Joint Crediting Mechanism Approved Methodology TH_AM006
"Installation of Displacement Ventilation Air Conditioning Unit in the Cleanroom of Semiconductor Manufacturing Factory"

A. Title of the methodology

Installation of Displacement Ventilation Air Conditioning Unit in the Cleanroom of Semiconductor Manufacturing Factory, Version 01.0

B. Terms and definitions

Terms	Definitions
Displacement ventilation	Air distribution technology that introduces conditioned air into a zone at a low velocity (less than 1.0 m/s) via diffusers located either at near floor level or middle space of a room and spreads the supply air over the floor to displace the warmer air from the occupied zone toward the ceiling for ventilation.
Displacement ventilation air conditioning unit	A supplying unit of conditioned air with application of displacement ventilation technology. The unit doesn't include outdoor-air processing units.
Mixing ventilation	A traditional air distribution technology that uses turbulent or laminar flow of fresh air supplied from the ceiling level so that mix and dilute any existing warmer air with supplied clean and conditioned air.
Mixing ventilation air conditioning unit	A supplying unit of conditioned air with application of mixing ventilation technology.
Airborne particulate cleanliness class	The level of cleanliness specified by the maximum allowable number of particles per cubic meter of air (per cubic foot of air).
Outdoor-air processing unit	The unit for processing the outdoor fresh air that is taken in for ventilation and/or for keeping the pressure inside a clean room a predetermined positive value. The unit also constituted of air filters and heating or cooling coils so that the outside air is brought to a required state of temperature,

	humidity, and cleanliness before letting the outside air in.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Installation of displacement ventilation air conditioning unit to improve energy efficiency of supplying conditioned air to the cleanroom of semiconductor plant leads to reduction of power consumption for ventilation.
Calculation of reference emissions	Reference emissions are calculated by multiplying power consumption of mixing ventilation air conditioning unit, the proportion of motive power of reference mixing ventilation air conditioning unit and project displacement ventilation air conditioning unit, and CO_2 emission factor for electricity consumed.
Calculation of project emissions	Project emissions are calculated by multiplying total power consumption of displacement ventilation air conditioning unit and CO_2 emission factor for electricity consumed.
Monitoring parameters	● The amount of power consumption by project displacement ventilation air conditioning unit ● The amount of fuel consumption and the amount of electricity generated by captive power, where applicable

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

Criterion 1	Displacement ventilation air conditioning unit, whose specification of velocity of the discharged air is designed to be more than 0.5 m/s and equals to or less than 1.0 m/s, is installed in the cleanroom of semiconductor plant.
Criterion 2	The project displacement ventilation air conditioning unit is constituted of at least cooling coil, HEPA (high efficiency particular air) or ULPA (ultra low penetration air) filter and air supply fan in one unit.
Criterion 3	The project displacement ventilation air conditioning unit is designed to meet the

	threshold values of Class 6 or class 7 of airborne particulate cleanliness class set by ISO 14644-1:2015[1].
Criterion 4	The project displacement ventilation air conditioning unit only supplies cooled air.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Power consumption by mixing ventilation air conditioning unit	CO_2
Power consumption by reference outdoor-air processing unit (excluded from calculation of reference emissions)	CO_2
Power consumption by reference chiller (excluded from calculation of reference emissions)	CO_2
Power consumption by reference exhaust fan (excluded from calculation of reference emissions)	CO_2
Project emissions	
Emission sources	GHG types
Power consumption by displacement ventilation air conditioning unit	CO_2
Power consumption by project outdoor-air processing unit (excluded from calculation of project emissions)	CO_2
Power consumption by project chiller (excluded from calculation of project emissions)	CO_2
Power consumption by project exhaust fan (excluded from calculation of project emissions)	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions are consisted of emissions from mixing ventilation air conditioning unit, outdoor-air processing unit and chillers supplying chilled water to cooling coil.
The temperature of outlet chilled water of the chiller is set higher (e.g. 14 degrees Celsius) with

[1] Cleanrooms and associated controlled environments -- Part 1: Classification of air cleanliness by particle concentration

displacement ventilation air conditioning unit compared to that with mixing ventilation air conditioning unit (e.g. 7 degrees Celsius). It is because displacement ventilation air conditioning unit diffuses conditioned air at floor level or middle space of a room while mixing ventilation air conditioning unit does from air supply ports located on the ceiling. Therefore, the heat load handled by the chillers in the case of displacement ventilation gets lower, and it leads to reduction of power consumption by the chillers.
In this methodology, GHG emissions reductions of chillers caused by the difference of heat load are not included in the calculation of total GHG emission reductions to ensure the net emission reductions.

