

*"Point of Use Abatement Device to Reduce  $\text{SF}_6$  emissions in LCD Manufacturing Operation in the Republic of Korea (South Korea)." LG Display's  $\text{SF}_6$  Abatement Project. Clean Development Mechanism Project: 3440. (<https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view>).*

+ F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHGs

Etch and Clean processes.  
Fluorinated heat transfer fluids are not used.

Sources:  
LG Display  
Korea Display Industry Association.

+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted

$\text{SF}_6$ , PFCs,  $\text{NF}_3$ .  
(HFCs are not used in processes).

Sources:  
Korea Display Industry Association.  
*LG Display's responses to the 2011 Carbon Disclosure Project Investor Questionnaire.*

Participation in national and/or international mandatory and/or voluntary efforts to reduce F-GHG emissions from flat panel display manufacturing

LG Display is a member of the Korea Display Industry Association (KDIA), 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 LCD Industry Cooperation Committee (WLICC), an international industry initiative that previously set goals to reduce F-GHG emissions.

Since 2010, LG Display has been participating in a United Nations Clean Development Mechanism Project to reduce  $\text{SF}_6$  emissions at two of its manufacturing fabs.

In recent years, the South Korean government set a long term national GHG emissions reduction goal until 2020 and also set different reduction goals for various industries, including the display panel industry. In 2010, the government launched a GHG target management scheme, which regulates  $\text{CO}_2$ , HFCs, PFCs, and  $\text{SF}_6$  (and non-FGHGs  $\text{N}_2\text{O}$  and  $\text{CH}_4$ ). Starting in 2015, the government will launch a 'cap and trade' system for limiting and trading domestic GHG emissions.

Overview		<p>Sources: LG Display</p> <p>Korea Display Industry Association.</p> <p>"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. (<a href="https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view">https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view</a>).</p>
	Corporate-wide GHG emissions reduction goals and reduction initiatives	<p>LG Display set a corporate-wide GHG reduction goal to reduce its GHG emissions intensity in metric tons of CO<sub>2</sub>e per unit of production by over 40 percent from 2009 to 2020.</p> <p>LG Display sets its goals in consultation with LG Corporation, which is the holding company. LG Corporation has been monitoring the results and LG Display's reduction target has been completed since 2010.</p> <p>LG Display participates in the Carbon Disclosure Project and most recently publicly reported on its GHG management efforts in 2011 for its 2010 calendar year.</p> <p>Sources: LG Display</p>
F-GHG Reduction Efforts	Process optimization	<p>LG Display has applied end-point detection and revised processes to optimize the use of F-GHGs.</p> <p>Source: LG Display</p>
	Use of alternatives	<p>LG Display has applied NF<sub>3</sub> remote plasma source chamber clean (RPSC) to all CVD manufacturing lines. An ordinary chamber's NF<sub>3</sub> utilization rate is only 70 percent, however RPSC's NF<sub>3</sub> utilization rate is 97 percent. LG Display has also used F<sub>2</sub> in chamber cleaning on one of its manufacturing lines instead of NF<sub>3</sub>. In addition, LG Display is researching lower GWP etching gases than SF<sub>6</sub> for the dry etching process.</p> <p>Source: LG Display</p>
	Capture and recycling	<p>LG Display is currently developing new SF<sub>6</sub>-concentrating and capturing technology with funding from industry and the South Korean government.</p> <p>Source: LG Display</p>

