

CI/CD Carbon Emissions Report

Acme Engineering | January 01, 2024 – December 31, 2024

Scope & Classification

This report discloses greenhouse gas emissions from CI/CD pipeline execution. Runner compute is classified under **GHG Protocol Scope 3, Category 3.3** (Fuel and Energy-Related Activities — upstream emissions from purchased electricity consumed by the cloud provider). AI inference API calls (OpenAI, Anthropic, Mistral, etc.) and self-hosted LLM inference (Ollama, vLLM, Llama) made during CI runs are classified as **Scope 3, Category 1** (Purchased Goods and Services) and are calculated using an activity-based method (token counts × energy factors), preferred over spend-based estimates per CSRD ESRS E1-6 §AR 46. Hardware embodied carbon is reported as Scope 3 Category 2 (Capital Goods, amortized over 4-year server lifetime). **Scope 1: 0.000 kg CO2e** (attested zero — no direct fuel combustion). **Scope 2 (location-based): 48.300 kg CO2e; market-based: 29.000 kg CO2e** (office electricity declared). The report is structured in alignment with the **EU Corporate Sustainability Reporting Directive (CSRD) / ESRS E1-6**, the **GHG Protocol Corporate Value Chain (Scope 3) Standard**, and the **Green Software Foundation SCI Specification v1.0**. GHG emissions use **IPCC AR6 100-year GWP values**; all emissions are CO2-equivalent.

Important — partial inventory disclosure: This report covers CI/CD pipeline emissions only. It does not represent the organisation's complete Scope 3 inventory. It is intended to be incorporated as a line item within a broader GHG inventory prepared under GHG Protocol Corporate Standard. Filing this document as a standalone Scope 3 disclosure without the broader inventory would not satisfy CSRD ESRS E1-6 §44 in full.

Key Metrics

Metric	Value	Notes
Scope 1 - Direct Emissions	0.000 kg CO2e	Attested zero
Scope 2 - Office Electricity (location)	48.300 kg CO2e	Declared office electricity
Scope 2 - Office Electricity (market)	29.000 kg CO2e	After REC/green-tariff adjustment
Runner Compute Energy (Scope 3)	1847.3200 kWh	CPU only - network/memory excluded (see methodology)
Runner Compute CO2 (Scope 3 Cat 3.3)	428.910 kg CO2e	CI/CD runner upstream energy
AI Inference Energy (Scope 3 Cat 1)	63.5000 kWh	Activity-based; token counts x model energy factors
AI Inference CO2 (Scope 3 Cat 1)	14.7300 kg CO2e	Purchased AI API services - activity-based calculation
AI Inference Water (Scope 3 Cat 1)	28.40 L	Estimated from provider WUE x energy (Liter equivalent)
Total AI Water Consumption	28.40 L	Inference + training; CSRD ESRS E3 (Water and Marine Resources)
Combined Total CO2 (Scope 3)	443.640 kg CO2e	approx 0.4436 t CO2e (runner + AI inference + training)
GWP Standard	IPCC AR6 100-year GWP	CO2 dominates; CH4/N2O negligible for cloud CI

Trees Required to Offset (1yr)	21.1 trees	at ~21 kg CO2/tree/year
Car Driving Equivalent	2113 km	avg petrol car at 0.21 kg CO2/km
Repositories Measured	6	
Estimation Confidence	+/-15%	end-to-end; see methodology for component breakdown

Disclosed-adjusted estimate (+10% for excluded components): 471.801 kg CO2e | 2032.0520 kWh — A +10% correction (midpoint of documented 5–15% undercount range) is applied as a supplementary figure to account for excluded network and memory energy. The primary figures above reflect only directly measured components, per CSRD ESRS E1-6 BP-2 §64.

Renewable Energy Attribution (Scope 3)

Attribution Method	Basis	Total CO2e (kg)	Reduction
Location-Based	Regional average grid carbon intensity	488.910	—
Renewable-Attributed	40% renewable declared (REC/PPA/CFE matching)	267.416	–171.564 kg (40%)

Scope classification note: These are Scope 3 Category 3.3 figures, not Scope 2. Electricity for GitHub-hosted runners is purchased by the cloud provider (Microsoft Azure), not by Acme Engineering. The renewable-attributed figure applies GHG Protocol Scope 3 renewable attribution guidance: 40% of upstream compute electricity is attributed to renewable sources via bundled RECs, PPAs, or a Cloud Flexibility Energy (CFE) matching programme. Retain documentary evidence of your renewable energy instruments for auditors.

