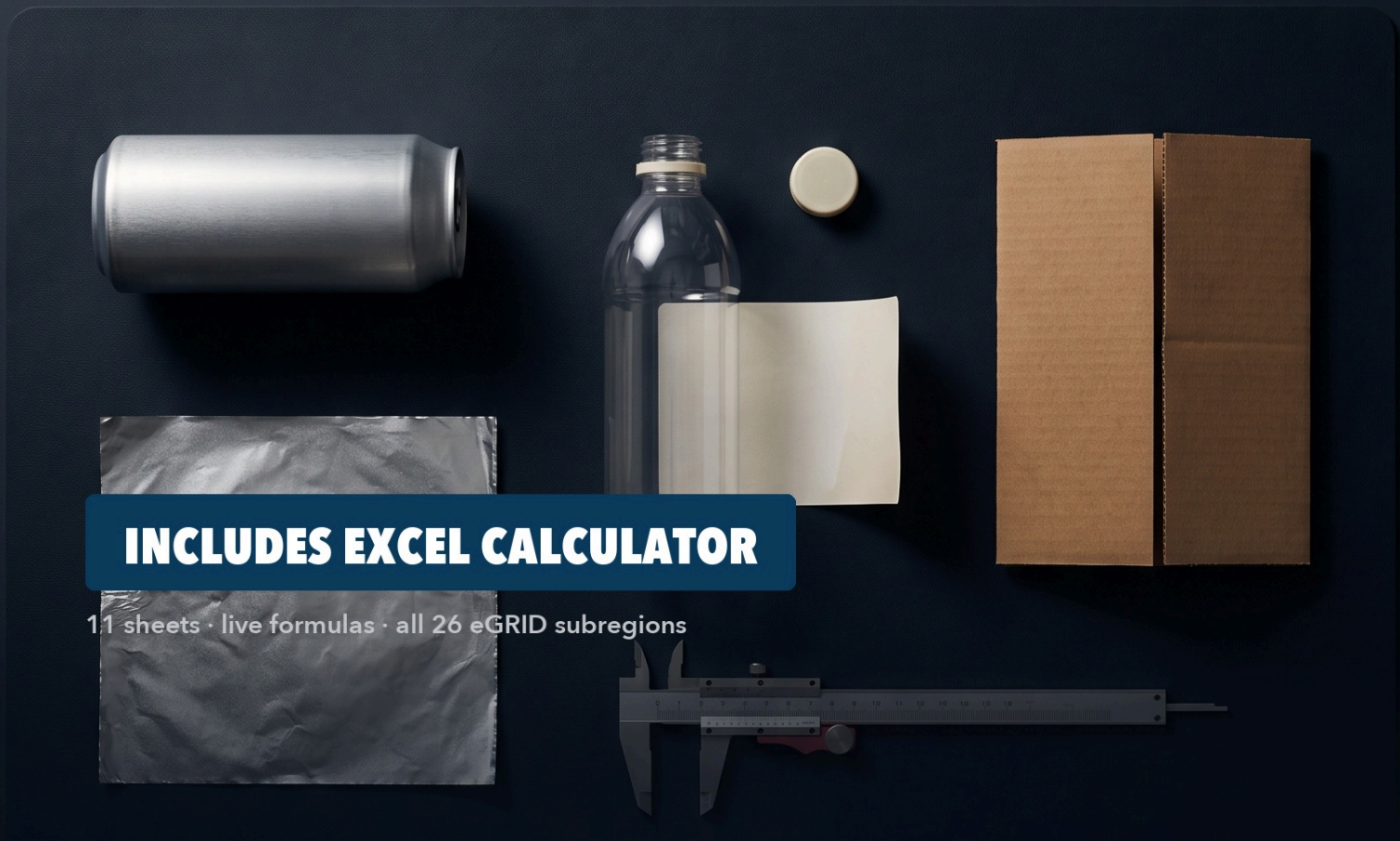
TECHNICAL MANUAL · 2026 EDITION

CARBON FOOTPRINT

FOR PACKAGING AND CONTAINERS

USA 2026

A calculation and reduction manual
for American manufacturing



INCLUDES EXCEL CALCULATOR

11 sheets · live formulas · all 26 eGRID subregions

Prof. Ing. Iván H. Rodríguez B.
ENVAPACK.COM

Contents

The master list of factors

This list opens the book on purpose. It is the complete map of what has to be accounted for when calculating the carbon footprint of packaging in an American manufacturing company, and it sits here, before the introduction, for a practical reason: so you can see the real size of the job at once and decide where to enter.

Do not try to fill it in now. Walk through it, mark what you recognize, and keep reading. Every block corresponds to a part of the book, and by the end of Chapter 5 you will come back with the judgment to complete the first column. The chapters in parentheses tell you where each item is explained.