F.2. Calculation of reference emissions

$$RE_p = \sum_i \sum_j \sum_k \left(EC_{PJ,DV,i,j,k,p} \times \frac{L_{RE,j,k}}{L_{PJ,j,k}} \times EF_{elec,k} \right)$$

with

$$L_{RE,j,k} = \frac{P_{d,RE,j,k} \times AFR_{RE,j,k}}{1{,}000 \times \eta_{RE,j,k}}$$

$$L_{PJ,j,k} = \frac{P_{d,PJ,j,k} \times AFR_{PJ,j,k}}{1{,}000 \times \eta_{PJ,j,k}}$$

$$AFR_{RE,j,k} = \frac{V_{cr,j,k} \times T_{vent,j,k}}{3{,}600}$$

$$AFR_{PJ,j,k} = \sum_i AFR_{PJ,i,j,k}$$

$$\eta_{RE,j,k} = \eta_{PJ,j,k}$$

* Since the fans with similar type and specification are installed both in displacement ventilation air conditioning unit and mixing ventilation air conditioning unit, energy efficiency of the fans are considered to be equal.

Therefore

$$RE_p = \sum_i \sum_j \sum_k \left(EC_{PJ,DV,i,j,k,p} \times \frac{L_{RE,j,k}}{L_{PJ,j,k}} \times EF_{elec,k} \right)$$

$$= \sum_i \sum_j \sum_k \left(EC_{PJ,DV,i,j,k,p} \times \frac{P_{d,RE,j,k} \times AFR_{RE,j,k}}{P_{d,PJ,j,k} \times AFR_{PJ,j,k}} \times EF_{elec,k} \right)$$

Where

RE_p	Reference emissions during the period *p* [tCO_2/p]
$EC_{PJ,DV,i,j,k,p}$	The amount of power consumption by the project displacement ventilation air conditioning unit *i* in cleanroom *j* of the project factory *k* during the period *p* [MWh/p]
$L_{RE,j,k}$	Motive power of reference mixing ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* [kW]
$L_{PJ,j,k}$	Motive power of project displacement ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* [kW]
$EF_{elec,k}$	CO_2 emission factor for consumed electricity in the project factory *k* [tCO_2/MWh]
$P_{d,RE,j,k}$	Discharge pressure of reference mixing ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* [Pa]
$P_{d,PJ,j,k}$	Discharge pressure of project displacement ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* [Pa]
$AFR_{RE,j,k}$	Airflow rate of reference mixing ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* [m^3/s]
$AFR_{PJ,j,k}$	Airflow rate of project displacement ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* [m^3/s]
$\eta_{RE,j,k}$	Fan efficiency of reference mixing ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* [-]
$\eta_{PJ,j,k}$	Fan efficiency of project displacement ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* [-]
$V_{cr,j,k}$	Volume of the cleanroom *j* in the project factory *k* [m^3]
$T_{vent,j,k}$	Number of times of ventilation required for the cleanroom *j* in the project factory *k* [times/h]
$AFR_{PJ,i,j,k}$	Airflow rate of project displacement ventilation air conditioning unit *i* supplying air to cleanroom *j* in the project factory *k* [m^3/s]
i	Identification number of the displacement ventilation air conditioning unit
j	Identification number of the cleanroom
k	Identification number of the factory

Emissions from power consumption by reference outdoor-air processing unit(s) and project outdoor-air processing unit(s) are considered to be equal. Emissions from power consumption by reference exhaust fan(s) and project exhaust fan(s) are also considered to be equal. Therefore, both of them are not included in calculation of reference emissions and project emissions.

Emissions from power consumption by reference chiller(s) are not included in calculation of reference emissions as explained in F.1 of this methodology.

G. Calculation of project emissions

$$PE_p = \sum_i \sum_j \sum_k \left(EC_{PJ,DV,i,j,k,p} \times EF_{elec,k}\right)$$

Where

PE_p	Project emissions during the period p [tCO_2/p]
$EC_{PJ,DV,i,j,k,p}$	The amount of power consumption by the displacement ventilation air conditioning unit i in cleanroom j of the project factory k during the period p [MWh/p]
$EF_{elec,k}$	CO_2 emission factor for consumed electricity in the project factory k [tCO_2/MWh]
i	Identification number of the displacement ventilation air conditioning unit
j	Identification number of the cleanroom
k	Identification number of the factory

Emissions from power consumption by reference outdoor-air processing unit(s) and project outdoor-air processing unit(s) are considered to be equal. Emissions from power consumption by reference exhaust fan(s) and project exhaust fan(s) are also considered to be equal. Therefore, both of them are not included in calculation of reference emissions and project emissions.

Emissions from power consumption by project chiller(s) are not included in calculation of project emissions as explained in F.1 of this methodology.