CSRD / ESRS E1 Disclosure Mapping

This report addresses the following disclosure requirements under **ESRS E1 Climate Change** (effective financial years starting 1 Jan 2024):

Framework / Disclosure	Requirement	EmitCI Coverage
ESRS E1-6 §44(a)	Gross Scope 3 GHG emissions	Reported - CI/CD (Cat 3.3), cloud compute (Cat 1), developer hardware (Cat 2), SaaS tools (Cat 1). Export via Scope 3 Compliance Downloads.
ESRS E1-6 §44(c)	Total GHG emissions (all scopes)	Scope 1 (direct combustion declared), Scope 2 (office electricity, location + market-based), Scope 3 (cloud + CI/CD + hardware + SaaS). See CSRD export.
ESRS E1-6 §45	GWP values source	IPCC AR6 100-year GWP; all emissions CO2-equivalent
ESRS E1-6 §46	GHG intensity metric	gCO2e per workflow run; gCO2e per repo; kgCO2e per engineer/yr (hardware)
ESRS E1-9 §69	Carbon removal targets	Out of scope (no sequestration assets)
ESRS E1-4 §34	GHG reduction targets	Set reduction budgets via EmitCI Goals feature
ESRS BP-2 §64	Basis of preparation	See Methodology section and Appendix A (detailed report)
GHG Protocol Scope 3	Category 3.3 upstream energy	Location-based and renewable-attributed totals
TCFD - Metrics	GHG emissions (Scope 1, 2, 3)	All three scopes covered - CI/CD + cloud (S3), office electricity (S2), direct combustion (S1)
California SB 253	Scope 1+2+3 disclosure (>\$1B revenue)	Scope 1 declared, Scope 2 dual-method, Scope 3 Cat 1/2/3.3 - export via CDP workbook and CSRD CSV

Year-over-Year Comparison

Metric	Prior Period	This Period	Change
Total Energy (kWh)	2104.1800	1847.3200	-12.2%
Total CO2e (kg)	488.370	428.910	↓ REDUCED 59.460 kg (-12.2%) (improvement)

Emissions by Repository

Repository	Energy (kWh)	CO2 (kg)	Runs	% of Total
acme/api-service	712.4000	165.2000	3842	38.5%
acme/frontend	489.1000	113.5000	2917	26.5%
acme/data-pipeline	318.6000	73.9000	1204	17.2%
acme/ml-training	198.7000	46.1000	438	10.7%
acme/infra-terraform	82.3000	19.1000	712	4.5%
acme/mobile-app	46.2000	11.1000	389	2.6%

Production Cloud Emissions (Scope 3 Category 3.3)

Production cloud infrastructure (AWS, GCP, Azure) emissions estimated from cloud billing API data using the Cloud Carbon Footprint (CCF) methodology. Classified as Scope 3 Category 3.3 (Fuel and Energy-Related Activities — upstream cloud compute). These figures are reported separately from CI/CD to enable distinct audit traceability.

Resource Type	Energy (kWh)	CO2 (g)	CO2 (kg)	% of Cloud Total
EC2 Compute	1224.8000	284200.00	284.2000	72.8%
RDS PostgreSQL	376.2000	87300.00	87.3000	22.4%
S3 Storage	52.1000	12100.00	12.1000	3.1%
CloudFront CDN	20.7000	4800.00	4.8000	1.2%
Lambda Functions	9.5000	2200.00	2.2000	0.6%
Total	1683.3000	390600.00	390.6000	100%

Developer Hardware Lifecycle (Scope 3 Category 2)

Embodied carbon from developer-owned devices declared by the organisation. Classified as Scope 3 Category 2 (Capital Goods). Annual amortized CO2 based on declared headcount, device type, and refresh cycle.

