

Supplementary Materials

Improving the Measurement of Characteristic Parameters for the Determination of GHG Emissions in the Semiconductor and Display Industries in Korea

Bong-Jae Lee* ¹, Soo-Young Yun ¹, In-Kwon Jeong ¹, Yujin Hwang ¹, Jun-Hyeok Park ¹,
Jonghoon Kim ¹

¹ Korea Testing & Research Institute (KTR), 98 Gyoyukwon-ro, Gwacheon-si, Gyeonggi-do, 13810, Republic of Korea

*Corresponding authors. Tel.: +82 2 2092 4056; fax: +82 2 2634 0067.

E-mail addresses: jae8076@ktr.or.kr (Bong-Jae Lee)

| Method | Emission factor | Explanation | Tier | Criteria for application of GHG emission factors |
|--------|--------------------------|--|------|---|
| Tier 1 | Default factor | The default factors specified in the certification guidelines or presented by Greenhouse Gas Information Center (GIR). | - | Default emission factors present in IPCC Guideline |
| | | | 2a | Typical electronics industry type (Semiconductor, Display, PV) |
| Tier 2 | Country-specific factor | Country-specific factors verified and published by the Greenhouse Gas Information Center (GIR). | 2b | Electronics industry process type (Etching, CVD) and wafer size ($\leq 200\text{mm}$, 300mm) |
| | | | 2c | Detailed electronics industry process type (EWC, RPC, IPC, TFD, etc.) and wafer size ($\leq 200\text{mm}$, 300mm) |
| Tier 3 | Facility-specific factor | Emission factors developed and reported through self-measurement by facilities. | 3a | Reporting facilities use site-specific emission factors |
| | | Included all emission factors developed and applied by facilities are not specified in the Tier 1,2 factors. | 3b | Reporting facilities measure GHG emission at the stack level |

Table S1. Composition of Tiers 1, 2, and 3 in the electronics industry based on emission sources using guidelines for estimating and reporting greenhouse gas (GHG) emissions

| Composition | Detection limit (DL) of FT-IR by gas cell's length | | | | | |
|------------------|--|-------|-------|--------|--------|--------|
| | 1 cm | 10 cm | 60 cm | 100 cm | 400 cm | 500 cm |
| N ₂ O | 400 | 40 | 7 | 4 | 1 | 0.8 |
| PFCs | CF ₄ | 10 | 1 | 0.2 | 0.1 | 0.025 |
| | C ₂ F ₆ | 25 | 2.5 | 0.5 | 0.25 | 0.06 |
| | C ₃ F ₈ | 50 | 5 | 1 | 0.5 | 0.125 |
| | c-C ₄ F ₈ | 50 | 5 | 1 | 0.5 | 0.125 |
| | CHF ₃ | 80 | 8 | 1.5 | 0.8 | 0.2 |
| HFCs | CH ₂ F ₂ | 30 | 3 | 0.6 | 0.3 | 0.075 |
| SF ₆ | 10 | 1 | 0.2 | 0.1 | 0.025 | 0.02 |
| NF ₃ | 50 | 5 | 0.8 | 0.5 | 0.15 | 0.12 |

Table S2. The detection limits (DLs) of FT-IR for each gas cell

| Composition | Point-of-use (POU) scrubber | House scrubber |
|-------------|--------------------------------|-------------------|
| Inlet | 1 cm | 10 cm |
| Outlet | 10 cm | 100 cm |

Table S3. The classification of applicable FT-IR gas cell lengths according to scrubber type

| Gas composition | Concentration |
|-----------------|---------------------------------------|
| N ₂ | 85 – 95 % |
| O ₂ | 5 – 10 % |
| Ar | Hundreds of thousands ppm |
| CO ₂ | Hundreds of thousands ppm |
| FCs | Different depend on process condition |
| Etc. | Less than 1% |

