Sustainable Games Standard Scope 3, Category 11

GHG emissions - Use of sold products (Mobile)

VERSION: 0.0.1

DATE: 30/04/2025

Top-level summaryConsult with other SGA resources

Emissions from:	• End-user gameplay on mobile devices • Customer premise equipment (CPE) required for play (e.g. router) • Energy losses from mobile device charging inefficiencies

Examples:	• Aggregate energy consumed by mobile devices (via battery state of charge measurement)
	• Aggregate play duration metrics
	• Internet backbone infrastructure energy used for online connected play
	• Cellular communications infrastructure used for online connected play
	• Energy losses associated with charging mobile devices
	• **EXCLUDES**:
	  • Energy from data transferred at initial install & during game updates (measured at Scope 3.9 downstream transport and distribution)
	  • Energy consumed by cloud & servers (during multiplayer) or by in-game ad service or analytics (measured under Scope 3.1 purchased goods and services)

Data sources:	• Measurement of energy consumed by mobile devices taken at battery level • Battery consumption (as a percentage) per region of play • In-game analytics • System reported device name and/or specifications
Data types:	• Battery charge level (%, and/or mWh) • Mobile device energy consumption totals (kWh) • Player duration total (hours) • Player location (Country/Region) • Expected game duration • Average play duration per user

Understanding the requirements and nature of this component of the GHG emissions standard may be aided by consulting the relevant data input spreadsheet to see the overall structure and major sections before reading the standard specification.

Overview

The SGA standard methodology for Scope 3 Category 11 "Use of sold products (Mobile)" aims to improve the baseline GHG Protocol "direct use-phase emissions from products that directly consume energy" for games that are played on mobile devices. The standard aims to support energy efficiency initiatives, enable the validation of before-and-after interventions of game software energy intensity, and support improved activity-level data collection and transparency.

The SGA Standard takes a platform-specific approach to calculating and specifying the emissions from end-users of games, requiring developers to report energy consumption and GHG emissions from end-users (i.e. players) on mobile devices. The SGA Standard considers any device used to play games with an internal battery and screen to be a mobile device. This includes phones, tablets, and other handheld gaming devices, with the exception of *hybrid devices* that can operate in either docked or handheld mode (This distinction is due to the differences in system components in mobile vs docked mode and their impact on calculations – e.g. Nintendo Switch & Steam Deck).

As in other parts of the standard, multiple methodologies are permitted for use depending on the availability of data, with users of the standard encouraged to improve their data collection practices over time to enable them to move towards accurate, truthful measurement of their players' impacts and interventions that can reduce those impacts.

Specification

Measurement of greenhouse gas emissions from Scope 3, Category 11 “Use of sold products (Mobile)” shall employ methods to achieve the comprehensive measurement of mobile device energy consumption, using one of four methods: 1) Directly measured battery energy consumption, 2) Indirectly measured battery energy consumption (via battery percentage + device specification), 3) Estimated consumption through measured play duration, or 4) Estimated consumption via sales, install, or other data (e.g. monthly-average users, Apple Arcade data, GamePass data, etc).

When to use a specific method

As the use of sold products is typically the largest source of Scope 3 emissions, and an area with some degree of influence, methods in this Standard component are presented in order of most accurate to least. Users of the Standard are strongly encouraged to consider aiming for the highest accuracy method possible, whilst acknowledging that for first-time reporters, some form of estimate (Options 3 and 4) will likely be required. Users of the Standard are strongly encouraged to plan for how to move towards direct or indirect measurement of power consumption by their end users (Options 1 & 2).

Importance of Charger Efficiency and Losses

In normal operation, mobile devices, unlike consoles and PCs, draw on power from an internal battery, which is charged in advance of its “use” by a game. This has two consequences. The first is that there is a “time delay” between the release of emissions through generating electrical power at charge time, and when it is “used up” by the device throughout playing a game. This introduces some uncertainty and currently limits the ability to measure real-time 24/7 emissions connected to electricity generation directly. This standard currently treats the time delay as a negligible effect, however, this may change in future as technology and data collection systems improve.

The second, more substantial consequence is that, during the charging process, a non-negligible amount of energy is lost due to inefficiencies in the electrical conversion from AC to DC. This standard currently adopts a flat, conservative conversion efficiency of 70% for mobile device chargers; however, as technology advances, this figure will (and already is) improving. When research becomes available to validate an improved average efficiency, these assumptions will be updated.

