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

Updated to reflect information for 2012

Introduction

U.S. Environmental Protection Agency
Office of Air and Radiation
April 2014

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. Additionally, in late 2013, leading electronics brands and retailers, Walmart, Dell, HP, Lenovo and Best Buy, began taking steps to foster further voluntary F-GHG reductions among their LCD suppliers. Consistent with the mission of the Center, EPA commends these companies for having submitted a proposal to their suppliers calling for them to 1) develop a standard method for measuring and recording F-GHG emissions for the industry, 2) establish a voluntary long-term F-GHG emissions reduction goal with public timelines for demonstrating progress, and 3) develop an annual progress report that can be shared with them and/or other supporting organizations.

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 (CHF3 or HFCs), nitrogen trifluoride (NF3), and sulfur hexafluoride (SF6); 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_2 equivalent (CO_2e).

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_2O (not an F-GHG, but another GHG which has a GWP of nearly 300) is also used in flat panel display manufacturing in the CVD process and in it is emitted from onsite stationary combustion. EPA is also interested in understanding the role of N_2O in flat panel display manufacturing and current and emerging opportunities to reduce N_2O 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 NF_3 instead of SF_6; NF_3 is a replacement gas for in-situ use for CVD and is also used in CVD remote plasma chamber cleaning. Though NF_3 still has very high GWP of 17,200, it is lower than that of SF_6 (which has a GWP of nearly 23,000) and is used more efficiently. Some companies are piloting the use of F2 to replace NF_3 in the remote plasma chamber cleaning process and are seeking to surmount some of challenges associated with transport, storage and use of 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 . 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 .

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 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. The emissions data are reported in either tons or metric tons to reflect how suppliers reported on their emissions.

AU Optronics (AUO)

BOE Technology

CEC-Panda

ChinaStar

Chunghwa Picture Tubes (CPT)

HannStar

Infovision

INX (Innolux)

LG Display

Panasonic

Samsung Display

Sharp

AU Optronics (AUO)

Overview

Specific F-GHG emissions reduction efforts and/or goals	AUO reduced manufacturing emissions, specifically F-GHGs, by 8.06 million metric tons of CO_2e from 2003 to 2012. 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_6 and NF_3. In 2011, AUO planned to begin installing abatement systems for fabs constructed prior to 2003 and estimates that doing so should reduce the PFC emissions by 419,400 tons of CO_2e based on the global warming potentials of gases used during production in 2012. AUO is the only member in WLICC that installed abatement systems in all small to medium-sized LCD fabs ranging from G3.5 to G5. *Sources:* *AUO 2012 Corporate Social Responsibility Report (page 49)* *(http://www.auo.com/upload/download/1/AUO_2012_CSR_EN_All.pdf)* *AUO 2011 Corporate Social Responsibility Report* *(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)* *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 the Taiwanese Environmental Protection Administration (EPA). In the guidance, HTFs are listed as emission sources for the semiconductor industry, but not for the 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_6, PFCs, HFCs, NF_3. *Source:* *AUO's responses to the 2013 Carbon Disclosure Project Investor Questionnaire.*

Overview

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 the Taiwanese 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 EPA 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_2e/m^2 of glass substrate area by 2010 (this target is TTLA's collective goal and does not necessarily reflect each individual supplier's goal). 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_2e 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_6 (including non-F-GHGs CO_2, CH_4, and N_2O) as air pollutants and has indicated that it will implement emissions control measures under the Air Pollution Control Act in the future. Taiwan's government has launched a national carbon trade program to encourage carbon reduction. AUO has engaged in developing the SF_6 abatement verification methodology, and applied for carbon credits based on the amount of PFCs reduced in the past. *Sources:* *AUO's responses to the 2012 Carbon Disclosure Project Investor Questionnaire.* *"SF_6 Abatement Strategy in Taiwan." Presentation by Taiwan's Industrial Technology Research Institute (ITRI) (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 of CO_2e/m^2. 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. The goal has been achieved and was announced in the AUO 2012 CSR report. 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.

Overview		*Sources:* *AUO 2011 CSR Corporate Social Responsibility Report on AUO's corporate-wide GHG reduction efforts (http://auo.com/upload/download/1/AUO_2011_CSR_EN_CH2_v1.pdf)* *AUO 2012 Corporate Social Responsibility Report (page 49) (http://www.auo.com/upload/download/1/AUO_2012_CSR_EN_All.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_6 supplier to investigate ways to reduce the quantity of SF_6 used in dry etching manufacturing processes for manufacture of its TFT-LCD panels. AUO found that by adjusting process parameters, SF_6 consumption could be considerably reduced. For example, at its G_6 fab in Taichung, Taiwan, if the fab is in full production capacity, by adjusting relevant process parameters the amount of SF_6 gas can be reduced by 720 kgs per year, equal to reducing 32,000 metric tons of CO_2 emissions annually. AUO plans to expand this SF_6 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 gas waste in chambers and improve gas utilization efficiencies. *Source:* *AUO 2011 Corporate Social Responsibility Report. (http://auo.com/upload/download/1/AUO_2011_CSR_EN_CH2_v1.pdf)*
	Use of alternatives	Though it is more expensive, AUO uses NF_3, which has a lower global warming potential (GWP), instead of SF_6 in chemical vapor deposition (CVD) chambers. AUO also started using NF_3 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*

F-GHG Reduction Efforts

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; 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)* *TTLA presentation at APEC meeting, August 2012, Taiwan.* *AUO's responses to the 2013 Carbon Disclosure Project Investor Questionnaire.*
+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	For abatement systems, the destruction or removal efficiency was checked when first installed. *Source: AUO*
+ 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_6, HFC, and PFC abatement technologies and the 95 percent default DRE value for NF_3 abatement technologies, taken from the 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions. *Source: AUO*

F-GHG Reduction Efforts

+ 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 at 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. Different parameters are monitored according to type of device. 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.

Source:
AUO's responses to the 2013 Carbon Disclosure Project Investor Questionnaire

F-GHG Emissions Measurements

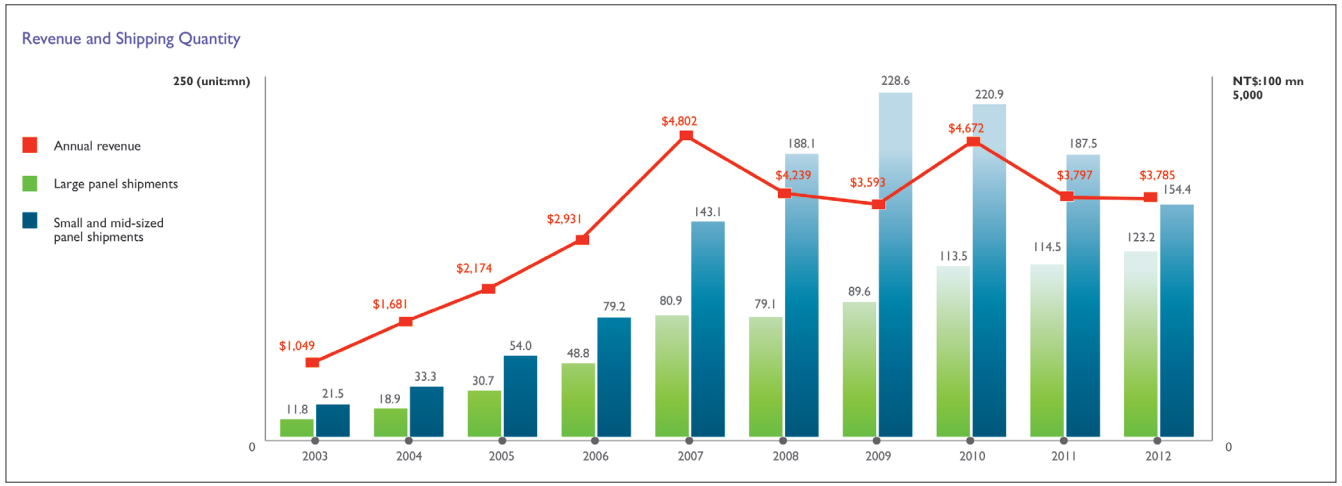
Total annual F-GHG emissions in CO_2e, emitted across all flat panel display manufacturing fabs