If you are auditing a calculation that already exists — yours or a supplier's — start at the end, with "The ten most frequent omissions."

The right-hand column says who normally holds the data: **Y** you, **S** your supplier, **P** a public source.

BLOCK 0 · Decisions taken before you calculate

(chapters 2, 3 and 4)

#	Item	What has to be defined	Source
0.1	**Object of the calculation**	**Product** footprint (kg CO2e per unit), not organization	Y
0.2	**Functional unit**	Function + quantity + protection or shelf life + number of uses	Y
0.3	**System boundary**	Cradle to gate / to customer / to grave. Recommended: **cradle to customer with end of life separate**	Y
0.4	**Cut-off rule and exclusions**	What is left out and the threshold applied	Y
0.5	**Standard**	ISO 14067, GHG Protocol Product, PAS 2050 — and whether third-party verification is required	Y

#	Item	What has to be defined	Source
0.6	**Data period**	The year or quarter every input belongs to	Y
0.7	**Gases and GWP set**	CO2, CH4, N2O as CO2e. **AR5 (EPA Hub) or AR6 (ISO 14067)** — state which	P

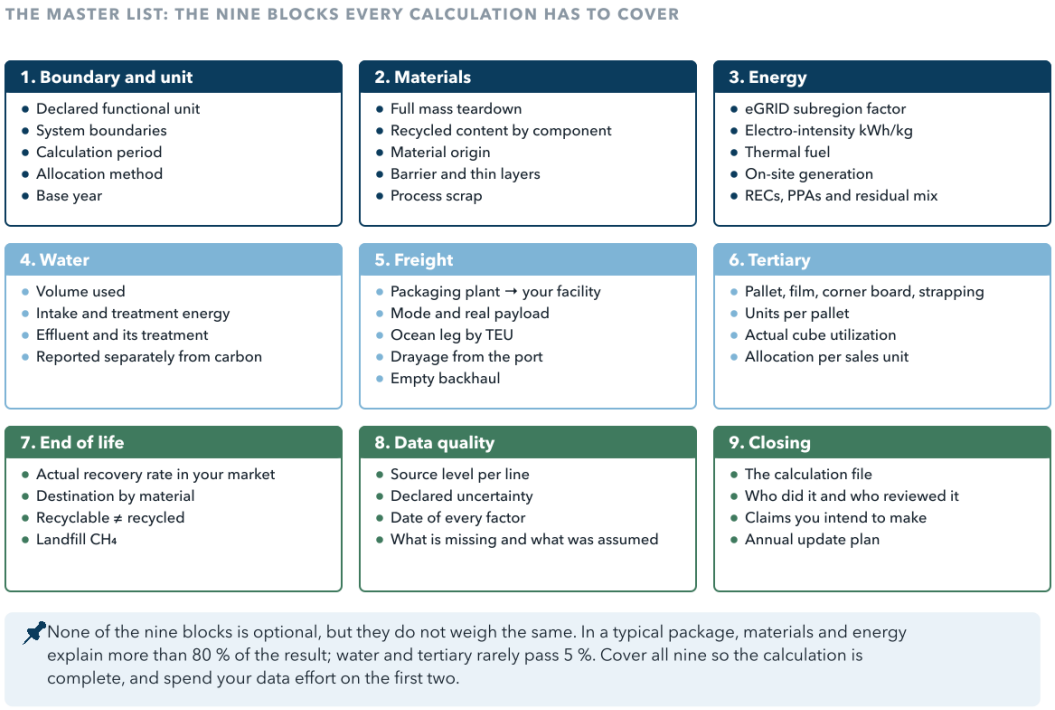


Figure 1. *The nine blocks every packaging footprint calculation has to cover.*

BLOCK 1 · Materials and mass

(chapters 5 and 10 to 19)

#	Item	Detail	Source
1.1	Complete teardown by component	One line per distinct material	Y
1.2	Actual mass per component	Average of at least 5 units, not the spec sheet	Y
1.3	Exact material identification	HDPE, not “plastic”; integrated route or	S

Introduction: the number you can no longer not have

For thirty years the conversation about packaging in American manufacturing had three axes: it has to protect, it has to look right, and it has to cost little. All three were measurable, all three were negotiable, and everybody knew how to argue about them.

Recently a fourth appeared: **how much it emits**. And it arrived through a door nobody was watching. It did not come in through the environmental department. It came in through procurement.

What changed

A consumer-products company that measures its emissions always finds the same thing, and it always surprises them: what they burn in their own plants is a minor share of their footprint. Most of it sits in what they buy. And within what they buy, packaging is a large line — and, importantly, an **easy one to identify**.

So the question travels down the chain. The brand asks its filler, the filler asks its packaging converter, the converter asks its resin or coil supplier. Each link asks the previous one for what it needs to close its own number, and somewhere along that chain, you.