**Abatement**

<p>+ Full or partial installation of abatement systems across all new generation fabs</p>	<p>LG Display has installed F-GHG abatement systems on all lines of CVD tools and on three lines of etch tools. For NF<sub>3</sub> in CVD tools, electrically heated point of use systems are installed. For SF<sub>6</sub> and PFCs in etch tools, combustion-type centralized systems are installed.</p> <p><i>Source: LG Display</i></p>
<p>+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications</p>	<p>Yes.</p> <p>At the construction stage, LG Display checks and monitors all items and processes in accordance with the specification. At the commissioning stage, LG Display confirms the performance of abatement in accordance with the guarantee condition of the manufacturer. At the operation stage, LG Display makes an operation contract with the manufacturer, and every year checks the operational performance.</p> <p>In the case of etch tools, LG Display is verified by a third party entity, which is the Designated Operational Entity of CDM projects.</p> <p><i>Source: LG Display</i></p>
<p>+ Indicate whether default factors or actual measurements were used to estimate the DRE</p> <p>Reported destruction or removal efficiency (DRE)</p>	<p>Actual and default used.</p> <p>LG Display conducts actual measurements for its centralized abatement systems for its SF<sub>6</sub> abatement projects under the CDM. Under the South Korean government’s regulation, LG Display uses the 90 percent default DRE value from 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions its SF<sub>6</sub>, abatement technologies. In the case of NF<sub>3</sub>, which is not regulated by Korean law, LG Display applies the 95 percent default DRE value for NF<sub>3</sub>, also taken from the 2006 IPCC Tier 2b Guidelines, in WLICC activities.</p> <p><i>Sources:</i> <i>LG Display</i></p> <p><i>“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. (<a href="https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view">https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view</a>).</i></p>
<p>+ Practices for monitoring abatement systems</p>	<p>For its centralized abatement systems, LG Display employs a continuous monitoring (FTIR, Annabar system), namely for its CDM project that destroys SF<sub>6</sub>. For its POU systems, LG Display monitors the abatement systems on an as-needed basis.</p> <p><i>Sources:</i> <i>LG Display</i></p> <p><i>“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. Monitoring Reports available at <a href="https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view">https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view</a>.</i></p>



Total annual F-GHG emissions in CO<sub>2</sub>e, emitted across all flat panel display manufacturing fabs

Include year

The following data for 2011 was verified by a third party:  
 Total amount of F-GHG emissions in metric tons of CO<sub>2</sub>e: 3,122,694  
 SF<sub>6</sub> emissions: 3,084,211  
 PFCs emissions: 5,680  
 HFCs emissions: 0  
 NF<sub>3</sub> emissions: 32,803

The following data for 2012 is undergoing verification by a third party:  
 Total amount of F-GHG emissions in metric tons of CO<sub>2</sub>e: 3,113,430  
 SF<sub>6</sub> emissions: 3,071,426  
 PFCs emissions: 6,098  
 HFCs emissions: 0  
 NF<sub>3</sub> emissions: 35,906

**Important:** The emissions listed cannot be compared to the emissions from other suppliers because they may use different estimation methods and monitoring practices to calculate their emissions. In addition, these process emissions may encompass more than emissions associated only with flat panel display manufacturing.

*Source: LG Display*

Total annual F-GHG emissions reductions and/or rate of emissions reductions

Total amount of F-GHG reductions in 2011 in metric tons of CO<sub>2</sub>e: 6,989,465  
 SF<sub>6</sub> reductions: 461,712  
 PFCs reductions: 0  
 HFCs reductions: 0  
 NF<sub>3</sub> reductions: 6,527,753

Total amount of F-GHG reductions in 2012 metric tons of CO<sub>2</sub>e: 8,288,277  
 SF<sub>6</sub> reductions: 1,143,028  
 PFCs reductions: 0  
 HFCs reductions: 0  
 NF<sub>3</sub> reductions: 7,145,249  
 Equation for SF<sub>6</sub> reductions:  
 = Emissions without destruction – Emissions with destruction

Equation for NF<sub>3</sub> reductions:  
 = Emissions without Remote Plasma Source Chamber Clean (RPSC), destruction – Emissions with RPSC, destruction

**Important:** The reductions listed cannot be compared to the reductions from other suppliers because they may use different estimation methods and monitoring practices to calculate their reductions.

*Source: LG Display*

**F-GHG Emissions Measurements**

Methodology used to estimate F-GHG emissions

LG Display uses national GHGs emission estimation guidelines issued by the Korean Ministry of Environment and estimates NF<sub>3</sub> emissions by using the IPCC Tier 2b guidelines.

Source: LG Display

Third party assurance for F-GHG emissions estimates

LG Display's GHG emissions, such as CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>, HFCs, PFCs and SF<sub>6</sub> are assured by a third party in accordance with South Korean government regulations. Also, LG Display received third party assurance for its SF<sub>6</sub> abatement project under the CDM. However, 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 WLICC members.