Include year

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

As part of its **2013** disclosure to the Carbon Disclosure Project, which discloses GHG emissions from **January 1, 2012 to December 31, 2012**, 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_2e:
HFCs: 8,139.39 (increase compared to 5,916.42 in CY 2011)
PFCs: 34,071.44 (decrease compared to 71,191.19 in CY 2011)
SF_6: 205,468.08 (decrease compared to 217,523.75 in CY 2011)

Context:
AUO's large panel shipments increased from 114.5 million in 2011 to 123.2 million units in 2012, and small and mid-sized panel shipments decreased from 187.5 million in 2011 to 154.4 million units in 2012.



F-GHG Emissions Measurements

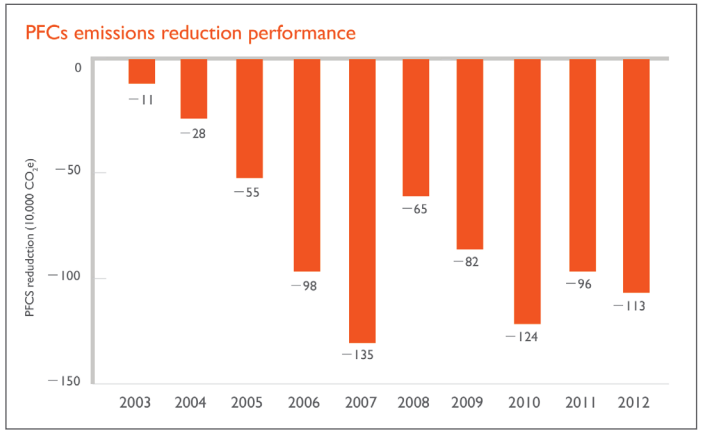
Important: The emissions listed cannot be compared to the emissions from other suppliers because they may use different estimation methods and monitoring practices to calculate their emissions. These process emissions may also reflect manufacturing processes that create additional products other than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

Sources:
AUO's responses to the 2013 Carbon Disclosure Project Investor Questionnaire.

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

AUO 2012 Corporate Social Responsibility Report (http://www.auo.com/upload/download/1/AUO_2012_CSR_EN_All.pdf)

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



AUO also estimated that it lowered SF_6 usage per substrate size by approximately 6.65 percent in 2011 compared with 2010.

Sources:
AUO 2012 Corporate Social Responsibility Report (http://www.auo.com/upload/download/1/AUO_2012_CSR_EN_All.pdf)

AUO 2011 Corporate Social Responsibility Report (http://auo.com/upload/download/1/AUO_2011_CSR_EN_CH2_v1.pdf)

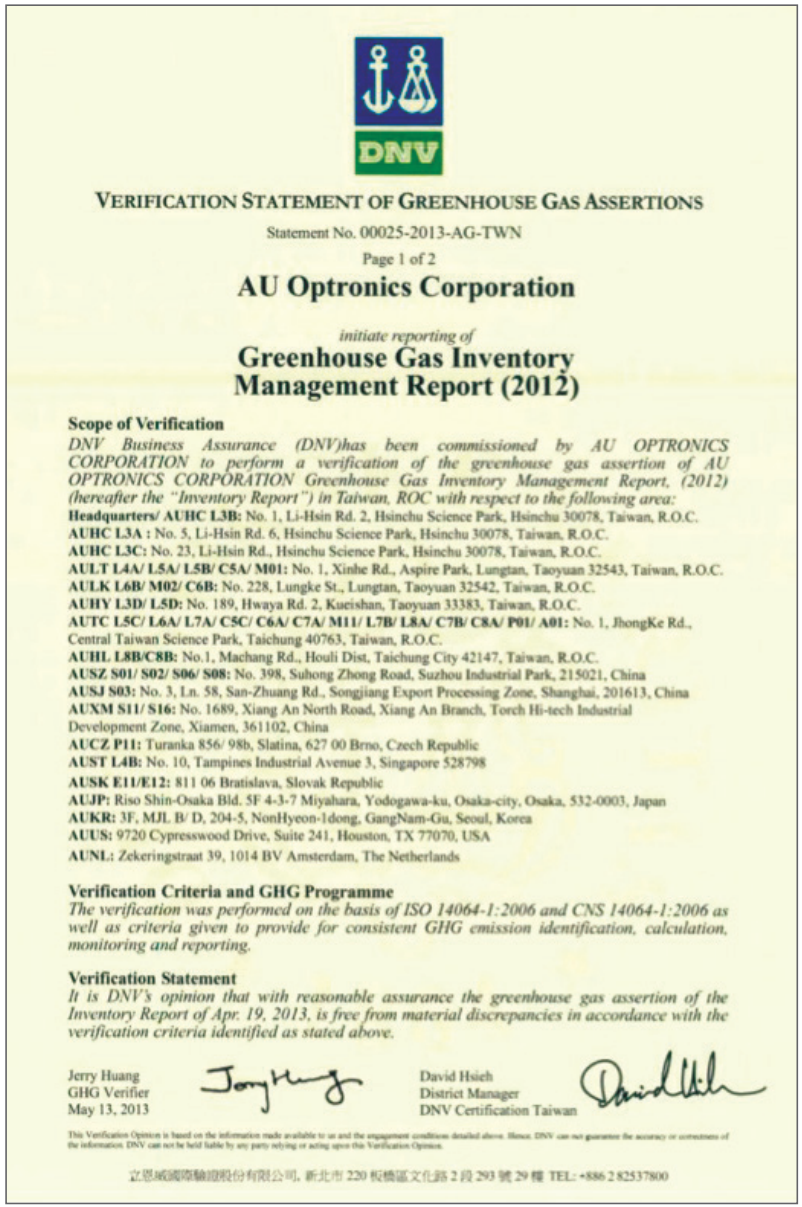
Methodology used to estimate F-GHG emissions

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

Third party assurance for F-GHG emissions estimates

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.



