

# Electronics Manufacturing

## Subpart I, Greenhouse Gas Reporting Program

### OVERVIEW

*Subpart I of the Greenhouse Gas Reporting Program (GHGRP) (40 CFR 98.90 – 98.98) applies to any facility engaged in electronics manufacturing and that meets the Subpart I source category definition. Some subparts have thresholds that determine applicability for reporting, and some do not. To decide whether your facility must report under this subpart, please refer to 40 CFR 98.91 and the GHGRP [Applicability Tool](#).*

*This Information Sheet is intended to help facilities reporting under Subpart I understand how the source category is defined, what greenhouse gases (GHGs) must be reported, how GHG emissions must be calculated and shared with EPA, and where to find more information.*



### How is This Source Category Defined?

The electronics manufacturing category consists of facilities engaged in any of the following electronics manufacturing production processes:

- Processes in which etching uses plasma-generated fluorine (F<sub>2</sub>) atoms and other reactive F<sub>2</sub>-containing fragments, which chemically react with exposed thin-films (e.g., dielectric, metals) or substrate (e.g., silicon (Si)) to selectively remove portions of material;
- Processes in which chambers used for depositing thin films are cleaned periodically using plasma-generated F<sub>2</sub> atoms and other reactive F<sub>2</sub>-containing fragments from fluorinated and other gases;
- Processes in which wafers are cleaned using plasma generated F<sub>2</sub> atoms or other reactive F<sub>2</sub>-containing fragments to remove residual material from wafer surfaces, including the wafer edge;
- Processes in which the chemical vapor deposition (CVD) process or other production processes use nitrous oxide (N<sub>2</sub>O); and
- Processes in which fluorinated greenhouse gases (GHGs) are used as heat transfer fluids (HTFs) to cool process equipment, to control temperature during device testing, to clean substrate surfaces and other parts, and for soldering (e.g., vapor phase reflow). HTFs commonly used in electronics manufacturing include those sold under the trade names "Galden®" and "Fluorinert™."

Facilities that use these processes include but are not limited to those that manufacture micro-electro-mechanical systems (MEMS), liquid crystal displays (LCDs), photovoltaic cells (PV), and semiconductors (including light-emitting diodes (LEDs)).



### What GHGs Must Be Reported?

All electronics manufacturing facilities must report:

- Fluorinated GHG emissions from electronic manufacturing production processes and HTF use.
- N<sub>2</sub>O emissions from CVD and other production processes.
- Controlled emissions of GHGs from abatement systems, if applicable.

- CO<sub>2</sub>, methane (CH<sub>4</sub>), and N<sub>2</sub>O emissions from each stationary combustion unit by following the requirements of Subpart C (General Stationary Combustion Sources), found at 40 CFR 98.30 – 98.38. The Subpart C Information Sheet summarizes the requirements for calculating and reporting emissions from these units.

Fluorinated GHGs include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF<sub>6</sub>), nitrogen trifluoride (NF<sub>3</sub>), hydrofluoroethers (HFEs), and others as defined in 40 CFR 98.6.

If multiple Greenhouse Gas Reporting Program (GHGRP) source categories are co-located at a facility, the facility may need to report greenhouse gas (GHG) emissions under a different subpart. Please refer to the relevant information sheet for a summary of the rule requirements for any other source categories located at the facility.



## How Must GHG Emissions Be Calculated?

A facility that engages in production processes covered by Subpart I and meets the reporting threshold must determine the total annual emissions of each fluorinated GHG emitted and account for fluorinated HTF emissions by electronics manufacturing production processes from each fab (as defined in 40 CFR 98.98) at the facility, including each input gas and each by-product gas. Facilities may use either default gas utilization rates and by-product formations or the stack test method to determine their emissions for all process types and sub-types.

If a facility manufactures semiconductors, they will calculate annual emissions of each input gas and of each by-product gas using Equations I-6, I-7, I-8A and I-8B.

If a facility manufactures MEMS or PVs and uses semiconductor tools and processes, they may calculate annual fab-level emissions according to 40 CFR 98.3(a)(1) as if they were manufacturing semiconductors. For all other tools and processes used to manufacture MEMs, LCD and PV, they will calculate annual fab-level emissions of each fluorinated GHG used for the plasma etching and chamber cleaning process types using default utilization and by-product formation rates as shown in Table I-5, I-6, or I-7 to this subpart, as appropriate, and by using Equations I-8A and I-8B.