Device Type	Headcount	CO2/Device/Year (kg)	Total CO2/Year (kg)
MacBook Pro 14" M3	28	5.2	145.6
Dell XPS 15	12	7.8	93.6
Total			239.2

AI Inference Services (Scope 3 Category 1)

Emissions from AI API calls and self-hosted LLM inference made during CI/CD pipeline execution. Classified as **Scope 3 Category 1 — Purchased Goods and Services** (GHG Protocol Scope 3 Standard, 2011). Calculated using an **activity-based method** (token counts × model-specific energy factors × provider grid intensity), which is preferred over spend-based estimation per CSRD ESRS E1-6 §AR 46. Confidence: 40–60% (energy factors are research-based estimates; provider-reported figures carry 95% confidence where disclosed). Sources: Patterson et al. (2022), MLPerf Inference v4.0.

Provider	Energy (kWh)	CO2 (kg)	Water (L)	API Calls	Calculation Method
Anthropic Claude	38.4000	8.9200	17.20	28,471	Activity-based (token counts)
OpenAI GPT-4	18.0000	4.1800	8.10	9,834	Activity-based (token counts)
Google Gemini	7.1000	1.6300	3.10	4,122	Activity-based (token counts)
Total	63.5000	14.7300	28.40		

GHG Scope Breakdown

GHG Scope	Category	CO2 (kg)	Energy (kWh)	Water (L)	Event Count
Scope 3	Category 1 — Purchased Goods and Services	14.7300	63.5000	0.00	0

Note on Scope 2 vs Scope 3: AI API calls to managed providers (OpenAI, Anthropic, Google, Mistral) are Scope 3 Cat 1 — the provider purchases the electricity, not your organisation. Self-hosted LLM inference on organisation-owned GPU servers constitutes **Scope 2** (purchased electricity) if directly metered; report those figures separately in your Scope 2 disclosure. **Water disclosure** follows CSRD ESRS E3 (Water and Marine Resources).

Methodology

Energy Estimation Formula (Compute only):

$$E \text{ (kWh)} = \text{TDP (W)} \times \text{CPU_utilization} \times \text{duration (h)} \times \text{PUE} / 1000$$

Carbon Intensity Formula:

$$\text{CO2 (g)} = E \text{ (kWh)} \times \text{grid_carbon_intensity (gCO2/kWh)}$$

Embodied Carbon Formula (Scope 3):

$$M \text{ (g)} = \text{embodied_per_vCPU_hour} \times \text{vCPUs} \times \text{duration_h}$$

Assumptions: 4-year server lifetime, 50% average utilization. Uncertainty: ±30%.

Sources: Boavizta database, Cloud Carbon Footprint coefficients.

Parameters:

- **TDP:** Runner hardware Thermal Design Power sourced from cloud provider specifications (Azure, AWS, GCP). GitHub Actions ubuntu-latest = Azure Standard_DS2_v2 ≈ 90W.
- **CPU utilization:** 0.65 default (CI workload average). Step-level profiles used where available. Actual range: 0.30–0.95 depending on workload type.
- **PUE:** 1.10 (cloud data center Power Usage Effectiveness, source: hyperscaler sustainability reports 2023–2024).
- **Carbon intensity:** Regional grid averages from IEA 2023 data. Real-time data from Electricity Maps / WattTime when configured.

Known exclusions (systematic undercount):

- Network transfer energy (GitHub API does not expose per-step data transfer)
 - Memory energy (GitHub API does not expose per-step memory usage)
- Estimated impact: 5–15% undercount for typical workloads; higher for artifact-heavy pipelines.

AI Inference Formula (Scope 3 Cat 1 — added v2.3.0):

$$\text{CO}_2 \text{ (g)} = (\text{input_tokens}/1000 \times \text{input_kWh}/1\text{k} + \text{output_tokens}/1000 \times \text{output_kWh}/1\text{k}) \times \text{PUE} \times \text{grid_gCO}_2/\text{kWh}$$

PUE: managed API providers 1.10–1.20 (provider-estimated); self-hosted 1.20 (typical DC average).

Grid intensity: known data centre location for managed APIs; regional IEA factor if region declared, else global average (442 gCO₂/kWh) for self-hosted.