Sources:  
LG Display

*"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. Validation Report, May 2, 2010. Available at <https://cdm.unfccc.int/filestorage/I/Z/J/IZJED5CT72MKRP8XUSHNBQY9A01436/Validation%20Report.pdf?t=cWN8bWk0ZjhmFDDMKAiOVZtCb5mdW9Go6TsG>.*

## Panasonic

### Overview

Specific F-GHG emissions reduction efforts and/or goals

Panasonic Liquid Display (PLD) considers installation of abatement systems to be the most effective and realistic technique to reduce F-GHG emissions. PLD established a 100% installation of abatement systems for both SF<sub>6</sub> and NF<sub>3</sub> from the start-up of the Himeji factory in 2010. Currently, because its production lines are integrated in the Himeji factory, PLD has a 100 percent rate of abatement system installation. "PLD would like to continue studying while assessing technology trends both inside and outside the company for further improvements in the future."

Source: *Panasonic Liquid Crystal Display (PLD)*

+ F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHGs

Etch and Clean processes.  
PLD uses fluorinated heat transfer fluids for dry-etcher and exposure equipment. PLD "manages leakage prevention properly with high sealability."

Source: *Panasonic Liquid Crystal Display (PLD)*

+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted

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

Source: *Panasonic Liquid Crystal Display (PLD)*

Participation in national and/or international mandatory and/or voluntary efforts to reduce F-GHG emissions from flat panel display manufacturing

Panasonic is a member of the Japan Electronics Industry Trade Association (JEITA), which participates on behalf of Japan's LCD suppliers in the World LCD Industry Cooperation Committee (WLICC), an international industry initiative that previously set goals to reduce F-GHG emissions. JEITA engages in WLICC activities to share information and promote activities to reduce F-GHG emissions via the installation of abatement systems and through other efforts. Japan's LCD industry set a collective goal to reduce F-GHG emissions 70 percent from 2000 to 2012.

Recently, the Japanese government established a Greenhouse Gas Accounting, Reporting and Disclosure system as part of their Global Warming Countermeasures Law, where companies are required to report F-GHG emissions that exceed 3,000 tons of CO<sub>2</sub>e. In addition, the government also established a target for reducing F-GHG emissions to help achieve GHG reduction targets under the Kyoto Protocol.

Source: *JEITA*

Corporate-wide GHG emissions reduction goals and reduction initiatives

Panasonic set a goal to halt GHG emissions increases, both from manufacturing and product use, after 2018 and maintain flat GHG emissions growth going forward.

Panasonic participates in the Carbon Disclosure Project and most recently publicly reported on its GHG management efforts in 2012 for its April 2011–March 2012 reporting year.

Source: *Panasonic's responses to the 2012 Carbon Disclosure Project Investor Questionnaire.*

F-GHG Reduction Efforts

Process optimization	<p>PLD is working on process optimization daily. Additional details not available.</p> <p><i>Source: Panasonic Liquid Crystal Display (PLD)</i></p>
Use of alternatives	<p>PLD uses SF<sub>6</sub> as an etching gas, and NF<sub>3</sub> as a cleaning gas for CVD. Regarding further improvements, PLD “would like to assess technology trends and respond accordingly.”</p> <p><i>Source: Panasonic Liquid Crystal Display (PLD)</i></p>
Capture and recycling	<p>PLD will continue gathering information to proceed with discussion and review [of capture and recycling technologies].</p> <p><i>Source: Panasonic Liquid Crystal Display (PLD)</i></p>
<b>Abatement</b>	
+ Full or partial installation of abatement systems across all new generation fabs	<p>PLD installs abatement systems to all CVD equipment and all dry-etchers.</p> <p><i>Source: Panasonic Liquid Crystal Display (PLD)</i></p>
+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	<p>PLD checks the performance at the time of installation of abatement systems, and operates them under proper management to ensure optimal results.</p> <p><i>Source: Panasonic Liquid Crystal Display (PLD)</i></p>
+ Indicate whether default factors or actual measurements were used to estimate the DRE	<p>“The ‘eco ideas’ Report by the Panasonic Group and CDP [Carbon Disclosure Project] is calculated with reference to the abatement rate actually measured. However, the figures used in the calculation have great allowance and therefore the actual abatement efficiency is higher.”</p> <p><i>Source: Panasonic Liquid Crystal Display (PLD)</i></p>
Reported destruction or removal efficiency (DRE)	
+ Practices for monitoring abatement systems	<p>PLD checks the performance at the time of installation of abatement systems.</p> <p><i>Source: Panasonic Liquid Crystal Display (PLD)</i></p>

F-GHG Emissions Measurements

Total annual F-GHG emissions in CO<sub>2</sub>e, emitted across all flat panel display manufacturing fabs

Include year

PLD's F-GHG emissions are disclosed in the Panasonic Group's 'eco ideas' Report 2012, and is also included in its reporting to the Carbon Disclosure Project. PLD's F-GHG emissions from its Himeji factory only, as reported from **April 1, 2011–March 31, 2012**, are as follows in tons of CO<sub>2</sub>e:  
SF<sub>6</sub> emissions: 5,722.