If a fab employs hydrocarbon-fuel-based combustion emissions control systems (HC-fuel-based CECS), including, but not limited to, abatement systems as defined at 40 CFR 98.98, that were purchased and installed on or after January 1, 2025 to control emissions from tools that use either NF<sub>3</sub> in remote plasma cleaning processes or F<sub>2</sub> as an input gas in any process type or sub-type, they must calculate the amount of carbon tetrafluoride (CF<sub>4</sub>) produced within and emitted from such systems using Equation I-9 using default utilization and by-product formation rates as shown in Table I-3 or I-4 to this subpart. A HC-fuel-based CECS is assumed not to form CF<sub>4</sub> from F<sub>2</sub> if the electronics manufacturer can certify that the rate of conversion from F<sub>2</sub> to CF<sub>4</sub> is <0.1% for that HC-fuel-based CECS.

If a given fab at a facility uses less than 50 kilograms (kg) of a fluorinated GHG in one reporting year, they may calculate emissions as equal to the fab's annual consumption for that specific gas as calculated in Equation I-11, plus any by-product emissions of that gas calculated using Equations I-6, I-7, I-8A, or I-8B.

Facilities must calculate the annual fab-level N<sub>2</sub>O emissions from all CVD processes and from the aggregate of all other electronics manufacturing production processes. For fabs that use less than 50 kg of N<sub>2</sub>O in one reporting year, a facility may calculate fab emissions as equal to annual consumption for N<sub>2</sub>O.

A checklist for data that must be monitored is available here: [Subpart I Monitoring Checklist](#).



## What Information Must Be Reported?

In addition to the information required by the General Provisions in Subpart A, found at 40 CFR 98.3(c), the following must be reported:

- Annual manufacturing capacity of each fab.
- For facilities that manufacture semiconductors, the diameter of wafers processed at each fab.
- Annual emissions, on a fab basis, of each fluorinated GHG emitted from each process type and process sub-type, N<sub>2</sub>O-using process, and HTF application, and the calculation method used.
- Annual production in terms of substrate surface area (e.g., Si, PV-cell, glass) for each fab, indicating specification of the substrate.
- For the fab-specific apportioning model used to apportion fluorinated GHG and N<sub>2</sub>O consumption:
  - The identification of the quantifiable metric used in the fab-specific engineering model to apportion gas consumption for each fab, and/or an indication of direct measurements that were used in addition to, or instead of, a quantifiable metric.
  - The start and end dates selected under 40 CFR 98.94(c)(2)(i).
  - Certification that the gas(es) you selected under 40 CFR 98.94(c)(2)(ii) for each fab corresponds to the largest quantity(ies) consumed, on a mass basis, of fluorinated GHG used at the fab during the reporting year for which you are required to apportion.
  - The result of the calculation comparing the actual and modeled gas consumption.
- For all HC-fuel-based CECS that were purchased and installed on or after January 1, 2025, that are used to control emissions from tools that use either NF<sub>3</sub> as an input gas in remote plasma clean processes or F<sub>2</sub> as an input gas in any process type or sub-type and for which you are not calculating emissions under Equation I-9, certification that the rate of conversion from F<sub>2</sub> to CF<sub>4</sub> is <0.1% and that the systems are installed, operated, and maintained in accordance with the directions of the HC-fuel-based CECS manufacturer. HC-fuel-based CECS include but are not limited to abatement systems as defined in 40 CFR 98.98 that are HC-fuel-based. If you make the certification based on your own testing, you must certify that you tested the model of the system according to the requirements specified in 40 CFR 98.94(e). If you make the certification based on testing by the HC-fuel-based CECS manufacturer, you must provide documentation from the HC-fuel-based CECS manufacturer that the rate of conversion from F<sub>2</sub> to CF<sub>4</sub> is <0.1% when tested according to the requirements specified in 40 CFR 98.94(e).
- If a facility is required to apportion fluorinated GHG consumption between fabs, certification that the gas(es) selected correspond to the largest quantity(ies), consumed on a mass basis, of fluorinated GHG used at the facility during the reporting year for which apportioning is required.
- Where missing data procedures were used to estimate inputs into the fluorinated HTF Mass Balance equation, the number of times missing data procedures were followed in the reporting year and the method used to estimate the missing data.
- If the facility includes emissions from research and development activities, report the approximate percentage of total GHG emissions, on a metric ton of carbon dioxide equivalent (CO<sub>2e</sub>) basis, that are attributable to research and development activities, using the following ranges: less than 5%, 5% to less than 10%, 10% to less than 25%, 25% to less than 50%, 50% and higher.

