CJV-MTH-1.0

Evidence-Graded Product Carbon Claim Registry — Specification

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Status: public specification, published for citation and review. It is not an accredited standard, not an ISO/IEC deliverable, and it confers no certification.

Disclosure. The author of this specification is also the operator of the platform and of the registry it describes. The body that would issue conclusions under it is not accredited, and no signing partner is contracted. Section 15 states what this document can and cannot support as evidence.

Document control

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Abstract

This document specifies a way to make product-level carbon claims checkable rather than merely asserted. Its unit of account is a verified unit: one batch, one fixed boundary, one functional unit, one ledger entry and one recomputable hash. The specification defines five properties a unit must satisfy to count as verifiable, a grade that is computed from the share of the footprint that is metered rather than estimated, a rule that the

counterfactual baseline must be co-signed before the improvement is claimed, four machine-readable refusal classes, and an append-only hash-chained register that a third party can recompute without trusting the issuer.

The specification also partitions claims: what an evidence layer may state without a signature, and what requires a countersignature from an accredited body. That partition is the reason the document exists as a separate artifact: the evidence layer can be published, audited and sold while the signature layer is still being built.

Conformance test vectors in Section 13 are taken from the live register and can be checked with a calculator or ten lines of code.

1 Scope

This specification applies to batch-level product carbon footprint records for agricultural and manufactured goods, issued by an operator that measures with meters the operator does not necessarily own, and consumed by buyers who need primary scope-3 evidence.

It specifies:

1.\tthe properties a unit must have to be verifiable (Section 6);

2.\tthe field set of the unit and its invariants (Sections 6.2, 6.3, Annex A);

3.\tthe evidence grade as a computed function of metered share (Section 7);

4.\tthe counterfactual baseline rule (Section 8);

5.\tthe refusal semantics and its machine representation (Section 9);

6.\tthe canonical payload, hash function, chain construction and revocation rules (Section 10);

7.\tthe publication format and the recomputation procedure (Section 11);

8.\tthe claim partition around countersignature (Section 12);

9.\tconformance test vectors (Section 13).

It applies to registries, to label records, to API responses and to the documents that cite them.

2 Non-goals

This specification does not, and no conforming implementation may claim that it does:

- determine whether land was deforested, or assess regulatory compliance of any kind;
- issue a carbon credit, an offset, or any tradable instrument;
- certify a product, a site, an organisation or a management system;
- substitute for accreditation under ISO/IEC 17065 or ISO 14065;
- file a due diligence statement or any regulatory submission;
- establish comparability between records produced under different method versions (Section 14);
- define the scientific validity of emission factors, which remain those of the cited sources.

> A registry that satisfies every requirement in this document may still be operated by an organisation that is not competent, not independent or not accredited. Conformance here is a statement about data structure and procedure, not about the body.

3 Normative references

Reference	What is taken from it
ISO 14064-3	The structure of a verification: scope, criteria, evidence, conclusion
ISO 14067	Product carbon footprint quantification; functional unit and system boundary
ISO/IEC 17065	Competence requirements for bodies certifying products
ISO 14065	Requirements for bodies validating and verifying GHG statements
ISO 14064-1	Quantification and reporting at the organisation level
Regulation (EU) 2023/1115 (EUDR)	Shipment-level evidence expectations; context only
RFC 2119	MUST / SHOULD / MAY keywords as used in Section 4
FNV-1a (Fowler–Noll–Vo)	The non-cryptographic hash used in Section 10

Where this specification and an ISO document differ, the ISO document governs the science and this document governs the record format.

4 Terms and definitions

Term (中文)	Definition
verified unit (可核证作业单元)	One batch of output with a fixed boundary and functional unit, whose footprint is recorded as one ledger entry with one hash, satisfying all five properties in Section 6.1
batch (批次)	A quantity of output produced in one cycle under one boundary, identifiable to physical goods
functional unit (功能单位)	The denominator of the claim, fixed before data collection, e.g. one delivered plantlet
metered share (计量占比)	The fraction of the total footprint, by mass of impact, that traceably originates from a measured quantity rather than an estimate, factor table or allocation
evidence grade (证据等级)	A letter A, B or C computed from the metered share by the function in Section 7
counterfactual baseline (反事实基线)	The footprint the batch would have had under the practice being displaced, co-signed before the improvement is claimed
refusal (弃权/拒绝)	A recorded output stating that no conclusion is issued, with a machine-readable reason class
countersignature (会签)	A conclusion issued by an accredited body over the evidence, referencing the unit hash
register (登记簿)	The append-only publication of unit records and their hashes
evidence layer (证据层)	The party that measures, grades and registers; it does not sign conclusions
signature layer (签名层)	The party that holds accreditation and issues the conclusion

The key words MUST, MUST NOT, REQUIRED, SHALL, SHALL NOT, SHOULD, SHOULD NOT, RECOMMENDED, MAY and OPTIONAL are to be interpreted as described in RFC 2119.