Table S4. The gas composition of internal process gas in the electronics manufacturing process

| Pre-set gas concentration (%) | | | | | |
|-------------------------------|----------------|----------------|------|-----------------|------|
| He | N ₂ | O ₂ | Ar | CO ₂ | Kr |
| 67.46 | 28.62 | 2.93 | 0.20 | 0.14 | 0.66 |
| 58.02 | 36.92 | 3.78 | 0.25 | 0.18 | 0.85 |
| 47.95 | 45.78 | 4.69 | 0.31 | 0.22 | 1.05 |
| 37.20 | 55.24 | 5.66 | 0.38 | 0.26 | 1.27 |
| 25.68 | 65.37 | 6.70 | 0.45 | 0.31 | 1.50 |
| 13.31 | 76.24 | 7.81 | 0.52 | 0.36 | 1.75 |

Table S5. Gas compositions according to He gas injections for Experiment 3

| Validity | | | Validity range | | | Measured Value | | |
|---------------------------|-------------------------|------------------|----------------------------|-------------------------|------------------|----------------|--|--|
| Accuracy | | | Less than 5 % | | | 0.07 % | | |
| Precision (Repeatability) | | | 95 – 105 % (90 – 110 %) | | | 100.09 % | | |
| Detection limit | | | - | | | 1.00 µmol/mol | | |
| Quantitative limit | | | - | | | 3.19 µmol/mol | | |
| Analyst 1 | | | Analyst 2 | | | | | |
| Expected Value (ppm) | Measured Value (ppm) | Precision (%) | Expected Value (ppm) | Measured Value (ppm) | Precision (%) | | | |
| 20 | 19.72 | 98.60 | 20 | 19.68 | 98.40 | | | |
| 40 | 39.53 | 98.82 | 40 | 39.37 | 98.43 | | | |
| 60 | 60.05 | 100.09 | 60 | 60.13 | 100.22 | | | |
| 80 | 80.02 | 100.02 | 80 | 80.11 | 100.14 | | | |
| 100 | 99.84 | 99.84 | 100 | 99.86 | 99.86 | | | |
| Analyst 3 | | | Analyst 4 | | | | | |
| Expected Value (ppm) | Measured Value (ppm) | Precision (%) | Expected Value (ppm) | Measured Value (ppm) | Precision (%) | | | |
| 20 | 19.82 | 99.12 | 20 | 19.58 | 97.91 | | | |
| 40 | 39.46 | 98.66 | 40 | 39.35 | 98.39 | | | |
| 60 | 60.07 | 100.12 | 60 | 60.08 | 100.13 | | | |
| 80 | 80.08 | 100.10 | 80 | 79.89 | 99.87 | | | |
| 100 | 99.93 | 99.93 | 100 | 99.56 | 99.56 | | | |

Table S6. Measurements on comparing the validity (CHF₃) of results between analysts to confirm the precision (reproducibility)

| Validity | | | Validity range | | | Measured Value | | |
|---------------------------|-------------------------|------------------|----------------------------|-------------------------|------------------|----------------|--|--|
| Accuracy | | | Less than 5 % | | | 0.03 % | | |
| Precision (Repeatability) | | | 95 – 105 % (90 – 110 %) | | | 99.89 % | | |
| Detection limit | | | - | | | 0.55 µmol/mol | | |
| Quantitative limit | | | - | | | 1.75 µmol/mol | | |
| Analyst 1 | | | Analyst 2 | | | | | |
| Expected Value (ppm) | Measured Value (ppm) | Precision (%) | Expected Value (ppm) | Measured Value (ppm) | Precision (%) | | | |
| 20 | 19.85 | 99.23 | 20 | 19.65 | 98.23 | | | |
| 40 | 39.78 | 99.44 | 40 | 39.65 | 99.12 | | | |
| 60 | 59.93 | 99.89 | 60 | 60.02 | 100.04 | | | |
| 80 | 80.12 | 100.16 | 80 | 80.23 | 100.28 | | | |
| 100 | 100.19 | 100.19 | 100 | 100.34 | 100.34 | | | |
| Analyst 3 | | | Analyst 4 | | | | | |
| Expected Value (ppm) | Measured Value (ppm) | Precision (%) | Expected Value (ppm) | Measured Value (ppm) | Precision (%) | | | |
| 20 | 19.82 | 99.12 | 20 | 19.67 | 98.37 | | | |
| 40 | 39.73 | 99.32 | 40 | 39.72 | 99.30 | | | |
| 60 | 59.95 | 99.92 | 60 | 60.04 | 99.93 | | | |
| 80 | 80.07 | 100.09 | 80 | 80.34 | 100.42 | | | |
| 100 | 100.13 | 100.13 | 100 | 100.45 | 100.45 | | | |