Energy factors: research-based estimates (Patterson et al. 2022; MLPerf Inference v4.0 2024; vLLM benchmarks 2024). Not provider-verified. Confidence: 40–50%.

Calculation type: activity-based (preferred over spend-based per CSRD ESRS E1-6 §AR 46).

GWP Values: IPCC Sixth Assessment Report (AR6), 100-year global warming potentials. CO₂ dominates CI/CD grid electricity emissions; CH₄ and N₂O contributions from cloud compute are negligible and excluded. All totals reported as CO₂-equivalent (CO₂e).

Base Year: The first complete 12-month period tracked on EmitCI serves as the base year for reduction target-setting and year-over-year comparison. Base year figures will be recalculated if the methodology version changes (see recalculation policy in Appendix A).

Biogenic carbon: Cloud CI/CD electricity is sourced from grid power; no biogenic fuels are directly combusted. Biogenic CO₂ contributions are zero for all values in this report.

Methodology Version: 2.3.0

Standard: Green Software Foundation Software Carbon Intensity (SCI) Specification v1.0

Confidence: ±15% (end-to-end estimation uncertainty)

Audit Trail

Document Hash (SHA-256): 06e2410a62d7ffe03b90093d83a576571eaf632ef1dc99052cb7464a626516bc

Methodology Pin (SHA-256 prefix): c252241fd272d7a3 — verifies the exact formula version used.

Generated: 2026-07-24T07:38:38Z UTC

Generated by: EmitCI v2.3.0

Both hashes should be stored in your ESG audit system alongside this PDF. The methodology hash allows independent verification that the calculation parameters have not changed between reporting periods.

This report was generated automatically by EmitCI. Emissions figures are estimates based on runner hardware specifications and regional grid carbon intensity data, classified under GHG Protocol Scope 3, Category 3.3 (Fuel and Energy-Related Activities). This document covers CI/CD pipeline emissions only and must be incorporated into a broader Scope 3 inventory — it does not constitute a complete CSRD ESRS E1-6 disclosure. Review by a qualified sustainability professional is recommended before inclusion in regulatory filings.

Appendix A — Extended Methodology

This appendix provides a complete basis-of-preparation statement for auditors and sustainability professionals reviewing this disclosure. It supplements the summary methodology section in the main report body.

A1. Organisational and Activity Boundary

Organisation: Acme Engineering
Reporting period: 2024-01-01 to 2024-12-31
Repositories in scope: 6
Activity boundary: All GitHub Actions workflow runs that completed during the reporting period on the repositories listed above. Includes all runner types (GitHub-hosted and self-hosted where instrumented).
GHG boundary: Operational control approach (GHG Protocol Corporate Standard §3). Cloud compute is treated as a purchased service; energy consumed by cloud provider data centres is classified as Scope 2 (location-based) and additionally as Scope 3 Category 3.3 (upstream energy-related activities).

Explicit exclusions (out of scope for this report):

Exclusion	Reason	Estimated Impact
Network data transfer energy	GitHub Actions API does not expose per-step transfer volumes	2-8% undercount
Memory (DRAM) energy	GitHub Actions API does not expose per-step memory usage	3-7% undercount
Storage I/O energy	Not measured by any CI platform at step level	<1% undercount
End-user device energy	Outside organisational boundary (developer laptops/desktops)	Not applicable
Scope 1 emissions	Cloud CI infrastructure has no direct fuel combustion (GHG Protocol §4.1)	Zero
AI inference not reported via SDK/action	Opt-in instrumentation — AI calls not wrapped are not captured	Depends on adoption
Other IT infrastructure	Office servers, build caches, artefact registries	Not measured

A2. Energy Estimation Model

Energy is estimated at the workflow-run level using a linear power interpolation model derived from the SPECpower_ssj2008 database and Cloud Carbon Footprint (CCF) methodology (cloudcarbonfootprint.org/docs/methodology/).