According to PLD, "it will be as follows when calculated by the IPCC Tier 2b guidelines default factors used in the Questionnaire of JEITA Display Devices Environment Committee.  
SF<sub>6</sub> emissions: 8,188 t-CO<sub>2</sub>  
NF<sub>3</sub> emissions: 2,069 t-CO<sub>2</sub>"

**Important:** The emissions listed cannot be compared to the emissions from other suppliers because they may use different estimation methods and monitoring practices to calculate their emissions.

Sources:

*Panasonic Liquid Crystal Display (PLD)*

'eco ideas' Report 2012 by the Panasonic Group

([http://panasonic.net/eco/env\\_data/back\\_number/pdf/panasonic\\_eiR2012e.pdf](http://panasonic.net/eco/env_data/back_number/pdf/panasonic_eiR2012e.pdf))

Total annual F-GHG emissions reductions and/or rate of emissions reductions

The "Himeji factory has started production from the middle of 2010. PLD will continue monitoring the transition between the fiscal years."

Source: *Panasonic Liquid Crystal Display (PLD)*

Methodology used to estimate F-GHG emissions

PLD estimates F-GHG emissions based on the Greenhouse Gas Accounting, Reporting and Disclosure system of the Japanese government.

Source: *Panasonic Liquid Crystal Display (PLD)*

Third party assurance for F-GHG emissions estimates

The 'eco ideas' Report by the Panasonic Group is audited by a third-party organization as described in the Report.

Source:

'eco ideas' Report 2012 by the Panasonic Group

([http://panasonic.net/eco/env\\_data/back\\_number/pdf/panasonic\\_eiR2012e.pdf](http://panasonic.net/eco/env_data/back_number/pdf/panasonic_eiR2012e.pdf))

## Samsung Display

### Overview

Specific F-GHG emissions reduction efforts and/or goals

Samsung Display's F-GHG emissions reduction efforts are part of its broader goals to reduce corporate-wide GHG emissions. Samsung Display has installed F-GHG abatement systems to reduce SF<sub>6</sub> and PFCs gases from its flat panel display (i.e., liquid crystal display) and semiconductor manufacturing processes, which has so far resulted in reducing emissions by 1,030,000 tons of CO<sub>2</sub>e.

Sources:

*Samsung 2012 Sustainability Report.* ([http://www.samsung.com/us/aboutsamsung/sustainability/sustainabilityreports/download/2012/2012\\_climate\\_change\\_energy.pdf](http://www.samsung.com/us/aboutsamsung/sustainability/sustainabilityreports/download/2012/2012_climate_change_energy.pdf)).

*Samsung Electronics SF<sub>6</sub> Abatement Project. Clean Development Mechanism Project: 3333.* (<http://cdm.unfccc.int/Projects/DB/JQA1264981590.19>).

+ F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHGs

Etch and Clean processes.  
Fluorinated heat transfer fluids are not used.

Sources:

*Samsung Display*  
*Korea Display Industry Association.*

+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted

SF<sub>6</sub>, PFCs, HFCs. NF<sub>3</sub> is targeted in some manufacturing lines.

Sources:

*Korea Display Industry Association.*  
*Samsung Electronics' responses to the 2012 Carbon Disclosure Project Investor Questionnaire.*

Participation in national and/or international mandatory and/or voluntary efforts to reduce F-GHG emissions from flat panel display manufacturing

Samsung Display is a member of the Korea Display Industry Association (KDIA), 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 LCD Industry Cooperation Committee (WLICC), an international industry initiative that previously set goals to reduce F-GHG emissions.

Since 2010, Samsung Display has been participating in a United Nations Clean Development Mechanism (CDM) Project to reduce SF<sub>6</sub> emissions at one of its manufacturing fabs.