Table S7. Measurements on comparing the validity (C₂F₆) of results between analysts to confirm precision (reproducibility)

| Gas | Tier 2a | Tier 2b | | Tier 2c | | | | | | | | |
|--------------------------------------|---------------------|---------------------|---------------------|---------------------|-------|------|-----|---------------------|-------|-----|------|-----|
| | (1-U _i) | (1-U _i) | (1-U _i) | (1-U _i) | | | | (1-U _i) | | | | |
| | | (≤200mm wafer size) | (300mm wafer size) | (≤200mm wafer size) | | | | (300mm wafer size) | | | | |
| | | | | EWC | RPC | IPC | TFD | EWC | RPC | IPC | ITC | TFD |
| CF ₄ | 0.73 | 0.79 | 0.65 | 0.73 | NA | 0.92 | NA | 0.65 | NA | NA | NA | NA |
| C ₂ F ₆ | 0.55 | 0.55 | 0.8 | 0.72 | NA | 0.55 | NA | 0.8 | NA | NA | NA | NA |
| C ₃ F ₈ | 0.4 | 0.4 | 0.3 | NA | NA | 0.4 | NA | 0.3 | 0.063 | NA | NA | NA |
| C ₃ F ₈ Remote | 0.063 | NA | 0.063 | - | - | - | - | - | - | - | - | - |
| C ₄ F ₆ | 0.15 | 0.12 | 0.15 | 0.12 | NA | NA | NA | 0.15 | NA | NA | NA | NA |
| c-C ₄ F ₈ | 0.13 | 0.12 | 0.18 | 0.14 | NA | 0.1 | NA | 0.18 | NA | NA | NA | NA |
| C ₄ F ₈ O | 0.14 | 0.14 | NA | NM | NA | 0.14 | NA | | | | | |
| C ₅ F ₈ | 0.085 | 0.072 | 0.1 | 0.0722 | NA | NA | NA | 0.1 | NA | NA | NA | NA |
| CHF ₃ | 0.47 | 0.51 | 0.38 | 0.51 | NA | NA | NA | 0.38 | NA | NA | NA | NA |
| CH ₂ F ₂ | 0.2 | 0.13 | 0.2 | 0.13 | NA | NA | NA | 0.2 | NA | NA | NA | NA |
| CH ₃ F | 0.35 | 0.7 | 0.32 | 0.7 | NA | NA | NA | 0.32 | NA | NA | NA | NA |
| CH ₂ F ₅ | 0.064 | 0.064 | NA | 0.064 | NA | NA | NA | - | - | - | - | - |
| NF ₃ Remote | 0.02 | 0.028 | 0.018 | - | - | - | - | - | - | - | - | - |
| NF ₃ | 0.18 | 0.18 | 0.18 | 0.19 | 0.028 | 0.18 | NA | 0.16 | 0.018 | 0.2 | 0.28 | NA |
| SF ₆ | 0.55 | 0.58 | 0.29 | 0.55 | NA | NM | NA | 0.29 | NA | NA | NA | NA |
| N ₂ O TFD | 0.78 | 1.0 | 0.5 | NA | NA | NA | 1.0 | NA | NA | NA | NA | 0.5 |
| N ₂ O other | 1.0 | 1.0 | 1.0 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| COF ₂ | NM | NM | NM | NM | NA | NM | NA | NM | NA | NA | NA | NA |
| F ₂ | NM | NM | NM | NM | NA | NA | NA | NM | NA | NA | NA | NA |

Table S8. Default use rate factors for GHG emissions in the semiconductor industry

| Gas | Tier 2c | | | |
|---------------------------------|---------------------|------|-----|------|
| | (1-U _i) | | | |
| | Etching | RPC | IPC | TFD |
| CF ₄ | 0.6 | NA | NA | NA |
| c-C ₄ F ₈ | 0.1 | NA | NA | NA |
| CHF ₃ | 0.2 | NA | NA | NA |
| NF ₃ | 0.11 | 0.03 | 0.3 | NA |
| SF ₆ | 0.3 | NA | 0.9 | NA |
| N ₂ O | NA | NA | NA | 0.63 |