5 Conformance

An implementation MAY claim conformance to this specification only if it satisfies every MUST in Sections 6 to 12 and reproduces the test vectors in Section 13. A claim of conformance MUST state:

1.\tthe version of this specification;

2.\tthe method identifier and method hash under which records are issued;

3.\twhether the implementation publishes a countersignature field and, if so, who holds the accreditation;

4.\tthe register head hash and the record count at the time of the claim.

Conformance MUST NOT be described as certification, accreditation, approval or compliance.

6 The verified unit

6.1 Five properties

A record is a verified unit only if all five properties hold. A record failing one property is not a weaker unit; it is not a unit.

Property	Requirement	Failure test
Metered	The footprint MUST be derived from measured quantities for the dominant impact category	Only invoices exist for the energy
Bounded	Boundary and functional unit MUST be fixed and recorded before data collection	Boundary chosen after the result is known
Attributed	The unit MUST have one owner, one location and one batch identifier; allocation across sites MUST NOT be by proportion of output	A batch is split across sites without a rule
Committed	The payload MUST be hashed into the chain at issuance and MUST NOT be editable	A value is revised without a new record
Recomputable	A third party MUST be able to reproduce the hash from published fields without access to the issuer	Verification requires asking the issuer

6.2 Required fields

Field	Type	Requirement
unit_id	string	MUST be unique and immutable; MAY be a label id
batch	string	MUST identify the physical goods
units	integer	MUST be positive; the count of functional units
unit_name	string	MUST name the functional unit

Field	Type	Requirement
kgco2e_per_unit	decimal, 3 dp	MUST equal kgco2e_total divided by units, within 0.001
kgco2e_total	decimal, 3 dp	MUST equal the sum of the line items, within 0.001
baseline_per_unit	decimal, 3 dp	MUST be co-signed per Section 8
reduction_pct	decimal, 1 dp	MUST equal (1 − per_unit / baseline) × 100, within 0.1
data_quality	decimal, 1 dp	The metered share in percent
grade	A | B | C	MUST equal grade(data_quality) per Section 7
method	string	MUST be the method identifier
method_hash	string	MUST be the method hash
issued	date	MUST be the issuance date
prev	string	MUST be the previous record hash or the literal genesis
hash	string	MUST equal the function in Section 10.3
payload	string	MUST equal the canonical payload in Section 10.2
provenance	enum	simulated | measured | pilot
status	enum	published | revoked

Implementations MAY add fields. Additional fields MUST NOT alter the canonical payload.

6.3 Invariants

A conforming implementation MUST reject at issuance any record where:

- per-unit × units differs from the total by more than 0.001;
- the grade disagrees with the metered share;
- the baseline is younger than the improvement it is used to measure (Section 8);
- prev does not equal the current register head;
- a policy field required by the register has no recorded value.

7 Evidence grading

The grade is arithmetic, not judgement. It reports how much of the claimed number came from measurement rather than estimation.

```
grade(metered_share):
    if metered_share >= 70.0:  return "A"
    if metered_share >= 45.0:  return "B"
    return "C"
```

Grade	Metered share	Permitted claim
A	≥ 70%	Primary scope-3 line item; may be cited in supplier programmes

Grade	Metered share	Permitted claim
B	≥ 45%	Usable with a stated share of secondary factors
C	< 45%	Directional only; MAY NOT carry a buyer-facing reduction claim

A grade MUST NOT be raised by commercial preference, by the size of the batch, or by the identity of the buyer. A record graded C MUST NOT be represented as a verified footprint in buyer-facing material; it MAY be used internally.

Thresholds are part of this method version. Changing a threshold requires a new version under Section 14.

8 Counterfactual baseline co-signing

A reduction claim needs a denominator. This specification requires the denominator to be fixed and co-signed before the improvement it is measured against.

1.\tThe baseline study MUST record boundary, functional unit, factor sources and the period it represents.

2.\tThe baseline MUST be co-signed by a party other than the operator of the batch.

3.\tThe co-signature MUST carry a date that precedes the date of the first record claiming a reduction.

4.\tA baseline established after the improvement MUST NOT be used for a reduction claim; such a record MAY be published as a footprint without a reduction, graded per Section 7.

5.\tRevision of a baseline MUST NOT alter earlier records; it produces a new baseline identifier and, where the reduction changes materially, a new method version.

Rationale: a baseline chosen after seeing the result makes the reduction a design choice rather than an outcome. The co-signature is the only mechanism in this specification that constrains that choice, and it is therefore the one that reviewers should test first.