The standard does not currently consider:

- The ***time of charge*** undertaken by the end-user and the specific emissions factor at that time (this includes Apple's iOS 'grid aware charging' feature)
- Embodied emissions in the device being used to play the game

System Boundaries Description

The basic system elements for the measurement of gameplay on mobile are to include:

- The device the game is played on and the energy it consumes
- Multiplayer module is not currently implemented

Methodologies for calculating end-user energy consumption (Mobile) (excl. Hybrid mobile devices)

Four options for end–user mobile emissions totals are permitted. These methods are presented in order of *most accurate* to least, and as a consequence from *most generative of insight and control* over these emissions to least. Users of the standard are encouraged to consider each method, apply the one that is most readily achievable (due to data availability, or other feasibility).

The four options are: 1. Measured battery consumption (taking readings from device battery levels at start and end of sessions), 2. Measured power consumption via battery % (making recordings of battery percentage at start and end, combined with known or average battery capacity information), 3. Estimated consumption via measuring total play duration by end users (aggregated by geographic region), 4. Estimated consumption via intermediate sales or install data (when direct play-duration data is not available).

Users of the standard are encouraged to aim to move up the hierarchy of methods, achieving more accurate measurement and more capacity for end-user energy consumption interventions in future reporting periods. Doing so may require the development or implementation of new data collection processes or systems. SGA members are encouraged to contact us directly for guidance on implementing advanced measurement approaches.

Option 1 – Measured battery consumption (kWh), aggregated by region

This method shall apply to each game developed primarily by the reporting organisation. This method shall involve collecting data by directly measuring battery charge levels at the start of a play session and again at the end of the session. Timestamps are to be recorded alongside battery charge levels to enable the calculation of energy intensity metrics, and collected data is to be allocated to a region (country-level minimum) for aggregation of results. The difference between the battery charge level at the start and end of the session shall be considered the energy consumed during a session: $Session\ energy\ consumption_{individual,\ Region}$.

The sum of all collected individual energy consumption readings for all sessions in a given region shall be reported as the aggregate energy consumption for that region. An allowance for charger energy losses shall be added to the total at the level of each aggregate regional total.

The sum of all regional aggregated energy consumption figures shall be reported as the *Total device energy consumption*$_{Game}$, and be reported as the total end user energy consumption (kWh).

To each regional aggregate total, the most appropriate regional emissions factor shall be used to calculate the attributable GHG emissions for a given end user energy consumption amount, and be reported in tonnes of CO2 equivalent (tCO2e).

The sum of all regional emissions shall be calculated and reported as the total emissions attributable to each game under Scope 3 Category 11 'Use of sold products' (mobile).

Energy intensity metrics

For each individual game, an energy intensity metric per hour (or minute) or gameplay shall be calculated by taking the sum of all energy consumption in a given region and dividing it by the total play duration represented by all recorded sessions in a region.

Additional Data Processing Before Aggregation

Because collected session data may not be entirely free of errors due to the nature of complex digital systems, some degree of data processing to clean the results will likely be necessary to ensure extreme outliers do not skew results. Excessively long session durations (i.e. sessions of greater than 4 hours, *or* which are of a duration longer than the expected maximum battery capacity would permit – whichever is the lesser) are to be excluded from calculations. Exclusions should not exceed 1% of total sessions.

Similarly, in cases where battery state of charge is higher at the *end* of a session than at the start, these shall be considered to be sessions that were undertaken while the battery was being charged. In such cases, session data for these are to be allocated to a separate pool excluded from direct measurement. If the total number of sessions in this pool is greater than 1%, then the methodology from Option 3 – Estimated consumption by measuring play

duration shall be applied to this pool. If the total number of sessions in this pool is less than 1% of total sessions, then preparers may apply *either* the methodology from Option 3 – Estimated consumption by measuring play duration or exclude them from disclosures and provide a statement of either the number or percentage of sessions that are excluded in this way. (e.g. "0.04% of sessions were excluded due to data collection errors")