Table S9. Default use rate factors for GHG emissions in the display industry

| Gas | B _{CF4} | B _{C2F6} | B _{C3F8} | B _{C4F6} | B _{C4F8} | B _{C5F8} | B _{CH3F} | B _{CH2F2} | B _{CHF3} |
|--------------------------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|-------------------|
| CF ₄ | NA | 0.042 | NA | 5.7e-4 | 0.0013 | 4.7e-4 | 0.002 | 0.0054 | 0.041 |
| C ₂ F ₆ | 0.19 | NA | NA | NA | NA | NA | NA | NA | 0.002 |
| C ₃ F ₈ | 0.2 | 1.8e-5 | NA | NA | NA | NA | 0* | NA | 1.2e-6 |
| C ₃ F ₈ Remote | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| C ₄ F ₆ | 0.06 | 0.063 | NA | NA | 0.0051 | NA | 6.4e-4 | 3e-5 | 0.018 |
| c-C ₄ F ₈ | 0.099 | 0.02 | NA | 0.0015 | NA | 0.0035 | 0.0004 | 2.6e-4 | 0.022 |
| C ₄ F ₈ O | 0.13 | 0.045 | NA | NA | NA | NA | NA | NA | NA |
| C ₅ F ₈ | 0.052 | 0.047 | 5.5e-5 | NA | NA | NA | NA | NA | 0.0053 |
| CHF ₃ | 0.082 | 0.045 | NA | 3e-5 | 0.0002 | 8.1e-4 | 0.0011 | 7.7e-4 | NA |
| CH ₂ F ₂ | 0.061 | 0.044 | NA | NA | 0.071 | NA | 0.043 | NA | 0.057 |
| CH ₃ F | 0.028 | 0.01 | NA | 0.0011 | 0.0065 | NA | NA | 0.0021 | 0.015 |
| CH ₂ F ₅ | 0.099 | 0.024 | NA | NA | NA | NA | NA | NA | NA |
| NF ₃ Remote | 0.034 | NA | NA | NA | NA | NA | NA | NA | NA |
| NF ₃ | 0.067 | 0.014 | NA | NA | NA | NA | 0.0021 | 2.3e-5 | 0.0067 |
| SF ₆ | 0.12 | 0.095 | NA | NA | NA | NA | 0.0009 | 2.1e-6 | 0.0014 |
| N ₂ O TFD | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| N ₂ O other | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| COF ₂ | NM | NM | NA | NA | NA | NA | NA | NA | NA |
| F ₂ | NM | NM | NA | NA | NA | NA | NA | NA | NA |

Table S10. GHG default emission factors for by-product generation rates in the semiconductor industry (Tier 2a)

| Gas | B_{CF4} | B_{C2F6} | B_{C3F8} | B_{C5F8} | B_{CHF3} |
|--------------------------------------|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| CF ₄ | NA | 0.03 | NA | 7.7e-4 | 0.059 |
| C ₂ F ₆ | 0.19 | NA | NA | NA | 0.002 |
| C ₃ F ₈ | 0.2 | NA | NA | NA | NA |
| C ₃ F ₈ Remote | NA | NA | NA | NA | NA |
| C ₄ F ₆ | 0.1 | 0.11 | NA | NA | 0.066 |
| c-C ₄ F ₈ | 0.11 | 0.019 | NA | 4.3e-4 | 0.02 |
| C ₄ F ₈ O | 0.13 | 0.045 | NA | NA | NA |
| C ₅ F ₈ | NA | 0.014 | NA | NA | 0.0039 |
| CHF ₃ | 0.085 | 0.035 | NA | 0.0012 | NA |
| CH ₂ F ₂ | 0.079 | 0.025 | NA | NA | 0.049 |
| CH ₃ F | NA | 0.0034 | NA | NA | NA |
| CH ₂ F ₅ | 0.077 | 0.024 | NA | NA | NA |
| NF ₃ Remote | 0.015 | NA | NA | NA | NA |
| NF ₃ | 0.11 | 0.0059 | NA | NA | NA |
| SF ₆ | 0.13 | 0.11 | NA | NA | 0.0011 |
| N ₂ O TFD | NA | NA | NA | NA | NA |
| N ₂ O other | NA | NA | NA | NA | NA |
| COF ₂ | NM | NM | NA | NA | NA |
| F ₂ | NM | NM | NA | NA | NA |