9 Refusal semantics

Refusal is a first-class output. A conforming implementation MUST be able to return, and record, each of the following instead of a conclusion:

Class	Trigger	Recorded output
INSUFFICIENT_METERING	Metered share below the grade requested	No unit; reason string; the requested grade and the achieved share
UNPUBLISHED_FACTOR	A material factor has no published source	No unit; list of factors without provenance
BASELINE_NOT_COSIGNED	The baseline is missing or postdates the improvement	Record with reduction_pct omitted; status qualified
IDENTITY_UNRESOLVED	The batch cannot be tied to physical goods	No unit; the identifier that could not be resolved

A refusal MUST be recorded with the same care as a unit: it MUST be possible to show what was requested and why no conclusion followed. A refusal MUST NOT be presented as a failure of the requester.

Implementations SHOULD expose refusal rates publicly. A register reporting a 100 percent issuance rate SHOULD be read as evidence that refusal is not being exercised, not as evidence of quality.

10 Label record and hash chain

10.1 Canonicalization

The canonical payload MUST be the UTF-8 encoding of the following, in this order, with a single vertical bar as separator and no whitespace:

```
payload = batch + "|" + kgco2e_total + "|" + kgco2e_per_unit + "|" + grade
```

Numbers MUST be formatted with exactly three decimal places and a period as the decimal separator. The grade MUST be the single uppercase letter. No other field participates in the hash.

10.2 Hash function

The hash MUST be FNV-1a, 32-bit, over the UTF-8 bytes of prev concatenated with payload, with the following constants and formatting:

Parameter	Value
Offset basis	0x811C9DC5
Prime	0x01000193
Arithmetic	XOR the octet, then multiply modulo 2^32
Output	8 lowercase hexadecimal digits, zero-padded
Input order	prev, then payload, no separator, no length prefix

FNV-1a is not a cryptographic hash. It detects accidental and casual modification; it does not resist an adversary who can rewrite the whole chain. A register requiring adversarial resistance MUST additionally anchor the head hash in a medium the issuer does not control, or replace this function with SHA-256 under a new method version.

10.3 Chain construction

```
record[0].prev = "genesis"
record[i].prev = record[i-1].hash
record[i].hash = fnv1a(record[i].prev + record[i].payload)
```

The register head MUST be the hash of the last record. Publication of the head SHOULD accompany every release of the register.

10.4 Revocation

Records MUST NOT be deleted or edited. Revocation MUST be an appended event that references the record hash and states the reason. A revoked record MUST remain visible and MUST carry status revoked. The chain MUST remain valid after revocation.

11 Register publication

A conforming register MUST publish, at a stable URL, a single document with the fields below, and a procedure by which any party can recompute the chain without contacting the issuer.

Field	Requirement
register	Human-readable name of the register
method / method_hash	The method in force when the records were issued

Field	Requirement
count	Number of records
head	The last record hash
sectors	Identifier to name mapping for the sector codes used
labels	Array of records per Section 6.2
note	A statement of provenance and of what the records are not

The recomputation procedure MUST be documented and MUST run in a browser without a server call. It MUST report the first failing record index if the chain does not verify.

12 Countersignature and the claim partition

This section defines what may be claimed at each layer. It is the normative expression of the separation between the evidence layer and the signature layer.

Claim	Evidence layer alone	With countersignature
Methodology published	MAY	MAY
Evidence graded A/B/C	MAY	MAY
Register recomputable	MAY	MAY
Footprint of this batch	MAY, as a professional statement	MAY, as a verified statement
Reduction against baseline	MAY, if the baseline is co-signed (Section 8)	MAY
“Verified by an accredited body”	MUST NOT	MAY, naming the body and its scope
“Certified”, “accredited”, “approved”	MUST NOT	MUST NOT, unless the body is accredited for that scope and the claim names it

A record carrying a countersignature MUST include the signing body, its accreditation reference, the date and the reference of the conclusion. A record without these fields MUST NOT be described as countersigned.

13 Conformance test vectors

The following vectors are taken from the published register (head 54980f3d, 20 records, 2026-11-06). An implementation conforms only if it reproduces them exactly.

#	prev	payload	hash
1	genesis	AP-8885|185.735|0.307|A	889fdaf6
2	889fdaf6	AP-2856|295.75|0.338|B	f24da836
20	f0238400	AP-7315|224.406|0.273|A	54980f3d

Reference implementation, in full:

```
def fnv1a(text: str) -> str:
    h = 0x811C9DC5
    for ch in text:
        h ^= ord(ch)
        h = (h * 0x01000193) & 0xFFFFFFFF
    return f"{h:08x}"
```

```
prev = "genesis"
for record in register:
    assert record["prev"] == prev
    assert record["hash"] == fnv1a(prev + record["payload"])
    prev = record["hash"]
assert prev == register_head
```

A conformance report SHOULD state the record count, the head hash and the date of the run.