Conversion of battery readings from mAh to Wh

If battery measurement cannot be collected by the measurement system in mWh directly, with only mAh collected, then a conversion will need to be undertaken. For this, it is permitted to assume that the voltage of the typical lithium mobile battery is approximately 3.7 V. Readings in mAh therefore need to be converted using Ohms law:

$$Power\ in\ Watts\ (P)\ =\ Voltage\ (V) \times Current\ (A)$$

$$P\ =\ 3.8 \times 800\ mAh$$

$$P\ =\ 2960\ mWh$$ (can also be written as 0.296 Wh)

Example Application of Option 1 Method

A mobile game collects 10,000 sessions of play over a reporting period. Records from each session include a starting battery level (mWh) and an end battery level, timestamps for each reading, and the region in which the session occurred. The difference between the starting and end battery level (mWh) is calculated as:

Session energy consumption$_{\text{individual, Region}}$ = 3800 mWh [session start timestamp] - 3000 mWh [*session end timestamp*], Finland [Region]
= 800 mWh, Finland

Total device energy consumption$_{\text{Region}}$ = Σ (800 mWh, Finland + 900 mWh, Finland + … [for all entries collected in the region Finland]) / [charger efficiency assumption]
= 100,000,000 mWh, Finland / 70%

= 142857142.86 mWh, Finland

= 142,857.143 kWh, Finland

Total device energy consumption$_{Game}$ = Σ 142,857.143 kWh [Finland total] ,... [remaining regions]

Regional GHG emissions$_{Finland}$ = 142,857.143 kwh * 72.25 (g CO2e, Finland 2024 EF)

= 10.32 tCO2e

Option 2 – Measured power consumption by battery percentage, per device (model), and region

This method shall involve collecting data by directly measuring remaining battery level **percentage** at the start of a play session, and the same again at the end of the session. Timestamps are to be recorded along with remaining battery percentage levels, to enable the calculation of intensity metrics, and collected data is to be allocated to a region (country level) for aggregation, and a text description of the device (i.e. “iPhone 12” or “Google Pixel 8”). The difference between the battery percentage at the start and end of the session shall be considered *Session energy consumption* $_{Individual\ Battery\ percentage,\ Region,\ Device}$.

Given the large number of devices possible (dozens of iPhones, potentially hundreds of Android devices), the top 10% of devices by total battery percentage shall be calculated for each region and used for full measurement. If an automated solution or algorithm for data processing and matching device models with their battery capacity exists, this may be used, and the entire cohort of devices measured. In the absence of an automatic method for processing the device model and matching to battery capacity, the remaining % of devices may be grouped according to year of manufacture, and an average battery capacity figure used for calculations.

For each group of devices, in each region, a simple multiplication of the *Session energy consumption* $_{\text{Individual Battery percentage, Region, Device}}$ by 1% of the device's rated battery capacity, producing a per device figure for each region. A regional emissions total figure shall be produced by simple multiplication of this energy consumption figure with the most appropriate regional emissions factor for the reporting period.

Example Application of Option 2 Method

An android developer has collected individual player data for 3 different devices over the reporting period, in a given region, and tallied the following total battery percentages consumed by all players on these devices, with the associated 1% battery values (refer to the section "Conversion of batter readings from mAh to Wh" for description of how 1% mAh readings are converted to Wh).

Handset	Total % of charge consumed (%)	Rated battery capacity (mAh)	1% battery capacity (Wh)	Energy consumption total (Wh)
Samsung Galaxy S20	9621%	4000	0.152	1462.392
Google Pixel 8 PRO	7231%	5050	0.1919	1462.392
Oppo Find X8	3215%	5630	0.21394	687.8171

Total energy consumption for these devices in this region is then the sum of entries in the final column, to which the most appropriate regional emissions factor is then applied to produce a regional CO2e total. This process is repeated for all regions with players and handset data, and the sum of all regions is reported as the total of Scope 3 Category 11 "Use of sold products" for mobile devices.

Option 3 – Estimated consumption by measured play duration

This is the expected method for first-time reporters, as it requires the most commonly collected data (aggregate play duration by region) and assumptions about typical low and high power consumption of mobile devices.