Table S11. GHG default emission factors for by-product generation rates in the semiconductor industry (Tier 2b, wafer-size, i.e., less than 200mm)

| Gas | B_{CF4} | B_{C2F6} | B_{C3F8} | B_{C4F6} | B_{C4F8} | B_{CH3F} | B_{CH2F2} | B_{CHF3} |
|--------------------------------------|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|--------------------------|-------------------------|
| CF ₄ | NA | 0.061 | NA | 0.0015 | 0.0033 | 0.0053 | 0.014 | 0.013 |
| C ₂ F ₆ | 0.21 | NA | NA | NA | NA | NA | NA | NA |
| C ₃ F ₈ | 0.21 | 0.18 | NA | NA | NA | 7.3e-4 | NA | 0.012 |
| C ₃ F ₈ Remote | NA | NA | NA | NA | NA | NA | NA | NA |
| C ₄ F ₆ | 0.059 | 0.062 | NA | NA | 0.0051 | 6.5e-4 | 3e-5 | 0.017 |
| c-C ₄ F ₈ | 0.046 | 0.028 | NA | 0.008 | NA | 0.0022 | 0.0014 | 0.03 |
| C ₄ F ₈ O | NA | NA | NA | NA | NA | NA | NA | NA |
| C ₅ F ₈ | 0.11 | 0.083 | 1.2e-4 | NA | NA | NA | NA | 0.0069 |
| CHF ₃ | 0.075 | 0.067 | NA | 0.0001 | 6.7e-4 | 0.037 | 0.0026 | NA |
| CH ₂ F ₂ | 0.06 | 0.044 | NA | NA | 0.072 | 0.0044 | NA | 0.057 |
| CH ₃ F | 0.031 | 0.011 | NA | 0.0012 | 0.007 | NA | 0.0023 | 0.016 |
| CH ₂ F ₅ | NA | NA | NA | NA | NA | NA | NA | NA |
| NF ₃ Remote | 0.038 | NA | NA | NA | NA | NA | NA | NA |
| NF ₃ | 0.04 | 0.02 | NA | NA | NA | 0.0036 | 3.9e-4 | 0.011 |
| SF ₆ | 0.034 | 0.041 | NA | NA | NA | 0.0082 | 2e-5 | 0.0039 |
| N ₂ O TFD | NA | NA | NA | NA | NA | NA | NA | NA |
| N ₂ O other | NA | NA | NA | NA | NA | NA | NA | NA |
| COF ₂ | NM | NM | NA | NA | NA | NA | NA | NA |
| F ₂ | NM | NM | NA | NA | NA | NA | NA | NA |

Table S12. GHG default emission factors for by-product generation rates in the semiconductor industry (Tier 2b, wafer-size, i.e., 300mm)

| Gas | EWC | | | | RPC | | IPC | |
|---------------------------------|------------------|-------------------|-------------------|-------------------|------------------|------------------|-------------------|--|
| | B _{CF4} | B _{C2F6} | B _{C3F8} | B _{CHF3} | B _{CF4} | B _{CF4} | B _{C2F6} | |
| CF ₄ | NA | 0.046 | 0.0012 | 0.09 | NA | NA | NA | |
| C ₂ F ₆ | 0.1 | NA | NA | 0.047 | NA | 0.21 | NA | |
| C ₃ F ₈ | NA | NA | NA | NA | NA | 0.2 | NA | |
| C ₄ F ₆ | 0.13 | 0.11 | NA | 0.066 | NA | NA | NA | |
| c-C ₄ F ₈ | 0.11 | 0.037 | 0.0086 | 0.04 | NA | 0.11 | NA | |
| C ₄ F ₈ O | NM | NM | NA | NA | NA | 0.13 | 0.045 | |
| C ₅ F ₈ | NA | 0.014 | NA | 0.0039 | NA | NA | NA | |
| CHF ₃ | 0.085 | 0.035 | 0.0012 | NA | NA | NA | NA | |
| CH ₂ F ₂ | 0.079 | 0.025 | NA | 0.049 | NA | NA | NA | |
| CH ₃ F | NA | 0.0034 | NA | NA | NA | NA | NA | |
| CH ₂ F ₅ | 0.077 | 0.024 | NA | NA | NA | NA | NA | |
| NF ₃ | 0.004 | 0.025 | NA | NA | 0.015 | 0.14 | NA | |
| SF ₆ | 0.13 | 0.11 | NA | 0.0012 | NA | NM | NM | |
| N ₂ O TFD | NA | NA | NA | NA | NA | NA | NA | |
| N ₂ O other | NA | NA | NA | NA | NA | NA | NA | |
| COF ₂ | NM | NM | NA | NA | NA | NM | NM | |
| F ₂ | NM | NM | NA | NA | NA | NA | NA | |