DNV

VERIFICATION STATEMENT OF GREENHOUSE GAS ASSERTIONS

Statement No. 00025-2013-AG-TWN

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AU Optronics Corporation

initiate reporting of

Greenhouse Gas Inventory Management Report (2012)

Scope of Verification

DNV Business Assurance (DNV)has been commissioned by AU OPTRONICS CORPORATION to perform a verification of the greenhouse gas assertion of AU OPTRONICS CORPORATION Greenhouse Gas Inventory Management Report, (2012) (hereafter the "Inventory Report") in Taiwan, ROC with respect to the following area:

Headquarters/ AUHC L3B: No. 1, Li-Hsin Rd. 2, Hsinchu Science Park, Hsinchu 30078, Taiwan, R.O.C.
AUHC L3A : No. 5, Li-Hsin Rd. 6, Hsinchu Science Park, Hsinchu 30078, Taiwan, R.O.C.
AUHC L3C: No. 23, Li-Hsin Rd., Hsinchu Science Park, Hsinchu 30078, Taiwan, R.O.C.
AULT L4A/ L5A/ L5B/ C5A/ M01: No. 1, Xinhe Rd., Aspire Park, Lungtan, Taoyuan 32543, Taiwan, R.O.C.
AULK L6B/ M02/ C6B: No. 228, Lungke St., Lungtan, Taoyuan 32542, Taiwan, R.O.C.
AUHY L3D/ L5D: No. 189, Hwaya Rd. 2, Kueishan, Taoyuan 33383, Taiwan, R.O.C.
AUTC L5C/ L6A/ L7A/ C5C/ C6A/ C7A/ M11/ L7B/ L8A/ C7B/ C8A/ P01/ A01: No. 1, JhongKe Rd., Central Taiwan Science Park, Taichung 40763, Taiwan, R.O.C.
AUHL L8B/C8B: No.1, Machang Rd., Houli Dist, Taichung City 42147, Taiwan, R.O.C.
AUSZ S01/ S02/ S06/ S08: No. 398, Suhong Zhong Road, Suzhou Industrial Park, 215021, China
AUSJ S03: No. 3, Ln. 58, San-Zhuang Rd., Songjiang Export Processing Zone, Shanghai, 201613, China
AUXM S11/ S16: No. 1689, Xiang An North Road, Xiang An Branch, Torch Hi-tech Industrial Development Zone, Xiamen, 361102, China
AUCZ P11: Turanka 856/ 98b, Slatina, 627 00 Brno, Czech Republic
AUST L4B: No. 10, Tampines Industrial Avenue 3, Singapore 528798
AUSK E11/E12: 811 06 Bratislava, Slovak Republic
AUJP: Riso Shin-Osaka Bld. 5F 4-3-7 Miyahara, Yodogawa-ku, Osaka-city, Osaka, 532-0003, Japan
AUKR: 3F, MJL B/ D, 204-5, NonHyeon-1dong, GangNam-Gu, Seoul, Korea
AUUS: 9720 Cypresswood Drive, Suite 241, Houston, TX 77070, USA
AUNL: Zekeringstraat 39, 1014 BV Amsterdam, The Netherlands

Verification Criteria and GHG Programme

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

Verification Statement

It is DNV's opinion that with reasonable assurance the greenhouse gas assertion of the Inventory Report of Apr. 19, 2013, is free from material discrepancies in accordance with the verification criteria identified as stated above.

Jerry Huang
GHG Verifier
May 13, 2013

David Hsieh
District Manager
DNV Certification Taiwan

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.

立恩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

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-GHGs emissions intensity to 0.0335 tons of CO_2e/m^2 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)* *CPT's responses to the 2009 Carbon Disclosure Project Supply Chain Questionnaire.* *"SF_6 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. 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)* *TTLA presentation at APEC meeting, August 2012, Taiwan.*
+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted	SF_6, PFCs, HFCs, NF_3. *Sources:* *CPT Website: Social Responsibility—Environmental Management (www.cptt.com.tw/index.php?option=com_content&task=view&id=447&Itemid=180)* *TTLA presentation at APEC meeting, August 2012, Taiwan.*

Overview

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 (EPA) 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_2e/m^2 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_2e 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_6 (including non-F-GHGs CO_2, CH_4, and N_2O) as air pollutants and has indicated that it will implement emissions control measures under the Air Pollution Control Act in the future.

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."

Sources:
CPT Website: Social Responsibility—Environmental Management (www.cptt.com.tw/index.php?option=com_content&task=view&id=447&Itemid=180)

"SF_6 Abatement Strategy in Taiwan." Presentation by Taiwan's Industrial Technology Research Institute (ITRI), 2004. (www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf).

TTLA

Corporate-wide GHG emissions reduction goals and reduction initiatives

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 to 2012.

Source:
CPT Website: Social Responsibility—Environmental Management (www.cptt.com.tw/index.php?option=com_content&task=view&id=447&Itemid=180)

F-GHG Reduction Efforts		
	Process optimization	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) [are] 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)." *Source:* *CPT Website: Social Responsibility—Environmental Management (www.cptt.com.tw/index.php?option=com_content&task=view&id=447&Itemid=180)*
	Use of alternatives	CPT is using lower global warming potential (GWP) gases, where possible. Additional details not available. *Sources:* *CPT* *TTLA presentation at APEC meeting, August 2012, Taiwan.*
	Capture and recycling	Information not available.
	Abatement	
	+ Full or partial installation of abatement systems across all new generation fabs	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. According to CPT, its "Taoyuan and Lungtan plants' TFT manufacturing process involves membrane molding and dry etching procedures that use SF_6 and NF_3 gases... Therefore, fluoride gases that have not reacted completely would be emitted from the end gas emissions. Because SF_6 and NF_3 are greenhouse gases with high 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… "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."

F-GHG Reduction Efforts		*Sources:* *CPT Website: Social Responsibility—Environmental Management (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.* *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)* *TTLA presentation at APEC meeting, August 2012, Taiwan.*
	+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	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. *Sources:* *CPT* *TTLA*
	+ Indicate whether default factors or actual measurements were used to estimate the DRE Reported destruction or removal efficiency (DRE)	Default factors used. CPT applies the 90 percent default DRE value for SF_6, HFC, and PFC abatement technologies and the 95 percent default DRE value for NF_3 abatement technologies, taken from the 2006 IPCC Tier 2b Guidelines for National Greenhouse Gas Inventories for electronics industry emissions. CPT reports the DRE of its abatement systems at 90 percent or higher. *Sources:* *CPT* *CPT Website: Social Responsibility—Environmental Management (www.cptt.com.tw/index.php?option=com_content&task=view&id=447&Itemid=180)*
	+ Practices for monitoring abatement systems	Information not available.