What did not travel down the chain was the method. The question arrived complete; the tools to answer it did not.

Why a book specifically for the United States

There is no shortage of literature on life cycle assessment. Most of it has two problems for someone working in an American plant.

The first is that it is written for specialists. It assumes you already know what a functional unit is, that you can tell cut-off allocation from end-of-life credit, and that you have access to commercial databases costing more than the project.

The second is more particular, and it is the reason this book exists as a separate work rather than a translation: **most of what is published was calculated on somebody else's electricity, and the American answer to "which grid?" is not the one people assume.**

There is no single federal emission factor for electricity in this country. There is a national average, and it is not what you should use. There is a factor for your state, and it is not the right one either — because the grid follows transmission, not politics. The EPA publishes **eGRID subregions**, twenty-six of them, and recommends that level.

How much does that matter? Between the cleanest subregion and the dirtiest, **the factor varies by 6.4 times**. And New York State alone spans three subregions that differ by a factor of five: a plant upstate and a plant on Long Island operate under the same state law, on grids that have almost nothing in common.

For a material like primary aluminum, which consumes roughly fourteen kilowatt-hours per kilogram, that difference means nearly double the footprint from the same production line.

PART I · WHAT YOU ARE MEASURING

1. Why they are asking you for this number

The email lands on a Tuesday and it does not look like much. Your customer — the one who takes about a fifth of your volume, the one you have shipped to for six years — wants "the carbon footprint of the primary and secondary packaging, in kg CO2e per unit, before the quarter closes." Two lines. Nobody senior is copied.

You call your resin supplier. They do not have it. You call the corrugated plant and they send a certificate for recycled fiber and tell you that is the same thing. It is not. You check the film spec sheet and find gauge, density, tear resistance, and not one gram of CO2. In Thursday's meeting somebody suggests answering that the packaging "is recyclable."

That answer stopped working a while ago.

I have sat in that meeting more times than I can count, and it usually goes the same way: people argue about what to answer before anyone has worked out who is actually asking. Without that, every answer is the wrong one.

Three different pressures wearing the same coat

What feels like "everyone suddenly wants the same thing" is three separate forces, with different origins, deadlines and consequences. Confusing them is what makes companies over-invest on one front and get blindsided on another.

The first is your customer, and it arrives first. When a consumer-products company measures its emissions, it finds something uncomfortable: what it burns in its own plants is a minor share of its total. Most of it sits in what it buys. In GHG Protocol language that is **Scope 3, Category 1 — purchased goods and services**.

Your packaging is Category 1. That is why the question reaches you before it reaches anyone else, and why it comes from procurement rather than from an environmental group. Nobody is asking you for an ecological favor. They are closing an inventory they have to file.

The second is state law, and this is the American peculiarity. There is no single federal packaging rule. What binds is a growing patchwork of state statutes:

- **California SB 54**, and the extended producer responsibility laws of **Oregon, Colorado, Maine and Minnesota**, which make whoever puts packaging on the market responsible for its collection and recovery — and for knowing, to the pound, what they put out there.
- **California SB 253 and SB 261**, which push large companies into climate disclosure that reaches Scope 3, and therefore into asking their suppliers.
- **California SB 343**, which governs when you may print the chasing-arrows symbol at all.

Each has its own scope, thresholds and calendar. A company selling into forty states is not facing one obligation. It is facing several, on different clocks.

📌 **Key figure**

In most consumer-products companies, supply-chain emissions dwarf the emissions of their own operations. That asymmetry is the mechanical reason the question travels down to you. *(Exact share and source to be confirmed before publication.)*

Sort your own case before you do anything

Five minutes of classification changes what you do next:

- **Do you sell into California, Oregon, Colorado, Maine or Minnesota?** You have an EPR obligation, and it runs on material data — weight by material, by year. That inventory is most of the work of a footprint.
- **Is a customer asking for the number for their own reporting?** Commercial pressure. A well-documented calculation with a declared method is normally enough, as long as you say plainly what is primary and what is estimated.
- **Do you export to the European Union?** Then the EU packaging regulation and the carbon border mechanism are in play too, and they want traceable, primary data.
- **Do you want to print an environmental claim on the pack?** The highest-risk case in the United States, because of class-action exposure. It has its own chapter — 29. Print nothing until you read it.

🗺️ **How it changes by region**

Where you **sell** decides which law binds you. Where you **manufacture** decides your number. Two different maps, and people mix them constantly. A plant in upstate New York and a plant on Long Island are in the same state, follow the same state rules — and sit on grids that differ by a factor of five. Chapter 6 is about the second map, and it is the one nobody looks at.