Table S13. GHG default emission factors for by-product generation rates in the semiconductor industry (Tier 2c, wafer-size, i.e., less than 200mm)

| Gas | EWC | | | | | | | | RPC | IPC | ITC |
|---------------------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|-------------------|------------------|------------------|------------------|
| | B _{CF4} | B _{C2F6} | B _{C3F8} | B _{C4F6} | B _{C4F8} | B _{CH3F} | B _{CH2F2} | B _{CHF3} | B _{CF4} | B _{CF4} | B _{CF4} |
| CF ₄ | NA | 0.061 | NA | 0.0015 | 0.0033 | 0.0053 | 0.014 | 0.013 | NA | NA | NA |
| C ₂ F ₆ | 0.21 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| C ₃ F ₈ | 0.21 | 0.18 | NA | NA | NA | 0.00073 | NA | 0.012 | NA | NA | NA |
| C ₄ F ₆ | 0.059 | 0.062 | NA | NA | 0.0051 | 0.00065 | 0.00003 | 0.017 | NA | NA | NA |
| c-C ₄ F ₈ | 0.046 | 0.028 | NA | 0.0083 | NA | 0.0022 | 0.0014 | 0.03 | NA | NA | NA |
| C ₄ F ₈ O | 0.11 | 0.083 | 0.00012 | NA | NA | NA | NA | 0.0069 | NA | NA | NA |
| C ₅ F ₈ | 0.075 | 0.067 | NA | 0.0001 | 0.00067 | 0.037 | 0.0026 | NA | NA | NA | NA |
| CHF ₃ | 0.06 | 0.044 | NA | NA | 0.072 | 0.0044 | NA | 0.057 | NA | NA | NA |
| CH ₂ F ₂ | 0.031 | 0.011 | NA | 0.0012 | 0.007 | NA | 0.0023 | 0.0016 | NA | NA | NA |
| CH ₃ F | 0.045 | 0.045 | NA | NA | NA | 0.008 | 0.00086 | 0.025 | 0.038 | 0.037 | 0.01 |
| CH ₂ F ₅ | 0.034 | 0.041 | NA | NA | NA | 0.0082 | 0.00002 | 0.0039 | NA | NA | NA |
| NF ₃ | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| SF ₆ | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| N ₂ O TFD | NM | NM | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| N ₂ O other | NM | NM | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| COF ₂ | NA | 0.061 | NA | 0.0015 | 0.0033 | 0.0053 | 0.014 | 0.013 | NA | NA | NA |
| F ₂ | 0.21 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Table S14. GHG default emission factors for by-product generation rates in the semiconductor industry (Tier 2c, wafer-size, i.e., 300 mm)

| Gas | B _{CF₄} | B _{C₂F₆} | B _{CHF₃} |
|---------------------------------|-----------------------------|---|------------------------------|
| CF ₄ | NA | NA | NA |
| c-C ₄ F ₈ | 0.009 | NA | 0.02 |
| CHF ₃ | 0.07 | 0.05 | NA |
| NF ₃ | NA | NA | NA |
| SF ₆ | NA | NA | NA |
| N ₂ O | NA | NA | NA |

Table S15. GHG default emission factors for by-product generation rates in the display industry (Tier 2c)