ISO-Compliant GHG Calculation Guide

For the Replit Development Agent

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Author: Replit Coach Too
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1. Objective

This document provides a detailed technical guide for the Replit Agent to **replace the entire Product LCA calculation methodology** with a new, ISO 14064-1 compliant process. The current method of retrieving a single GWP100 value from OpenLCA will be deprecated. The new system will query the raw Life Cycle Inventory (LCI) data, extract the elementary flows for the seven major greenhouse gases, and perform the CO_2 equivalent (CO_2e) calculation within our backend.

2. Part 1: Backend & Database Enhancements

2.1. New Database Table: gwp_factors

A new table is required to store the official Global Warming Potential (GWP) factors.

Column Name	Data Type	Constraints	Description
id	UUID	PRIMARY KEY	Unique identifier for the entry.
gas_name	VARCHAR(100)	NOT NULL, UNIQUE	Common name of the greenhouse gas.
gas_formula	VARCHAR(50)	NOT NULL, UNIQUE	Chemical formula (e.g., 'CH4').
gwp_100yr_ar5	INTEGER	NOT NULL	The 100-year GWP factor from IPCC AR5.

Action: This table must be created and pre-populated (seeded) with the following data:

gas_name	gas_formula	gwp_100yr_ar5

Carbon Dioxide	CO2	1
Methane	CH4	28
Nitrous Oxide	N2O	265
Sulphur Hexafluoride	SF6	23500
Nitrogen Trifluoride	NF3	16100
HFCs (example)	HFC-134a	1300
PFCs (example)	PFC-14 (CF4)	6630
(Note: HFCs and PFCs have many variants; the table should be populated with the most common ones.)		

2.2. Update to reports.report_data_json Structure

The structure of the JSONB field in the reports table must be updated to store the detailed, disaggregated GHG data for auditability.

New JSON Structure:

```
{
  "total_co2e": 1.2345,
  "ghg_breakdown": [
    {
      "gas_name": "Carbon Dioxide",
      "mass_kg": 1.15,
      "gwp_factor": 1,
      "co2e": 1.15
    },
    {
      "gas_name": "Methane",
      "mass_kg": 0.0025,
      "gwp_factor": 28,
      "co2e": 0.07
    }
  ],
  "water_footprint": { ... },
  "waste_output": { ... }
```

}

3. Part 2: Overhaul of the LCA Calculation Service (Celery Worker)

The core logic of the Celery worker that performs the LCA calculation must be completely replaced with the following sequence.

- **Step 1: Run Life Cycle Inventory (LCI) in OpenLCA**
    - The worker will still construct the full product system in OpenLCA as before.
    - **Crucial Change:** Instead of calling olca.calculate() with an Impact Assessment Method, the worker will now call the OpenLCA API to get the raw **Life Cycle Inventory Result** for the entire product system. This provides a list of all elementary flows (emissions to air, water, etc.).
- **Step 2: Extract Relevant GHG Flows**
    - The worker must parse the LCI result from OpenLCA.
    - It will iterate through the entire list of elementary flows and filter it to find **only the flows to "air"** for the seven major greenhouse gases: **CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3.**
    - The result of this step is a list of the total mass (in kg) emitted for each of these specific gases.
- **Step 3: Calculate CO_2 Equivalent (CO_2e)**
    - The worker will initialize a total_co2e variable to zero and an empty ghg_breakdown array.
    - It will then iterate through the extracted GHG flows from Step 2. For each gas:
      a. Fetch GWP Factor: Query our new gwp_factors table to get the gwp_100yr_ar5 value for that gas.
      b. Calculate CO_2e: Perform the calculation: co2e_for_gas = mass_of_gas_kg * gwp_factor.
      c. Append to Breakdown: Add a new object to the ghg_breakdown array containing the gas_name, mass_kg, gwp_factor, and the calculated co2e_for_gas.
      d. Add to Total: Add the co2e_for_gas to the total_co2e variable.
- **Step 4: Store Detailed, Auditable Results**
    - Once the iteration is complete, the worker will have the final total_co2e and the detailed ghg_breakdown array.
    - This entire structure must be saved into the reports.report_data_json field, following the new JSON format.
    - The report status is then updated to draft and the user is notified.

This new methodology ensures that our platform's carbon footprint calculations are transparent, auditable, and fully compliant with the rigorous requirements of the ISO 14064-1 standard.