In recent years, the South Korean government set a long term national GHG emissions reduction goal until 2020 and also set different reduction goals for various industries, including the display panel industry. In 2010, the government launched a GHG target management scheme, which regulates CO<sub>2</sub>, HFCs, PFCs, and SF<sub>6</sub> (and non-FGHGs N<sub>2</sub>O and CH<sub>4</sub>). Starting in 2015, the government will launch a 'cap and trade' system for limiting and trading domestic GHG emissions.

Overview		<p>Sources: Korea Display Industry Association.</p> <p>Samsung Electronics SF<sub>6</sub> Abatement Project. Clean Development Mechanism Project: 3333. (<a href="http://cdm.unfccc.int/Projects/DB/JQA1264981590.19">http://cdm.unfccc.int/Projects/DB/JQA1264981590.19</a>).</p>
	Corporate-wide GHG emissions reduction goals and reduction initiatives	<p>Samsung Electronics, Samsung Display's parent company until 2012, set a corporate-wide GHG reduction goal to reduce its GHG emissions intensity in metric tons of CO<sub>2</sub>e per unit revenue by 50 percent from 2008 to 2013. Its most recent normalized base year GHG emissions were reported as 8,092,000 metric tons of CO<sub>2</sub>e. Samsung Electronics also set a separate GHG reduction goal to improve products' energy efficiency by 40 percent over 5 years from a 2008 baseline year and estimates reducing GHG emissions by 84 million tons. Lastly Samsung Electronics also increased outreach to its suppliers, encouraging them to reduce their own GHG emissions.</p> <p>Samsung Electronics participates in the Carbon Disclosure Project and most recently publicly reported on its GHG management efforts in 2012 for its 2011 calendar year. In 2012 Samsung Display became a separate company from Samsung Electronics.</p> <p>Sources: Samsung's Climate Strategy. (<a href="http://www.samsung.com/us/aboutsamsung/sustainability/environment/climatestrategy/climatestrategy.html">http://www.samsung.com/us/aboutsamsung/sustainability/environment/climatestrategy/climatestrategy.html</a>).</p> <p>Samsung Electronics' responses to the 2012 Carbon Disclosure Project Investor Questionnaire</p>
F-GHG Reduction Efforts	Process optimization	Information not available.
	Use of alternatives	Information not available.
	Capture and recycling	Information not available.
	Abatement	
	+ Full or partial installation of abatement systems across all new generation fabs	<p>Samsung Display has installed electrically heated F-GHG abatement systems on all lines of CVD tools and SF<sub>6</sub> abatement systems on some lines of etch tools. Samsung Displays uses centralized systems and point of use (POU) systems, all of which include combustion, catalytic, plasma, electrical heated types of abatement systems.</p> <p>Sources: Samsung Display Korea Display Industry Association.</p>
+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications <sup>1</sup>	Details not available.	

F-GHG Reduction Efforts	<p>+ Indicate whether default factors or actual measurements were used to estimate the DRE</p> <p>Reported destruction or removal efficiency (DRE)</p>	<p>Actual and default used.</p> <p>Samsung Display conducts actual measurements for its centralized abatement systems for its SF<sub>6</sub> abatement project under the CDM. In other instances, Samsung Display uses the 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions, which apply a 90 percent default DRE value for SF<sub>6</sub>, HFCs and PFCs abatement technologies. Samsung Display has abatement for NF<sub>3</sub> on some lines and uses the 95 percent default DRE value for NF<sub>3</sub> abatement technologies.</p> <p><i>Sources:</i> Samsung Display</p> <p><i>Samsung Electronics SF<sub>6</sub> Abatement Project. Clean Development Mechanism Project: 3333. Monitoring Reports available at: <a href="http://cdm.unfccc.int/Projects/DB/JQA1264981590.19">http://cdm.unfccc.int/Projects/DB/JQA1264981590.19</a>.</i></p>
	<p>+ Practices for monitoring abatement systems</p>	<p>For its centralized abatement systems, Samsung employs a continuous monitoring (FTIR, Annabar system) for its CDM project that destroys SF<sub>6</sub>. For its other abatement systems, Samsung Display applies the IPCC guidelines.</p> <p><i>Sources:</i> Samsung Display</p> <p><i>Samsung Electronics SF<sub>6</sub> Abatement Project. Clean Development Mechanism Project: 3333. Monitoring Reports available at: <a href="http://cdm.unfccc.int/Projects/DB/JQA1264981590.19">http://cdm.unfccc.int/Projects/DB/JQA1264981590.19</a>.</i></p>
F-GHG Emissions Measurements	<p>Total annual F-GHG emissions in CO<sub>2</sub>e, emitted across all flat panel display manufacturing fabs</p> <p>Include year</p>	<p>The total amount of F-GHG emissions attributed to panel manufacturing is not publicly available.</p> <p>As part of its <b>2012</b> disclosure to the Carbon Disclosure Project, which discloses GHG emissions from <b>Jan 1, 2011–Dec 31, 2011</b>, Samsung Electronics lists its total Scope 1 emissions. These Scope 1 emissions represent its organizational boundary, using an operational control approach that includes facilities within South Korea and in other countries. Its F-GHG emissions, as reported, are as follows, in metric tons of CO<sub>2</sub>e:</p> <p>HFCs emissions: 107,754 PFCs emissions: 858,743 SF<sub>6</sub> emissions: 1,737,702</p> <p><b>Important:</b> The emissions listed cannot be compared to the emissions from other suppliers because they may use different estimation methods and monitoring practices to calculate their emissions. These process emissions may also reflect manufacturing processes that create additional products other than large-area flat panel displays.</p> <p><i>Source: Samsung Electronics' responses to the 2012 Carbon Disclosure Project Investor Questionnaire.</i></p>
	<p>Total annual F-GHG emissions reductions and/or rate of emissions reductions</p>	<p>Information not available.</p>