14 Versioning and change control

Change	Required action
Editorial correction, no effect on stored values	Patch version; existing records unchanged
New optional field	Minor version; old records remain valid
Change to grade thresholds, canonical payload or hash function	New method version; earlier records continue to point at the version under which they were issued
Change to a baseline	New baseline identifier; earlier records unchanged
Deprecation of a field	Minor version; the field remains readable and marked deprecated

A record MUST always disclose the method version that produced it. Silent recomputation under a new version MUST NOT occur; a recomputation produces a new record.

15 Limitations and threats to validity

1.\tDual role. The author of this specification operates the platform and the registry. Nothing in this document demonstrates independence, and the organisational form required to demonstrate it has not been established.

2.\tNo accreditation. No conclusion issued under this specification has been accredited, and the document confers no permission to claim compliance with any regulation.

3.\tDemonstration data. The published register contains one live record and nineteen simulated records. The simulated records exercise the chain; they are not measurements of real batches.

4.\tSelf-declared baseline. The baseline in the reference case is declared by the operator. Section 8 constrains when it must be co-signed, not whether the value is correct.

5.\tSingle case. The economic parameters in the accompanying material derive from one aeroponic nursery and do not generalise without re-derivation.

6.\tNon-cryptographic chain. See Section 10.2.

7.\tField validation. Plot coordinates, satellite baselines and legality review are not implemented; records that would require them cannot be issued.

16 How to cite

Cite this document as: Wong, Erik C. (ZeroCarbon Verify (HK) Limited (in incorporation)). CJV-MTH-1.0 — Evidence-Graded Product Carbon Claim Registry: Specification, version 1.0, 2026. ORCID 0009-0004-6360-4415. DOI 10.5281/zenodo.24015355.

When citing the register, cite the record count and head hash alongside the date, so that the citation can be checked against a specific register state.

Annex A Field dictionary

Field	Unit	Example	Constraint
label_id	—	ZC-COF-2026-0001	unique, immutable
batch	—	AP-8885	ties to goods
units	count	605	> 0
unit_name	—	plantlet	functional unit
kgco2e_per_unit	$kgCO_2e$/unit	0.307	3 dp, = total / units
kgco2e_total	$kgCO_2e$	185.735	3 dp, = Σ line items
baseline_per_unit	$kgCO_2e$/unit	0.449	3 dp, co-signed
reduction_pct	%	31.6	= (1 − per/baseline) × 100
data_quality	%	74.8	metered share
grade	—	A	= grade(data_quality)
fee_cny	CNY	80	per fee schedule in force

Annex B Worked example (reference batch AP-0712)

Item	Value	Note
Batch	AP-0712	rooted cuttings, aeroponic nursery
Units	480	plantlets
$kgCO_2e$ per plantlet	0.1951	engine result, grade B
Metered share	61.5%	electricity + nutrients metered
Baseline per plantlet	0.420	co-signed before the improvement
Reduction	53.5%	= (1 − 0.1951 / 0.420) × 100
Line items	electricity 61.5%, hardware 17.9%, transport 10.3%, packaging 6.2%, nutrients 4.2%	shares from one reference nursery; not a default
Label fee	¥40 per batch	verifier share of the buyer-side ¥60 at grade B

The declared figure printed on the label is 0.200 $kgCO_2e$ with a 52 percent reduction; the engine figure above is 0.1951 with 53.5 percent. The difference is the rounding rule and the electricity average period. Both are recomputable; the record's hash is the arbiter.

Annex C Register document schema

```
{
  "register": "string",
  "method": "string",
  "method_hash": "8-hex",
  "count": "integer",
  "head": "8-hex",
  "sectors": { "COF": "string", ... },
  "note": "string",
  "labels": [
```

```
    { "label_id": "string", "batch": "string", "units": "integer",
      "unit_name": "string", "kgco2e_per_unit": "decimal(3)",
      "kgco2e_total": "decimal(3)", "baseline_per_unit": "decimal(3)",
      "reduction_pct": "decimal(1)", "data_quality": "decimal(1)",
      "grade": "A|B|C", "method": "string", "method_hash": "8-hex",
      "issued": "YYYY-MM-DD", "prev": "8-hex|genesis", "hash": "8-hex",
      "payload": "string", "provenance": "simulated|measured|pilot",
      "status": "published|revoked" }
  ]
}
```

Annex D Publication checklist

#	Item	Done when
1	Register published with head hash	URL reachable; count and head match a local recomputation
2	Recomputation page live	A third party reproduces the head without contacting the issuer
3	Test vectors in Section 13 reproduced	Reference implementation passes
4	Refusal classes implemented and recorded	At least one refusal exists in the register history
5	Baseline co-signature recorded	Date precedes the first reduction record
6	Claim partition respected in all public copy	No “certified” or “accredited” outside Section 12
7	DOI deposited	Zenodo record public with this document and the register JSON