F-GHG Emissions Measurements	
Total annual F-GHG emissions in CO_2e, emitted across all flat panel display manufacturing fabs **Include year**	In 2012, CPT's F-GHG emissions accounted for 30.17 percent of the company's total GHG emissions. In 2011, CPT's F-GHG emissions accounted for 24 percent of the company's total GHG emissions. **Important:** 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. *Source:* *CPT Website: Social Responsibility—Environmental Management (www.cptt.com.tw/index.php?option=com_content&task=view&id=447&Itemid=180)*
Total annual F-GHG emissions reductions and/or rate of emissions reductions	CPT estimates reducing F-GHG emissions by approximately 23.8 million tons of CO_2e between 2002 and 2012. In contrast, CPT estimates having reduced F-GHG emissions by approximately 21.8 million tons of CO_2e between 2002 and 2011. *Source:* *CPT Website: Social Responsibility—Environmental Management (www.cptt.com.tw/index.php?option=com_content&task=view&id=447&Itemid=180)* *CPT*
Methodology used to estimate F-GHG emissions	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. *Source:* *CPT*
Third party assurance for F-GHG emissions estimates	CPT's annual total GHG inventory undergoes third party verification. *Source:* *CPT Website: Social Responsibility—Environmental Management (www.cptt.com.tw/index.php?option=com_content&task=view&id=447&Itemid=180)*

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 or removal efficiency (DRE) in all new fabs designed after 2003. HannStar reduced approximately 1.33 million tons of F-GHG emissions in CO_2e from 2007 to 2012. *Sources:* *HannStar* *"SF_6 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_6, PFCs, HFCs, NF_3. *Sources:* *HannStar 2012 Corporate Social Responsibility Report. (www.hannstar.com/HannStarUserFile/files/Quality/Hannstar_2012CSR_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_2e/m^2 of glass substrate area by 2010 (this target is TTLA's collective goal and does not necessarily reflect each individual supplier's goal).

Overview		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_2e 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_6 (including non-F-GHGs CO_2, CH_4, and N_2O) as air pollutants and has indicated that it will implement emissions control measures under the Air Pollution Control Act in the future. *Sources:* *"SF_6 Abatement Strategy in Taiwan." Presentation by Taiwan's Industrial Technology Research Institute (ITRI), 2004. (www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf)* *TTLA*
	Corporate-wide GHG emissions reduction goals and reduction initiatives	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 61 percent from 2005 to 2012 down to 0.069 tons of CO_2e/m_2 of glass input. In addition, HannStar has performed ISO 14064-1 inventory and external verification since 2005 and reduces GHG voluntarily. *Source:* *HannStar 2012 Corporate Social Responsibility Report. (www.hannstar.com/HannStarUserFile/files/Quality/Hannstar_2012CSR_en.pdf)*
F-GHG Reduction Efforts	**Process optimization**	HannStar is optimizing the use of F-GHGs in the process chambers. Additional details not available. *Sources:* *HannStar* *TTLA presentation at APEC meeting, August 2012, Taiwan.*
	Use of alternatives	HannStar is using lower global warming potential (GWP) gases, where possible. Additional details not available. *Sources:* *HannStar* *TTLA presentation at APEC meeting, August 2012, Taiwan.*
	Capture and recycling	Information not available.

F-GHG Reduction Efforts

Abatement	
+ Full or partial installation of abatement systems across all new generation fabs	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. Additional details not available. *Sources:* *HannStar 2012 Corporate Social Responsibility Report. (www.hannstar.com/HannStarUserFile/files/Quality/Hannstar_2012CSR_en.pdf)* *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)* *TTLA presentation at APEC meeting, August 2012, Taiwan*
+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	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. *Sources:* *HannStar* *TTLA*
+ Indicate whether default factors or actual measurements were used to estimate the DRE Reported destruction or removal efficiency (DRE)	Default factors used. HannStar 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_6, CF_4, HFC, and PFC abatement technologies and a 95 percent default DRE value for NF_3 abatement technologies. *Source: HannStar*
+ Practices for monitoring abatement systems	Information not available.

F-GHG Emissions Measurements

Total annual F-GHG emissions in CO_2e, 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.

2012 GHG Emission Inventory		
GHG	Emissions (t-CO_2-e)	Ratio to Total Emissions (%)
CO_2	196,897.76	62.1%
CH_4	433.58	0.1%
N_2O	1.65	0.0%
HFC	1,191.79	0.4%
PFC	1,863.98	0.6%
SF_6	116,463.25	36.8%
Total	316,849.01	100.0%

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

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

With regard to F-GHG emissions, HannStar reduced approximately 1.33 million tons of CO_2e from 2007 to2012.

F-GHG emissions reductions (in tons) for Tainan plant only in 2012:

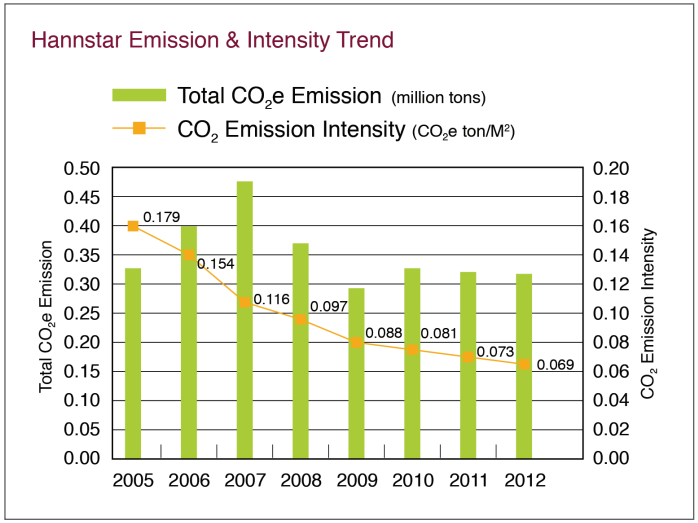
Performance of PFC Emission Reduction				
Year	PFC Production	PFC Emission Reduction	PFC Emission	Ratio of PFC Emission Reduction
2007	404,143	225,725	178,418	56%
2008	455,236	332,039	123,197	73%
2009	224,361	135,508	88,852	60%
2010	307,662	192,336	115,326	63%
2011	367,502	248,222	119,280	68%
2012	317,330	199,002	118,327	63%

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

Source: HannStar

F-GHG Emissions Measurements

F-GHG emissions intensity in tons of CO_2e/m^2 of glass input for Tainan plant only in 2012:



Source:
HannStar 2012 Corporate Social Responsibility Report.
(www.hannstar.com/HannStarUserFile/files/Quality/Hannstar_2012CSR_en.pdf)

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 performed ISO 14064-1 inventory and external verification since 2005 and reduces GHG voluntarily.

Source:
HannStar 2012 Corporate Social Responsibility Report.
(www.hannstar.com/HannStarUserFile/files/Quality/Hannstar_2012CSR_en.pdf)

Innolux Corporation (INX)

Overview

Specific F-GHG emissions reduction efforts and/or goals

As of 2010, INX had met and exceeded an earlier reduction goal to where its emissions intensity was 0.0094 tons of CO_2e/m^2 of glass substrate. INX then set a new goal to further reduce F-GHG emissions intensity to 0.0089 tons of CO_2e/m^2 in 2013. From 2010 to 2011, INX reduced its F-GHGs emissions intensity by 13 percent from 0.0094 tons down to 0.0082 tons of CO_2e/m^2 of glass input. In 2012, the F-GHG emissions intensity was 0.008558 tons of CO_2e/m^2.