This method shall involve producing a 'high' and 'low' range of energy consumption and emissions figures, by collecting the total duration of play undertaken by players on mobile devices in a given region (country). This aggregate play total shall then be multiplied by both a high and low device power consumption estimate (5 watts for 'high', 3 watts for 'low' – utilizing a range reflected in Microsoft testing published in the 'Untangling carbon complexity' report (P4PA 2023)) to produce aggregate energy consumption figures for each region. To both ends of this range, an increase to account for charger losses will also be added. The resulting energy consumption figures will be multiplied by the most accurate regional emissions factor available for the reporting period.

*** TBC: Decide how to report in final totals - report the high end figure, the low end, both or an average ***

Example Application of Option 3 Method

Players in France played a game for a cumulative total of 67,800 hours over the reporting period. This is separately multiplied by high device consumption figure (5 watts) and a low device consumption figure (3 watts):

67,800 x 5 = 339,000 Watt Hours (can also be represented as 339 kWh)

67,800 x 3 = 203,400 Watt Hours (can also be represented as 203.4 kWh)

Addition for charger losses due to inefficiency:

339 kWh / 70% = 440.7 kWh

203.4 kWh / 70% = 264.42 kWh

Apply the most accurate regional emissions factor:

440.7 x 56.02 g CO2e (2023 French average grid emissions factor) = 24,648.8 g CO2e (high)

264.42 x 56.02 g CO2e (2023 French average grid emissions factor) = 14812.81 g CO2e (low)

** Future work: Describe final step to decide which number to disclose and use in corporate total footprint **

Option 4 – Estimated power consumption by sales data or install data

This method is only recommended as a last resort, as it involves the most assumptions and produces the least actionable insight. It should only be used when measured play duration data is not available (for example, when certain platform limitations are in place that prevent this data, such as Apple Arcade, subscription game services, etc.).

This method shall involve collecting proxy data such as sales data, total installs, monthly/daily-average-user data, and applying assumptions about either the total duration of the game, or an assumed media play duration.

For games designed with a clearly expected total play time – for instance, single-player story-focused games, or games with a set expected length, then total installs shall be multiplied by the typical expected length of completion of the game. For games designed to be a repeated experience, with no fixed end, e.g. casual or hypercasual games, puzzle, match games, run-based games, etc., an “expected total play duration” shall be used, informed by a median average user.

In either case, the expected play duration or expected total play duration shall be multiplied by the number of total installs in a given region to produce an amount for Total expected

player hours$_{region}$. To this amount, the same process is to be applied as in Option 3 – Estimated consumption by measured play duration, in which this regional total is multiplied by both high and low device energy consumption figures, to produce a high and low range of device energy consumption. Again, as in Option 3, an increase for charger inefficiency shall be applied to both totals, and be multiplied by the most appropriate regional emission factor available for the reporting period.

Example Application of Option 4 Method:

A Melbourne-based studio publishes a highly successful mobile game about a couple going through a breakup. The game is single-player in nature and is designed to be a single experience completed in around 4-6 hours by most players. It is published on a mobile platform that does not share play duration metrics, and these are not collected by the studio itself. To estimate energy consumption and emissions from this game, the team multiplies regional sales figures with the expected length of completion of the game (5 hours, choosing a median point between the range expected by internal and external playtests) to produce a total expected player hours per region.

Total installs$_{Region}$ = 1,500,000
Expected game duration = 5 hours
Total expected player hours$_{Region}$ = 7,500,000 hours

This value is then multiplied by separate high and low device energy consumption figures to produce the following:

High device energy consumption: 5 watts
Expected device consumption (high)$_{Region}$ = 7,500,000 x 5 watts
= 37,500,000 watt hours
= 37,500 kWh

Low device energy consumption: 3 watts

Expected device consumption $(low)_{Region}$ = 7,500,000 x 3 watts

= 22,500,000 watt hours

= 22,500 kWh

Both the high and low device energy consumption figures are then multiplied by the most appropriate EF:

Australian 2024 Emissions Factor = 551.59 g/CO2e per kWh

Expected device emissions $(high)_{Region}$ = 551.59 * 37,500

= 20,684,625 gCO2e

= 20.68 tCO2e

Expected device emissions $(low)_{Region}$ = 551.59 * 22,500

= 12,410,775 gCO2e

= 12.41 tCO2e

Total Reportable Scope 3 Category 11

The reportable results for Scope 3 Category 11 Mobile emissions will be the sum of the results of the chosen methodology for calculating emissions, plus the results of the Multiplayer Module if the game is multiplayer and gameplay requires or involves internet data transmission between end user client and a “server” (including P2P multiplayer, where another player is simply the “server”).