Primary formula (per step):
$$E \text{ (kWh)} = (\text{MinWatts} + \text{utilization} \times (\text{TDP} - \text{MinWatts})) \times \text{duration_hours} \times \text{PUE} / 1000$$

Parameter	Value / Source	Notes
TDP (W)	Runner-type specific; GitHub ubuntu-latest ~90 W	Source: Azure Standard_DS2_v2 spec; CCF coefficients
MinWatts	30% of TDP (idle power floor)	SPECpower data: modern servers idle at 20-36% of peak
CPU utilization	0.15-0.95 per step type; 0.65 global default	Step-name heuristics; checkout=0.15, test=0.90, build=0.75
PUE	1.09-1.26 per region	Azure/AWS/GCP 2023-2024 sustainability reports

duration_hours	Measured from GitHub Actions step timestamps	Direct measurement; +/-0 uncertainty
Embodied carbon (Scope 3)	Boavizta DB: ~0.44 gCO2/vCPU-hour at 50% util, 4yr life	Category 2 Capital Goods; +/-30% uncertainty

A3. Carbon Intensity Emission Factors

Grid carbon intensity (gCO2/kWh) is sourced at three tiers of precision. Each run record stores the source used at the time of measurement.

Tier	Source	Confidence	Coverage	Update Frequency
1 (highest)	WattTime MOER (Marginal Operating Emission Rate)	~90%	US grid regions	5-minute granularity
2	Electricity Maps zone average	~80%	EU + APAC major zones	Hourly
3 (fallback)	IEA 2023 national averages (static)	~65%	All regions	Annual update

Data quality for this reporting period:

Carbon Intensity Source	Runs	% of Total
WattTime (Tier 1)	2	66.7%
Electricity Maps (Tier 2)	1	33.3%
Total	3	100%

A4. Accuracy and Uncertainty Assessment

The following table documents the uncertainty contribution of each model component. End-to-end accuracy has been validated against direct power-meter measurements in controlled tests (arXiv:2510.26413, 2024).

Component	Uncertainty	Primary Driver
CPU utilization inference	±30-50%	Step-name heuristic; actual utilization not measured
TDP (runner hardware)	±5-10%	Runner spec variation within instance type
Memory energy (excluded)	+3-7% undercount	Not available from GitHub Actions API
Network energy (excluded)	+2-8% undercount	Not available from GitHub Actions API
PUE (data centre efficiency)	±5-10%	Provider-reported; actual varies by time of day
Carbon intensity (static tier)	±15-25%	Annual averages vs real-time grid mix
Carbon intensity (live tier)	±5-10%	Real-time data; forecast error in MOER
Embodied carbon	±30%	Boavizta DB; varies by hardware generation
End-to-end (vs direct meter)	±40-60%	Quadrature sum of dominant contributors

Recalculation policy: If the methodology version changes between reporting periods, prior period totals will be recalculated using the new methodology and both versions disclosed. The methodology pin in the audit trail allows verification of which formula version produced each report.

Third-party verification: EmitCI's SHA-256 document hash proves data integrity (the figures have not been altered since generation) but does not constitute third-party assurance of the estimation methodology. For CSRD limited assurance (required for large companies from FY2025) or reasonable assurance (FY2028), engage an accredited verifier (e.g. PwC, Bureau Veritas, or an accredited CSRD assurance provider).

Appendix B — Run-Level Emissions Data

This appendix lists each individual CI/CD workflow run included in the emissions total. Auditors can use this data to verify the aggregate figures in the main report body. Total runs in this period: **3**.

Date (UTC)	Repository	Workflow	Region	Dur (s)	Energy (kWh)	CO2 (g)	Grid Source	Conf %
2024-06-15 T14:22:01Z	acme/api-service	CI — Test Suite	us-east-1	284	0.002180	0.8040	watttime	95
2024-06-15 T18:44:12Z	acme/frontend	Build & Deploy	us-west-2	412	0.001470	0.4410	electricity_maps	88
2024-06-16 T02:10:55Z	acme/data-pipeline	Nightly ETL	eu-west-1	1820	0.009310	2.1430	watttime	92

Column definitions: **Dur (s)** = wall-clock duration of the workflow run in seconds. **Energy (kWh)** = estimated compute energy (CPU model; excludes network/memory — see Appendix A). **CO2 (g)** = energy × grid carbon intensity at time and region of run. **Grid Source** = carbon intensity data tier used (watttime / electricity_maps / static). **Conf %** = confidence score reflecting data quality of the carbon intensity source.