In 2012, INX reduced approximately 11,919 tons of F-GHG emissions, and then set a target of achieving annual F-GHG emissions at 0.17 MMTCE for 2013, continuing with its F-GHG reductions. INX attributes achieving its results to process optimization to reduce the amount of F-GHGs needed, and to replacing a local scrubber to achieve better abatement.

Sources:
INX

2011 INX Corporate Social Responsibility (CSR) Report (www.innolux.com/Files/CWSFiles/csr/Chimei%20Innolux%202011%20CSR%20Report%20in%20English.pdf)

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

INX's responses to the 2013 Carbon Disclosure Project Investor Questionnaire.

2012 INX CSR Report (www.innolux.com/Pages/EN/CSR/Report_Download_EN.html)

"SF_6 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.
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.

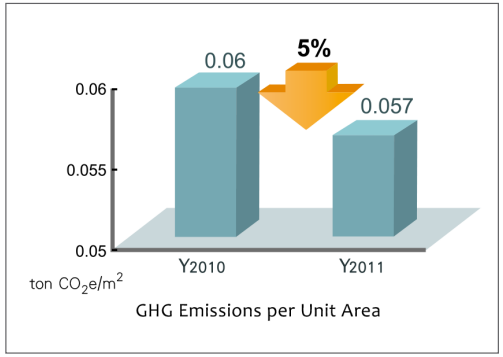
Overview

+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted	SF_6, PFCs, HFCs, NF_3. *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 the Taiwanese 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_2e/m^2 of glass substrate area by 2010 (this target is TTLA's collective goal and does not necessarily reflect each individual supplier's goal). In 2013, INX, together with TTLA, began discussions with the Taiwan EPA to initiate a second MOU to pursue additional commitments to voluntary reductions. 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_2e 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_6 (including non-F-GHGs CO_2, CH_4, and N_2O) 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).* *INX's responses to the 2013 Carbon Disclosure Project Investor Questionnaire.* *"SF_6 Abatement Strategy in Taiwan." Presentation by Taiwan's Industrial Technology Research Institute (ITRI), 2004. (www.epa.gov/electricpower-sf6/documents/conf04_lu.pdf)* *TTLA*

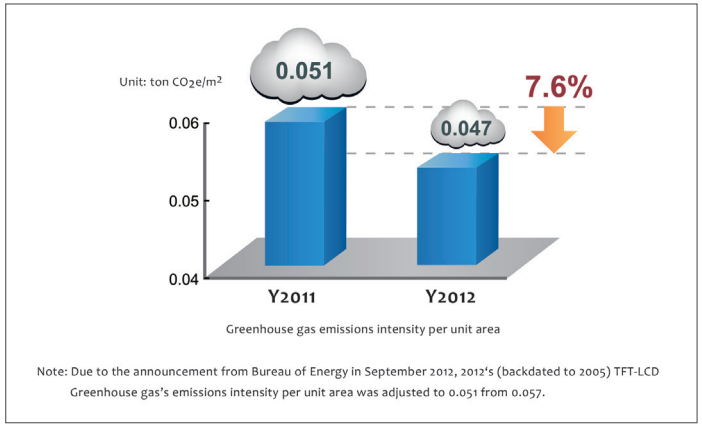
Corporate-wide GHG emissions reduction goals and reduction initiatives

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_2e. 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 (later adjusted to 0.051) metric tons of CO_2e/m^2 of input glass and again down to 0.047 tons of CO_2e/m^2 in 2012. INX attributes these reductions to installing more efficient F-GHG abatement equipment and promoting energy saving projects.



GHG Emissions per Unit Area



Greenhouse gas emissions intensity per unit area

Note: Due to the announcement from Bureau of Energy in September 2012, 2012's (backdated to 2005) TFT-LCD Greenhouse gas's emissions intensity per unit area was adjusted to 0.051 from 0.057.

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.

INX most recently publicly reported on its GHG management efforts to the Carbon Disclosure Project in 2013 for its 2012 calendar year.

Sources:
2011 INX CSR Report (www.innolux.com/Files/CWSFiles/csr/Chimei%20Innolux%202011%20CSR%20Report%20in%20English.pdf)

2012 INX CSR Report (http://www.innolux.com/Pages/EN/CSR/Report_Download_EN.html)

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

INX's responses to the 2013 Carbon Disclosure Project Investor Questionnaire

F-GHG Reduction Efforts		
	Process optimization	INX is optimizing the use of F-GHGs in the process chambers. Additional details not available. *Sources:* *INX* *TTLA presentation at APEC meeting, August 2012, Taiwan.*
	Use of alternatives	INX is using lower global warming potential (GWP) gases, where possible. Additional details not available. *Sources:* *INX* *TTLA presentation at APEC meeting, August 2012, Taiwan.*
	Capture and recycling	INX is working with Industrial Technology Research Institute of Taiwan to test a SF_6 liquefaction recovery system. If it works, INX will expand the system across applicable fabs. *Source: INX*
	Abatement	
	+ Full or partial installation of abatement systems across all new generation fabs	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. *Sources:* *2011 INX CSR Report (www.innolux.com/Files/CWSFiles/csr/Chimei%20Innolux%202011%20CSR%20Report%20in%20English.pdf)* *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)* *TTLA presentation at APEC meeting, August 2012, Taiwan.*
	+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	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. *Sources:* *INX* *TTLA*

F-GHG Reduction Efforts	+ Indicate whether default factors or actual measurements were used to estimate the DRE Reported destruction or removal efficiency (DRE)	Default factors used. INX 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_6, CF_4, HFC, and PFC abatement technologies and a 95 percent default DRE value for NF_3 abatement technologies. *Source:* *INX's responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).*
	+ Practices for monitoring abatement systems	INX controls all processes to follow the standard in the whole process. Additional details not available. *Source: INX*
F-GHG Emissions Measurements	**Total annual F-GHG emissions in CO_2e, emitted across all flat panel display manufacturing fabs** **Include year**	F-GHG emissions represented approximately 11 percent of INX's 2011 total GHG emissions inventory (Scope 1 and 2 emissions). In 2012, F-GHGs represented 15 percent of INX's total GHG emissions. As part of its **2013** responses to the Carbon Disclosure Project, which discloses its GHG emissions from **January 1, 2012 to December 31, 2012**, 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_2e: HFCs: 5,590 (increase compared to 2,685 in CY 2011) PFCs: 23,253 (increase compared 14,687 in CY 2011) SF_6: 491,183 (increase compared to 416,533 in CY 2011) Context: INX's F-GHG emissions increased from CY 2011 to CY 2012 mainly due to increased capacity in production. **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. *Sources:* *2011 INX CSR Report (www.innolux.com/Files/CWSFiles/csr/Chimei%20Innolux%202011%20CSR%20Report%20in%20English.pdf)* *2012 INX CSR Report (http://www.innolux.com/Pages/EN/CSR/Report_Download_EN.html)* *INX's responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).* *INX's responses to the 2013 Carbon Disclosure Project Investor Questionnaire.*