H. Calculation of emissions reductions

$$ER_p = RE_p - PE_p$$

Where

ER_p	Emission reductions during the period p [tCO_2/p]
RE_p	Reference emissions during the period p [tCO_2/p]

PE_p	Project emissions during the period p [tCO_2/p]

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
$AFR_{RE,j,k}$	Airflow rate of reference mixing ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* Calculated with the following equation: $$AFR_{RE,j,k} = \frac{V_{cr,j,k} \times T_{vent,j,k}}{3,600}$$	Calculated
$AFR_{PJ,j,k}$	Airflow rate of project displacement ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* One value is determined *ex ante* for each project cleanroom. Where outdoor-air processing units are supplying air to one cleanroom, the total value is applied.	Design document or specification document of the displacement ventilation air conditioning unit.
$P_{d,RE,j,k}$	Discharge pressure of reference mixing ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* [Pa] The default value of [1,200] is applied.	Hearing survey with manufacturer of mixing ventilation air conditioning unit.
$P_{d,PJ,j,k}$	Discharge pressure of project displacement ventilation air conditioning unit(s) supplying air to cleanroom *j* in the project factory *k* One value is determined *ex ante* for each project cleanroom.	Design document or specification document of the displacement ventilation air conditioning unit.
$V_{cr,j,k}$	Volume of the cleanroom *j* in the project factory *k*	Design document of the cleanroom.

	The value is determined by the actual volume of the cleanroom where the project in implemented.	
$T_{vent,j,k}$	Number of times of ventilation required for the cleanroom *j* in the project factory *k* The default value from the following table is applied corresponding to the airborne particulate cleanliness class required for the cleanroom *j*. <table><tr><th colspan="2">cleanliness class</th><th rowspan="2">$T_{vent,j,k}$</th></tr><tr><th>ISO 14644-1:2015</th><th>FED-STD-209E</th></tr><tr><td>Class 6</td><td>1,000</td><td>80</td></tr><tr><td>Class 7</td><td>10,000</td><td>40</td></tr></table>	Published documents on the web.
$EF_{elec,k}$	CO_2 emission factor for consumed electricity. When project chiller consumes only grid electricity or captive electricity, the project participant applies the CO_2 emission factor respectively. When project chiller may consume both grid electricity and captive electricity, the project participant applies the CO_2 emission factor with lower value. [CO_2 emission factor] For grid electricity: The most recent value available from the source stated in this table at the time of validation For captive electricity, it is determined based on the following options:	[Grid electricity] The most recent value available at the time of validation is applied and fixed for the monitoring period thereafter. The data is sourced from "Grid Emission Factor (GEF) of Thailand", endorsed by Thailand Greenhouse Gas Management Organization unless otherwise instructed by the Joint Committee. [Captive electricity] For the option a) Specification of the captive power generation system provided by the manufacturer (η_{elec} [%]).

	a) Calculated from its power generation efficiency (η_{elec} [%]) obtained from manufacturer's specification The power generation efficiency based on lower heating value (LHV) of the captive power generation system from the manufacturer's specification is applied; $$EF_{elec} = 3.6 \times \frac{100}{\eta_{elec}} \times EF_{fuel}$$ b) Calculated from measured data The power generation efficiency calculated from monitored data of the amount of fuel input for power generation ($FC_{PJ,p}$) and the amount of electricity generated ($EG_{PJ,p}$) during the monitoring period p is applied. The measurement is conducted with the monitoring equipment to which calibration certificate is issued by an entity accredited under national/international standards; $$EF_{elec} = FC_{PJ,p} \times NCV_{fuel} \times EF_{fuel} \times \frac{1}{EG_{PJ,p}}$$ Where: NCV_{fuel} : Net calorific value of consumed fuel [GJ/mass or weight] Note: In case the captive electricity generation system meets all of the following conditions, the value in the following table may be applied to EF_{elec} depending on the consumed fuel type. • The system is non-renewable generation system • Electricity generation capacity of the system is less than or equal to 15 MW	CO_2 emission factor of the fossil fuel type used in the captive power generation system (EF_{fuel} [tCO_2/GJ]) For the option b) Generated and supplied electricity by the captive power generation system ($EG_{PJ,p}$ [MWh/p]). Fuel amount consumed by the captive power generation system ($FC_{PJ,p}$ [mass or weight/p]). Net calorific value (NCV_{fuel} [GJ/mass or weight]) and CO_2 emission factor of the fuel (EF_{fuel} [tCO_2/GJ]) in order of preference: 1) values provided by the fuel supplier; 2) measurement by the project participants; 3) regional or national default values; 4) IPCC default values provided in tables 1.2 and 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Lower value is applied. [Captive electricity with diesel fuel] CDM approved small scale methodology: AMS-I.A.

	<table><tr><td>fuel type</td><td>Diesel fuel</td><td>Natural gas</td></tr><tr><td>EF_{elec}</td><td>0.8 *1</td><td>0.46 *2</td></tr></table> *1 The most recent value at the time of validation is applied. *2 The value is calculated with the equation in the option a) above. The lower value of default effective CO_2 emission factor for natural gas (0.0543tCO_2/GJ), and the most efficient value of default efficiency for off-grid gas turbine systems (42%) are applied.	[Captive electricity with natural gas] 2006 IPCC Guidelines on National GHG Inventories for the source of EF of natural gas. CDM Methodological tool "Determining the baseline efficiency of thermal or electric energy generation systems version02.0" for the default efficiency for off-grid power plants.

History of the document

Version	Date	Contents revised
01.0	21 August 2017	JC3, Annex 8 Initial approval.