**F-GHG Emissions Measurements**

Methodology used to estimate F-GHG emissions

Samsung Display uses national GHGs emission estimation guidelines issued by the South Korean Ministry of Environment and the 2006 IPCC Tier 2b guidelines.

Source: Samsung Display

Third party assurance for F-GHG emissions estimates

Samsung Display received third party assurance for its SF<sub>6</sub> abatement project under the CDM. Most of Samsung Display's F-GHG emissions data is verified by a third party. However, NF<sub>3</sub> emissions data estimated by the 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions does not undergo third party verification.

Sources:

Samsung Electronics SF<sub>6</sub> Abatement Project Validation Report, May 12, 2010. Available at: [http://cdm.unfccc.int/filestorage/8/4/6/846DVPZREQF9WNY53KGLM2XJ17TCS0/Validation\\_Report%20Ver.%2001.1%20clean-2?t=ckh8bWk0YnlzfdCmy4YVLxcxZFgiFeh1IIRZ](http://cdm.unfccc.int/filestorage/8/4/6/846DVPZREQF9WNY53KGLM2XJ17TCS0/Validation_Report%20Ver.%2001.1%20clean-2?t=ckh8bWk0YnlzfdCmy4YVLxcxZFgiFeh1IIRZ).

Samsung Display

<sup>1</sup> According to the Korea Display Industry Association, suppliers ensure that abatement systems are installed, operated, maintained according to manufacturer specifications.

## Sharp

Overview	Specific F-GHG emissions reduction efforts and/or goals	Information not available.
	+ F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHG	Etch and Clean processes. Information on fluorinated heat transfer fluids not available.  <i>Source: Nishida, et al. PFC Emission Reduction Strategy for the LCD Industry. Journal of the SID 13/10. 2005</i>
	+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted	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> .  <i>Source: Japan Electronics and Information Technology Industries Association (JEITA).</i>
	Participation in national and/or international mandatory and/or voluntary efforts to reduce F-GHG emissions from flat panel display manufacturing	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 LCD Industry Cooperation Committee (WLICC), an international industry initiative that previously set goals to reduce F-GHG emissions. JEITA engages in WLICC activities to share information and promote activities to reduce F-GHG emissions via the installation of abatement systems and through other efforts Japan's LCD industry set a collective goal to reduce F-GHG emissions 70 percent from 2000 to 2012.  Recently, the Japanese government established a Greenhouse Gas Accounting, Reporting and Disclosure system as part of their Global Warming Countermeasures Law, where companies are required to report F-GHG emissions that exceed 3,000 tons of CO <sub>2</sub> e. In addition, the government also established a target for reducing F-GHG emissions to help achieve GHG reduction targets under the Kyoto Protocol.  <i>Source: JEITA</i>
	Corporate-wide GHG emissions reduction goals and reduction initiatives	Sharp set a goal to reduce absolute GHG emissions year to year below 2007 baseline fiscal year emissions levels for ten manufacturing fabs by 2011. Its most recent base year emissions were reported as 986,000 metric tons of CO <sub>2</sub> e. Sharp also set another goal to reduce GHG emissions intensity by 35 percent per adjusted production units (tons of CO <sub>2</sub> e/100 million yen) across the ten fabs by 2012. By end of fiscal year 2011, Sharp met both of its goals and reduced total emissions by 40 percent and emissions intensity by 42 percent.  Sharp participates in the Carbon Disclosure Project and most recently publicly reported on its GHG management efforts in 2012 for its April 2011-March 2012 reporting year.  <i>Source: Sharp's responses to the 2012 Carbon Disclosure Project Investor Questionnaire.</i>