F-GHG Emissions Measurements

Total annual F-GHG emissions reductions and/or rate of emissions reductions	In 2012, INX reduced total annual F-GHG emissions by 2,691,168 tons of CO_2e, increasing its rate of emissions reductions by 28.3 percent from the previous year. In 2011, INX reduced total annual F-GHG emissions by 2,097,068 tons of CO_2e. *Sources:* *INX* *2011 INX CSR Report (www.innolux.com/Files/CWSFiles/csr/Chimei%20Innolux%202011%20CSR%20Report%20in%20English.pdf)* *2012 INX CSR Report (http://www.innolux.com/Pages/EN/CSR/Report_Download_EN.html)* *INX's responses to the 2012 Carbon Disclosure Project Investor Questionnaire (responded as CMI).* *INX's responses to the 2013 Carbon Disclosure Project Investor Questionnaire*
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 will finish its most recent inventory of GHG emissions at the end of April 2013. *Source: INX*

LG Display

Overview

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 NF_3 emissions from all of its flat panel display (LCD, OLED) manufacturing fabs, and 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 SF_6 emissions in LCD Manufacturing Operation in the Republic of Korea (South Korea)." LG Display's 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	SF_6, PFCs, NF_3. (HFCs are not used in processes). *Sources:* *LG Display* *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 (CDM) Project to reduce SF_6 emissions at two of its manufacturing fabs.

Overview		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_2, HFCs, PFCs, and SF_6 (and non-FGHGs N_2O and CH_4). Starting in 2015, the government will launch a 'cap and trade' system for limiting and trading domestic GHG emissions. *Sources:* *LG Display* *Korea Display Industry Association.* *"Point of Use Abatement Device to Reduce SF_6 emissions in LCD Manufacturing Operation in the Republic of Korea (South Korea)." LG Display's SF_6 Abatement Project. Clean Development Mechanism Project: 3440. (https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view)*
	Corporate-wide GHG emissions reduction goals and reduction initiatives	LG Display set a corporate-wide GHG reduction goal to reduce its GHG emissions intensity in metric tons of CO_2e per unit of production by over 40 percent from 2009 to 2020. 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. LG Display participates in the Carbon Disclosure Project and most recently reported on its GHG management efforts in 2012 for its 2011 calendar year. *Sources:* *LG Display* *LG Display's responses to the 2011 Carbon Disclosure Project Investor Questionnaire.*
F-GHG Reduction Efforts	**Process optimization**	LG Display has applied end-point detection and revised processes to optimize the use of F-GHGs. *Source: LG Display*
	Use of alternatives	LG Display has applied NF_3 remote plasma source chamber clean (RPSC) to all chemical vapor deposition (CVD) manufacturing lines. An ordinary chamber's NF_3 utilization rate is only 70 percent, however RPSC's NF_3 utilization rate is 97 percent. LG Display has also used F_2 in chamber cleaning on one of its manufacturing lines instead of NF_3. In addition, LG Display is researching lower global warming potential (GWP) etching gases than SF_6 for the dry etching process. *Source: LG Display*

F-GHG Reduction Efforts		
	Capture and recycling	LG Display is currently developing new SF_6-concentrating and capturing technology with funding from industry and the South Korean government. *Source: LG Display*
	Abatement	
	+ Full or partial installation of abatement systems across all new generation fabs	LG Display has installed F-GHG abatement systems on all lines of CVD tools and on three lines of etch tools. For NF_3 in CVD tools, electrically heated point-of-use systems are installed. For SF_6 and PFCs in etch tools, combustion-type centralized systems are installed. *Source: LG Display*
	+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	Yes. 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. In the case of etch tools, LG Display is verified by a third party entity, which is the Designated Operational Entity of CDM projects. *Source: LG Display*
	+ Indicate whether default factors or actual measurements were used to estimate the DRE Reported destruction or removal efficiency (DRE)	Actual and default used. LG Display conducts actual measurements for its centralized abatement systems for its SF_6 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_6 abatement technologies. In the case of NF_3, which is not regulated by Korean law, LG Display applies the 95-percent default DRE value for NF_3, also taken from the 2006 IPCC Tier 2b Guidelines, in WLICC activities. *Sources:* *LG Display* *"Point of Use Abatement Device to Reduce SF_6 emissions in LCD Manufacturing Operation in the Republic of Korea (South Korea)." LG Display's SF_6 Abatement Project. Clean Development Mechanism Project: 3440. (https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view)*

F-GHG Reduction Efforts	+ Practices for monitoring abatement systems	For its centralized abatement systems, LG Display employs a continuous monitoring (FTIR, Annabar system), namely for its CDM project that destroys SF_6. For its point-of-use systems, LG Display monitors the abatement systems on an as-needed basis. *Sources:* *LG Display* *"Point of Use Abatement Device to Reduce SF_6 emissions in LCD Manufacturing Operation in the Republic of Korea (South Korea)." LG Display's SF_6 Abatement Project. Clean Development Mechanism Project: 3440. (https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view)*
F-GHG Emissions Measurements	**Total annual F-GHG emissions in CO_2e, emitted across all flat panel display manufacturing fabs** **Include year**	The following data for 2012 was verified by a third party: Total amount of F-GHG emissions in metric tons of CO_2e: 3,115,747 (decrease compared to 3,122,694 in CY 2011) SF_6 emissions: 3,074,008 (decrease compared to 3,084,211 in CY 2011) PFC emissions: 5,833 (increase compared to 5,680 in CY 2011) HFC emissions: 0 (same as CY 2011) NF_3 emissions: 35,906 (increase compared to 32,803 in CY 2011) The data for 2013 is undergoing verification by a third party. **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*

F-GHG Emissions Measurements

Total annual F-GHG emissions reductions and/or rate of emissions reductions	Total amount of F-GHG reductions in 2012 in metric tons of CO_2e: 8,288,277 (increase in reductions compared to 6,989,465 in CY 2011) SF_6 reductions: 1,143,028 (increase in reductions compared to 461,712 in CY 2011) PFC reductions: 0 (same as CY 2011) HFC reductions: 0 (same as CY 2011) NF_3 reductions: 7,145,249 (increase in reductions compared to 6,527,753 in CY 2011) The data for 2013 is undergoing verification by a third party. Equation for SF_6 reductions: = Emissions without destruction – Emissions with destruction Equation for NF_3 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*
Methodology used to estimate F-GHG emissions	LG Display uses national GHG emissions estimation guidelines issued by the South Korean Ministry of Environment and estimates NF_3 emissions by using the 2006 IPCC Tier 2b guidelines. *Source: LG Display*
Third party assurance for F-GHG emissions estimates	LG Display's GHG emissions, such as CO_2, N_2O, CH_4, HFCs, PFCs, and SF_6 are assured by a third party in accordance with South Korean government regulations. Also, LG Display received third party assurance for its SF_6 abatement project under the CDM. However, NF_3 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_6 emissions in LCD Manufacturing Operation in the Republic of Korea (South Korea)." LG Display's SF_6 Abatement Project. Clean Development Mechanism Project: 3440. Validation Report, May 2, 2010. (https://cdm.unfccc.int/Projects/DB/SGS-UKL1266943063.39/view)*

Panasonic Liquid Crystal Display (PLD)