### Abatement

- Inventory and description of all abatement systems through which fluorinated GHGs or N<sub>2</sub>O flow at the facility and for which destruction or removal efficiency is claimed, including:
  - The number of abatement systems controlling emissions for each process sub-type, or process type, as applicable, for each gas used in the process sub-type or process type.
  - The basis of the destruction or removal efficiency being used (default, manufacturer-verified, or site-specific measurement according to 40 CFR 98.94(f)(4)(i)) for each process sub-type or process type and for each gas.
- For all abatement systems through which fluorinated GHGs or N<sub>2</sub>O flow for which controlled emissions are reported:

- Certification that all abatement systems at the facility have been installed, maintained, and operated in accordance with the site maintenance plan for abatement systems that is developed and maintained in facility records.
- If default destruction or removal efficiency values are used in the facility emissions calculations, certification that the site maintenance plan for abatement systems for which emissions are being reported contains manufacturer's recommendations and specifications for installation, operation, and maintenance for each abatement system. To use the default or lower manufacturer-verified destruction or removal efficiency values, operation of the abatement system must be within manufacturer's specifications, which may include, for example, specifications on vacuum pumps' purges, fuel and oxidizer settings, supply and exhaust flows and pressures, and utilities to the emissions control equipment including fuel gas flow and pressure, calorific value, and water quality, flow, and pressure.
- If default destruction or removal efficiency values are used in the facility emissions calculations, certification that the abatement systems for which emissions are being reported were specifically designed for fluorinated GHG or N<sub>2</sub>O abatement, as applicable. Facility must support this certification by providing abatement system supplier documentation stating that the system was designed for fluorinated GHG or N<sub>2</sub>O abatement, as applicable, and supply the destruction or removal efficiency value at which each abatement system is certified for the fluorinated GHG or N<sub>2</sub>O abated, as applicable. You may only use the default destruction or removal efficiency value if the abatement system is verified to meet or exceed the destruction or removal efficiency default value in Table I-16 to this subpart. If the system is verified at a destruction or removal efficiency value lower than the default value, you may use the verified value.
- Facility must report an effective fab-wide destruction or removal efficiency value for each fab at the facility.

### Stack Systems

- For all stack systems for which a facility calculates fluorinated GHG emissions according to the procedures specified in 40 CFR 98.93(i)(3), certification that facility has included and accounted for all abatement systems and any respective downtime in emissions calculations.
- If applicable, for fab-level emissions of fluorinated GHG using the stack test methods, the facility must report the following for each stack system:
  - The date of any stack testing conducted during the reporting year, and the identity of the stack system tested.
  - An inventory of all stack systems from which process fluorinated GHG are emitted.

### Technology Assessment Reports

- If the semiconductor manufacturing facility manufactures wafers >150 millimeter (mm) and emits >40,000 metric tons CO<sub>2</sub>e of GHG emissions, based on the most recently submitted annual report, prepare and submit a technology assessment report every five years to the Administrator (or an authorized representative) that meets the requirements specified. Any other semiconductor manufacturing facility may voluntarily submit this report to the Administrator. If your semiconductor manufacturing facility manufactures only 150 mm or smaller wafers, you are not required to prepare and submit a technology assessment report, but you are required to prepare and submit a report if your facility begins manufacturing wafers 200 mm or larger during or before the calendar year preceding the year the technology assessment report is due. If your semiconductor manufacturing facility is no longer required to report to the GHGRP under Subpart I due to the cessation of semiconductor manufacturing as described in 40 CFR 98.2(i)(3), you are not required to submit a technology assessment report.
  - Reports must be delivered every five years no later than March 31<sup>st</sup> of the year in which it is due.
  - The report must include the following information:
    - A description of how the gases and technologies used in semiconductor

manufacturing using 200 mm and 300 mm wafers in the U.S. have changed in the past five years and whether any of the identified changes are likely to have affected the emissions characteristics of semiconductor manufacturing processes in such a way that the default utilization and by-product formation rates or default destruction or removal efficiency factors of this subpart may need to be updated.