Additional guidance: Additions to Privacy, Terms & Conditions to enable data gathering

To enable the efficient collection of battery level data from mobile devices, the SGA suggests the following text be inserted into the privacy/terms & conditions document to explain in advance what/why these will be reported.

** TO BE DEVELOPED WITH MEMBERS **

Further examples & comparisons across 4 Options

	Option 1	Option 2	Option 3	Option 4
Type of emissions source	Mobile users in country/region, measured via battery level observation	Mobile users in country/region, measured by battery level % change	Mobile users in country/region, measured by play duration	Mobile users in country/region, estimated via sales or install numbers & expected duration
Data source(s)	Battery charge readings (mWh/mAh) at start and end of play session, region information (from analytics)	Battery % change at start and end of session, and associated model name (iPhone 12, Samsung Galaxy S12)	Internal player metrics (from analytics)	Sales data, App store sales or install data, estimates of typical total play duration.
Data type(s)	mWh, kWh (when aggregated for final reporting)	Percentage of total battery charge level consumed (%), Total battery capacity (mAh/mWh)	Play duration totals (hours) per region	Total sold copies of game, total users, total installs (all per region)
Collected data:	Individual Finnish play session start/end difference: 500 mAh All Finnish players: 345 kWh	All Finnish iPhone 16 players: 6700% battery consumption	All Finnish players duration: 18,000 hours.	1,455 installs in Finland. Average expected play duration: 5 hours.
Adjustment for charger losses	+30%	+30%	+30%	+30%
Type of emissions factor	Grid EF	Grid EF	Grid EF	Grid EF

Example emissions factor	72.25 (gCO2e per kWh) (EMBER)	72.25 (gCO2e per kWh) (EMBER)	72.25 (gCO2e per kWh) (EMBER)	72.25 (gCO2e per kWh) (EMBER)
Calculation method	Multiplication (energy x emissions factor)	Multiplication (battery percentage * device battery capacity/100 x emissions factor)	Multiplication (total play duration in a region x low/high device energy consumption assumptions x emissions factor)	Multiplication (Total installs/players/ etc x expected play duration low/high device energy consumption assumptions x emissions factor)
Example calculation	345 kWh x 72.25 gCO2e/kWh	6700% battery consumption x 1.3561 Wh [derived from 3,561mAh] / 1000 x 72.25 gCO2e/kWh	18,000 hours x (3 watts/1000) x 72.25 gCO2e/kWh also 18,000 hours x (5 watts/1000) x 72.25 gCO2e/kWh	1,455 players x 5 hrs x (3 watts/1000) x 72.25 gCO2e/kWh also 1,455 hours x (5 watts/1000) x 72.25 gCO2e/kWh
Result	24.92 (kg CO2e)	0.656 (kg CO2e)	0.3901 (kg CO2e; low) 0.6502 (kg CO2e; high)	0.31537 (kg CO2e) 0.52562 (kg CO2e)

Appendix – References and Equations

Resources that have informed this draft:

- GESI ICT Sector Guidance for measuring software energy consumption (Ch6)

GHG Protocol Direct use-phase emissions method, for reference:

Calculation formula [11.1] Direct use-phase emissions from products that directly consume energy (fuels or electricity) during use

CO_2e emissions from use of sold products =

sum across fuels consumed from use of products:
∑ (total lifetime expected uses of product × number sold in reporting period
× fuel consumed per use (kWh) × emission factor for fuel (kg CO_2e/kWh))
+
sum across electricity consumed from use of products:
∑ (total lifetime expected uses of product × number sold in reporting period
× electricity consumed per use (kWh) × emission factor for electricity (kg CO_2e/kWh))
+
sum across refrigerant leakage from use of products:
∑ (total lifetime expected uses of product × number sold in reporting period
× refrigerant leakage per use (kg) × global warming potential (kg CO_2e/kg))

Mobile

None

Total Reportable Emissions Sum Equation

None

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Sum of device measurement (Options 1, 2, 3 or 4) and Multiplayer
Module (if relevant)
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