Overview

Specific F-GHG emissions reduction efforts and/or goals	Panasonic Liquid Crystal Display (PLD) considers installation of abatement systems to be the most effective and realistic technique to reduce F-GHG emissions. PLD established a 100 percent installation of abatement systems for both SF_6 and NF_3 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 and 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_6, NF_3. *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	PLD is a member of the Japan Electronics Industry Trade Association (JEITA), which participates on behalf of Japan's liquid crystal display (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_2e. 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	PLD participates in the Carbon Disclosure Project (CDP) and most recently publicly reported on its GHG management efforts in 2013 for its April 2012–March 2013 reporting year. *Source: Panasonic's responses to the 2013 Carbon Disclosure Project Investor Questionnaire.*

F-GHG Reduction Efforts		
	Process optimization	PLD is working on process optimization daily. Additional details not available. *Source: Panasonic Liquid Crystal Display (PLD)*
	Use of alternatives	PLD uses SF_6 as an etching gas and NF_3 as a cleaning gas for chemical vapor deposition (CVD). Regarding further improvements, PLD would like to assess technology trends and respond accordingly. *Source: Panasonic Liquid Crystal Display (PLD)*
	Capture and recycling	PLD will continue gathering information to proceed with discussion and review of capture and recycling technologies. *Source: Panasonic Liquid Crystal Display (PLD)*
	Abatement	
	+ Full or partial installation of abatement systems across all new generation fabs	PLD installs abatement systems to all CVD equipment and all dry-etchers. *Source: Panasonic Liquid Crystal Display (PLD)*
	+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	PLD checks the performance of abatement systems at the time of installation and operates them under proper management to ensure optimal results. *Source: Panasonic Liquid Crystal Display (PLD)*
	+ Indicate whether default factors or actual measurements were used to estimate the DRE Reported destruction or removal efficiency (DRE)	The Sustainability Report by the Panasonic Group and CDP 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. *Source: Panasonic Liquid Crystal Display (PLD)*
	+ Practices for monitoring abatement systems	PLD checks the performance of abatement systems at the time of installation. *Source: Panasonic Liquid Crystal Display (PLD)*

F-GHG Emissions Measurements

Total annual F-GHG emissions in CO_2e, emitted across all flat panel display manufacturing fabs **Include year**	PLD's F-GHG emissions are disclosed in the Panasonic Group's Sustainability Report **2013**, and are also included in its reporting to the CDP. PLD's F-GHG emissions from its Himeji factory only, as reported from **April 1, 2012 to March 31, 2013**, are as follows in tons of CO_2e: SF_6 emissions: 6,583 (an increase from FY 2012, where emissions were 5,722). According to PLD, when calculated by the IPCC Tier 2b guidelines default factors used in the Questionnaire of JEITA Display Devices Environment Committee, F-GHG emissions are as follows in tons of CO_2e: SF_6 emissions: 8,477 (an increase from FY 2012, where emissions were 8,188) NF_3 emissions: 2,145 (an increase from FY 2012, where emissions were 2,069) **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)* *Sustainability Report 2013 by the Panasonic Group (http://panasonic.net/sustainability/en/downloads/)*
Total annual F-GHG emissions reductions and/or rate of emissions reductions	Himeji factory started production in the middle of 2010. PLD will continue monitoring F-GHG emissions during this transition to production at the Himeji factory. *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 Sustainability Report by the Panasonic Group is audited by a third-party organization as described in the report. *Source: Sustainability Report 2013 by the Panasonic Group (http://panasonic.net/sustainability/en/downloads/)*

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_6 and PFC 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_2e. *Sources:* *Samsung 2012 Sustainability Report (www.samsung.com/us/aboutsamsung/sustainability/sustainabilityreports/download/2012/2012_climate_change_energy.pdf)* *Samsung Electronics SF_6 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_6, PFCs, HFCs. NF_3 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	If 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_6 emissions at one of its manufacturing fabs. In recent years, the South Korean government set a long-term national GHG emissions reduction goal for 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_2, HFCs, PFCs, and SF_6 (and non-FGHGs N_2O and CH_4). Starting in 2015, the government will launch a 'cap and trade' system for limiting and trading domestic GHG emissions.

Overview		*Sources:* *Korea Display Industry Association* *Samsung Electronics SF_6 Abatement Project. Clean Development Mechanism Project: 3333. (http://cdm.unfccc.int/Projects/DB/JQA1264981590.19)*
	Corporate-wide GHG emissions reduction goals and reduction initiatives	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_2e 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_2e. 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. Samsung Electronics participates in the Carbon Disclosure Project (CDP) and most recently publicly reported on its GHG management efforts for its 2013 calendar year. In 2012, Samsung Electronics' absolute GHG emissions were reduced mostly due to its structural reorganization, with the separation of its LCD business division and incorporation of the LED division in April 2012. As a result, Samsung Display's total F-GHG process emissions for 2012 are not included in Samsung Electronics' 2013 CDP Report. *Sources:* *Samsung's Climate Strategy* *(www.samsung.com/us/aboutsamsung/sustainability/environment/climatestrategy/climatestrategy.html)* *Samsung Electronics' responses to the 2012 and 2013 Carbon Disclosure Project Investor Questionnaire* *Samsung 2013 Sustainability Report* *(www.samsung.com/us/aboutsamsung/sustainability/sustainabilityreports/2013sustainabilityreport.pdf)*
F-GHG Reduction Efforts	**Process optimization**	According to Samsung Electronics' 2013 Sustainability Report, "each operation site is taking a variety of reduction measures such as [the] introduction of process gas facilities…" *Source:* *Samsung 2013 Sustainability Report* *(www.samsung.com/us/aboutsamsung/sustainability/sustainabilityreports/2013sustainabilityreport.pdf)*
	Use of alternatives	Information not available.
	Capture and recycling	Information not available.

F-GHG Reduction Efforts		
Abatement		
	+ Full or partial installation of abatement systems across all new generation fabs	Samsung Display has installed electrically heated F-GHG abatement systems on all lines of chemical vapor deposition (CVD) tools and SF_6 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, and electrical heated types of abatement systems. *Sources:* *Samsung Display* *Korea Display Industry Association*
	+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications[1]	Details not available.
	+ Indicate whether default factors or actual measurements were used to estimate the DRE Reported destruction or removal efficiency (DRE)	Actual and default used. Samsung Display conducts actual measurements for its centralized abatement systems for its SF_6 abatement project under the CDM. In other instances, Samsung Displays 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_6, HFC, and PFC abatement technologies. Samsung Display has abatement for NF_3 on some lines and uses the 95-percent default DRE value for NF_3 abatement technologies. *Sources:* *Samsung Display* *Samsung Electronics SF_6 Abatement Project. Clean Development Mechanism Project: 3333. (http://cdm.unfccc.int/Projects/DB/JQA1264981590.19)*
	+ Practices for monitoring abatement systems	For its centralized abatement systems, Samsung employs a continuous monitoring (FTIR, Annabar system) for its CDM project that destroys SF_6. For its other abatement systems, Samsung Display applies the IPCC guidelines. *Sources:* *Samsung Display* *Samsung Electronics SF_6 Abatement Project. Clean Development Mechanism Project: 3333. (http://cdm.unfccc.int/Projects/DB/JQA1264981590.19)*

[1] According to the Korea Display Industry Association, suppliers ensure that abatement systems are installed, operated, and maintained according to manufacturer specifications.