- A description of the effect on emissions of the implementation of new process technologies and/or finer line width processes in 200 mm and 300 mm technologies, the introduction of new tool platforms, and the introduction of new processes on previously tested platforms.
  - A description of the status of implementing 450 mm wafer technology and the potential need to create or update default emission factors (EFs) compared to 300 mm technology.
  - Any utilization and by-product formation rates and/or destruction or removal efficiency data that have been collected in the previous five years that support the changes in semiconductor manufacturing processes described in the report. Any utilization or by-product formation rate data submitted must be reported using both the all-input gas method and the reference emission factor method if multiple fluorinated input gases are used, unless one of the input gases does not have a reference process utilization rate in Table I-19 or I-20 for the process type and wafer size whose EFs are being measured, in which case the data must be submitted using the all-input gas method. If only one fluorinated input gas is fed into the process, you must use Equations I-29A and I-29B of this subpart. In addition to using the all-input gas method and the reference emission factor method, facilities have the option to calculate and report the utilization or by-product formation rate data using any alternative calculation methodology. If facilities choose to use an additional alternative calculation methodology to calculate and report the input gas EFs and by-product formation rates, facilities must also provide a complete, mathematical description of the alternative method used (including the equation used to calculate each reported utilization and by-product formation rate).
  - The report must include the input gases used and measured, the utilization rates measured, the by-product formation rates measured, the process type, the process subtype for chamber clean processes, the wafer size, and the methods used for the measurements. The report must also specify the method used to calculate each reported utilization and by-product formation rate and provide a unique record number for each data set. For any destruction or removal efficiency data submitted, the report must include the input gases used and measured, the destruction and removal efficiency measured, the process type, the methods used for the measurements, and whether the abatement system is specifically designed to abate the gas measured under the operating conditions used for the measurement.
  - A descriptions of the use of a new gas, use of an existing gas in a new process type or sub-type, or a fundamental change in process technology.
- If the report indicates that GHG emissions from semiconductor manufacturing may have changed from those represented by the default utilization and by-product formation rates, or the default destruction or removal efficiency values in this subpart, the report must lay out a data gathering and analysis plan focused on the areas of potential change. The plan must describe the following elements:
    - The testing of tools to determine the potential effect on current utilization and by-product formation rates and destruction or removal efficiency values under the new conditions.
    - A planned analysis of the effect on overall facility emissions using a representative gas-use profile for a 200 mm, 300 mm, or 450 mm fab (depending on which

technology is under consideration).

- Multiple semiconductor manufacturing facilities may submit a single consolidated technology assessment report if the facility identifying information in 40 CFR 98.3(c)(1) and the certification statement in 40 CFR 98.3(c)(9) is provided for each facility for which the consolidated report is submitted.



## What Records Must Be Maintained?

Reporters are required to retain records that pertain to their annual GHGRP as described at 40 CFR 98.3(g). Please see the [Subpart A Information Sheet](#) and 40 CFR 98.3(g) for general recordkeeping requirements. Specific recordkeeping requirements for Subpart I are listed at 40 CFR 98.97.



## When and How Must Reports Be Submitted?

Reporters must submit their annual GHGRP reports for the previous calendar year to the EPA by March 31<sup>st</sup>, unless the 31<sup>st</sup> falls on a Saturday, Sunday, or federal holiday, in which case reports are due on the next business day. Annual reports must be submitted electronically using the [electronic Greenhouse Gas Reporting Tool \(e-GGRT\)](#), the GHGRP's online reporting system.

Additional information on setting up user accounts, registering a facility, and submitting annual reports is available on the [GHGRP Help webpage](#).



## When Can a Facility Stop Reporting?

A facility may discontinue reporting under several scenarios, which are summarized in Subpart A (found at 40 CFR 98.2(i)) and the [Subpart A Information Sheet](#).



## For More Information

For additional information on Subpart WW, please visit the [Subpart I webpage](#). For additional information on the GHGRP, please visit the [GHGRP website](#), which includes additional information sheets, [data](#) previously reported to the GHGRP, [training materials](#), and links to Frequently Asked Questions ([FAQs](#)). For questions that cannot be answered through the GHGRP website, please contact us at: [GHGreporting@epa.gov](mailto:GHGreporting@epa.gov).

*This Information Sheet is provided solely for informational purposes. It does not replace the need to read and comply with the regulatory text contained in the rule. Rather, it is intended to help reporting facilities and suppliers understand key provisions of the GHGRP. It does not provide legal advice; have a legally binding effect; or expressly or implicitly create, expand, or limit any legal rights, obligations, responsibilities, expectations, or benefits with regard to any person or entity.*