**F-GHG Reduction Efforts**

Process optimization <sup>1</sup>	Details not available.
Use of alternatives <sup>2</sup>	Details not available.
Capture and recycling <sup>3</sup>	Details not available.
<b>Abatement</b>	
+ Full or partial installation of abatement systems across all new generation fabs <sup>4</sup>	Details not available.
+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	Information not available.
+ Indicate whether default factors or actual measurements were used to estimate the DRE  Reported destruction or removal efficiency (DRE)	Information not available.
+ Practices for monitoring abatement systems <sup>5</sup>	Details not available.

F-GHG Emissions Measurements

Total annual F-GHG emissions in CO<sub>2</sub>e, emitted across all flat panel display manufacturing fabs

Include year

The total amount of F-GHG emissions attributed to panel manufacturing is not publicly available.

As part of its **2012** responses to the Carbon Disclosure Project, which discloses its corporate GHG emissions from **April 1, 2011–March 31, 2012**, Sharp lists its Scope 1 emissions. These Scope 1 emissions represent its organizational boundary, using a financial control approach, which includes factories and offices within Japan and in other countries. Sharp’s F-GHG emissions, as reported, are as follows, in metric tons of CO<sub>2</sub>e.

HFCs emissions: 5,500  
 PFCs emissions: 60,000  
 SF<sub>6</sub> emissions: 54,000

**Important:** The emissions listed cannot be compared to the emissions from other suppliers because they may use different estimation methods and monitoring practices to calculate their emissions. These process emissions may also reflect manufacturing processes that create additional products other than large-area flat panel displays.

*Source: Sharp’s responses to the 2012 Carbon Disclosure Project Investor Questionnaire.*

Total annual F-GHG emissions reductions and/or rate of emissions reductions

Information not available.

Methodology used to estimate F-GHG emissions<sup>6</sup>

Details not available.

Third party assurance for F-GHG emissions estimates

Information not available.

<sup>1</sup> According to the Display Devices Environment Committee within the Japan Electronics and Information Technology Industries Association (JEITA), panel suppliers optimize their processes to reduce gas consumption.

<sup>2</sup> According to the Display Devices Environment Committee within JEITA, panel suppliers use alternative gases with lower GWP.

<sup>3</sup> According to the Display Devices Environment Committee within JEITA, panel suppliers are collecting information on F-GHG recycling and recovery technologies.

<sup>4</sup> According to the Display Devices Environment Committee within JEITA, panel suppliers have installed F-GHG abatement systems in all new generation fabs built since 2001. Additional source: Nishida, et al. *PFC Emission Reduction Strategy for the LCD Industry*. Journal of the SID 13/10. 2005.

<sup>5</sup> JEITA’s Display Devices Environment Committee recommends that Japanese flat panel display suppliers use the following guidelines to monitor and measure F-GHG emissions: “JEITA Guidelines for F-GHG Characterization and Measurement.” *Semiconductor Environment Committee/Semiconductor Environment Expert Committee on PFC and Display Devices Environment Committee, JEITA* and “S29-0712 Guide for F-GHG (Fluorinated Greenhouse Gas) Emission Characterization and Reduction.” *SEMI F-GHG Measurement Guidelines*.

<sup>6</sup> JEITA’s Display Devices Environment Committee recommends that Japanese flat panel display suppliers use the following guidelines to monitor and measure F-GHG emissions: “JEITA Guidelines for F-GHG Characterization and Measurement.” *Semiconductor Environment Committee/Semiconductor Environment Expert Committee on PFC and Display Devices Environment Committee, JEITA* and “S29-0712 Guide for F-GHG (Fluorinated Greenhouse Gas) Emission Characterization and Reduction.” *SEMI F-GHG Measurement Guidelines*.