F-GHG Emissions Measurements

Total annual F-GHG emissions in CO_2e, 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 **2013** disclosure to the Carbon Disclosure Project, which discloses GHG emissions from **January 1, 2012 to December 31, 2012**, 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_2e: HFCs: 134,318 (increase compared to 107,754 in CY 2011) PFCs: 1,014,660 (increase compared to 858,743 in CY 2011) SF_6: 114,941 (decrease compared to 1,737,702 in CY 2011) Context: In 2012, Samsung Electronics' absolute GHG emissions were reduced mostly due to its structural reorganization, with the separation of its LCD business division and incorporation of the LED division in April 2012. As a result, Samsung Display's total F-GHG process emissions for 2012 are not included in Samsung Electronics' 2013 CDP Report. **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. *Sources:* *Samsung Electronics' responses to the 2013 Carbon Disclosure Project Investor Questionnaire.* *Samsung 2013 Sustainability Report* *(http://www.samsung.com/us/aboutsamsung/sustainability/sustainabilityreports/2013sustainabilityreport.pdf)*
Total annual F-GHG emissions reductions and/or rate of emissions reductions	Information not available from Samsung Display for F-GHG emissions reductions associated with LCD manufacturing (for information on Samsung Electronics' efforts to reduce F-GHG emissions from other manufacturing processes, see its 2013 Sustainability Report at www.samsung.com/us/aboutsamsung/sustainability/sustainabilityreports/2013sustainabilityreport.pdf).
Methodology used to estimate F-GHG emissions	Samsung Display uses national GHG emissions estimation guidelines issued by the South Korean Ministry of Environment and the 2006 IPCC Tier 2b guidelines. *Source: Samsung Display*

F-GHG Emissions Measurements

Third party assurance for F-GHG emissions estimates

Samsung Display received third party assurance for its SF_6 abatement project under the CDM. Most of Samsung Display's F-GHG emissions data is verified by a third party. However, NF_3 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_6 Abatement Project Validation Report, May 12, 2010. (http://cdm.unfccc.int/filestorage/8/4/6/846DVPZREQF9WNY53KGLM2XJ17TCS0/Validation_Report%20Ver.%2001.1%20clean-2?t=b3l8bjQ1a20yfDCNTEMSCX6rXcntrPqdMgfH)

Samsung Display

Samsung Electronics SF_6 Abatement Project VALIDATION OPINION on changes from the project activity as described in the registered PDD. November 2, 2011. (http://cdm.unfccc.int/filestorage/Y/3/F/Y3F2QU6HVSNAGEMJP49DI7BWXTL85K/Validation%20Opinion%20for%20PDD%20Change%20%28ver.2.1%29?t=RmN8bjQ1a3AzfDBurLgxU_V01feTBNpwdhuC)

Sharp

Overview

Specific F-GHG emissions reduction efforts and/or goals	Sharp has, as a part of F-GHG emission reduction activities, installed abatement systems on all F-GHG using process lines of all liquid crystal display (LCD) manufacturing fabs, and has been maintaining the abatement systems appropriately. *Source: Sharp (Sharp Corporation)*
+ F-GHG emissions reduction efforts/goals target the following key processes that emit F-GHGs	Etch and Clean processes. Information on fluorinated heat transfer fluids not available. *Source: Nishida, et al. PFC Emission Reduction Strategy for the LCD Industry. Journal of the SID 13/10. 2005.*
+ F-GHG emissions reduction efforts/goals target the following F-GHGs emitted	SF_6, PFCs (CF_4, C_2F_6, C_4F_8), HFCs (CHF_3), NF_3. *Source: Japan Electronics and Information Technology Industries Association (JEITA).*
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 by 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_2e. 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	Sharp set a goal to reduce absolute GHG emissions per year to below 2007 baseline fiscal year emissions levels for ten manufacturing fabs by 2011. Its most recent base year emissions were reported as 968,000 metric tons of CO_2e. Sharp also set another goal to reduce GHG emissions intensity by 35 percent per adjusted production units (tons of CO_2e/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 (CDP) and most recently publicly reported on its GHG management efforts in 2013 for its April 2012–March 2013 reporting year. *Source: Sharp's responses to the 2013 Carbon Disclosure Project (CDP) Investor Questionnaire.*

F-GHG Reduction Efforts

Process optimization	Sharp has been researching ways to improve process optimization and manufacturing process conditions at the time that manufacturing equipment is first installed and in daily operations. *Source: Sharp (Sharp Corporation)*
Use of alternatives	Sharp has been collecting the latest information from relevant sources and researching the possibility of lower global warming potential (GWP) alternative gases usage. *Source: Sharp (Sharp Corporation)*
Capture and recycling	Sharp implements the recycling of F-GHGs in some manufacturing processes. *Source: Sharp (Sharp Corporation)*
Abatement	
+ Full or partial installation of abatement systems across all new generation fabs	Sharp has installed abatement systems on all etching and cleaning process equipment. *Source: Sharp (Sharp Corporation)*
+ Ensured that abatement systems are installed, operated, maintained, according to manufacturer specifications	Sharp has been managing abatement systems appropriately during all installation, operation, and maintenance processes, in cooperation with the abatement system manufacturing professionals. *Source: Sharp (Sharp Corporation)*
+ Indicate whether default factors or actual measurements were used to estimate the DRE Reported destruction or removal efficiency (DRE)	Sharp uses the IPCC Tier 2b Guidelines Default Factors to answer the questionnaire from JEITA. *Source: Sharp (Sharp Corporation)*
+ Practices for monitoring abatement systems	Sharp verifies the performance of abatement systems at the time of installation, and implements the maintenance and verifications for performance retention. *Source: Sharp (Sharp Corporation)*

F-GHG Emissions Measurements	
Total annual F-GHG emissions in CO_2e, 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 **2013** responses to the CDP, which discloses its corporate GHG emissions from **April 1, 2012 to March 31, 2013**, 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_2e. HFCs: 4,000 (a decrease from 5,500 in FY 2012) PFCs: 31,000 (a decrease from 60,000 in FY 2012) SF_6: 33,000 (a decrease from 54,000 in FY 2012) Context: Sharp's F-GHG emissions were reduced in FY 2012 from FY 2011 due to a decrease in production and the removal of one fab as reflected in its responses to the 2013 CDP questionnaire. **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 2013 CDP Investor Questionnaire.*
Total annual F-GHG emissions reductions and/or rate of emissions reductions	Sharp works to reduce F-GHG emissions in accordance with the targets of Ministry of Economy, Trade and Industry; JEITA; and other industrial associations. *Source: Sharp (Sharp Corporation)*
Methodology used to estimate F-GHG emissions	Sharp uses the IPCC Tier 2b Guidelines Default Factors to estimate F-GHG emissions. *Source: Sharp (Sharp Corporation)*
Third party assurance for F-GHG emissions estimates	Sharp's Sustainability Report is audited by a third-party organization (KPMG AZSA Sustainability Co., Ltd.). *Source: Sharp (Sharp Corporation)*