🔎 **Ask your supplier**

This is the email that opens the chain upward. Send it today, before you know how to calculate anything:

“For a product carbon footprint exercise, we need the following for each material you supply: (1) the plant and ZIP code where it is produced, (2) the cradle-to-gate emission factor in kg CO2e per kg of material, (3) the standard and method it was calculated under, (4) whether it has been third-party verified, and (5) the actual recycled content percentage with its allocation method. If you do not have this yet, please tell us when you expect to.”

What comes back — and what does not — tells you more about your supply chain than any audit. Item 5 separates the suppliers who know from the ones who improvise. Item 1 is the one this book keeps coming back to.

What to do today

1. Send the email above to your three highest-volume suppliers. Do not wait until you finish this book.
2. Classify your case into one of the four categories above and write it down. If more than one applies, order them by deadline.

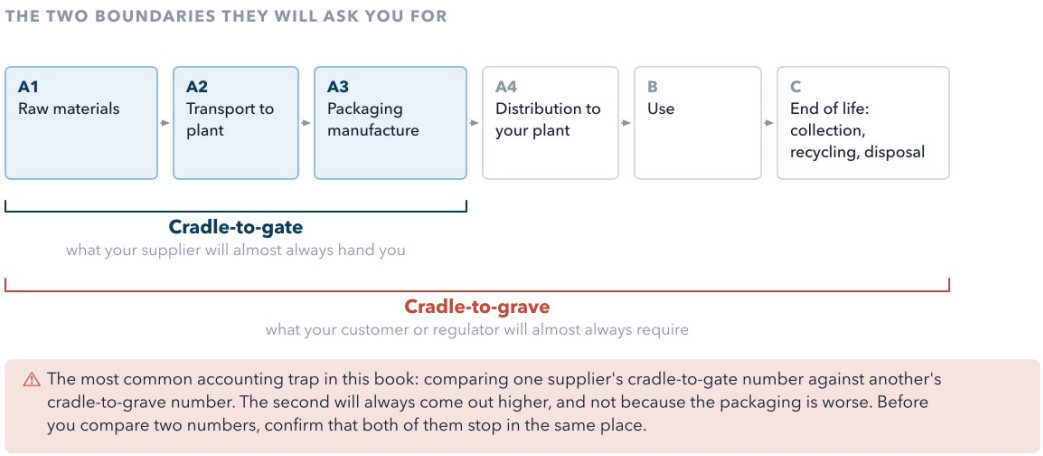


Figure 3. *The two boundaries you will be asked for, and why they cannot be compared.*

Product and organization are not the same thing

This is the confusion flagged in Chapter 1, and it deserves to be taken apart properly, because it wastes more time than any other.

The **organization footprint** answers “how much does my company emit?” It is measured in metric tons of CO2e per year, covers everything the company does, and is what shows up in a corporate sustainability report or a CDP submission. Its reference is the GHG Protocol Corporate Standard, or ISO 14064-1.

The **product footprint** answers “how much does this package emit?” It is measured in kg CO2e per unit, covers one specific value chain, and its reference is ISO 14067 or the GHG Protocol Product Standard.

You do not convert one into the other by dividing. If your plant emitted 4,000 metric tons last year and produced 40 million containers, the division gives 0.1 kg per container — and that number is false, or at best useless. It excludes the resin, which is by far the largest part of the container’s footprint, and it includes things that have nothing to do with the product, like the sales team’s travel. It looks like data. It is not.

Where your packaging sits in your customer’s books

The GHG Protocol splits a company’s emissions into three scopes. **Scope 1** is what the company burns directly: its boilers, its own trucks. **Scope 2** is the electricity it buys. **Scope 3** is everything else in its value chain, divided into fifteen categories.

Category 1 of Scope 3 is called “purchased goods and services.”

Your packaging is there, and nowhere else.

This has a practical consequence worth understanding: **your Scope 1 and 2 are your customer’s Scope 3.** What you burn in your plant and the electricity you buy become, the moment you invoice the package, a line in their inventory. That is why the question travels down

3. The functional unit

The supplier brings a twelve-slide deck and slide seven is the one that matters. A bar chart, two columns, restrained colors. Their material has a lower footprint than the one you use today. The gap is large, nearly double, and the vertical axis reads: *kg CO2e per kilogram of material*.

Everything on that slide is true. And it is useless for deciding anything.

Because you do not buy kilograms. You buy the ability to package one liter of product, deliver it intact, survive stacking in a warehouse and hold up through six months on a shelf. If delivering that takes three times more mass of the material that is cheap in carbon, the chart inverts — and nobody said so in the meeting.

This is the most important chapter in the book. Not because it is difficult, it is not, but because the error it prevents is invisible. A calculation with a badly defined functional unit looks impeccable: it has decimals, it has sources, it has charts. And it is wrong from the first line.

What a functional unit is

It is the written answer to a simple question: **what does this package have to do?**

Not what it is made of. What it does. And to be usable, the answer needs four things:

- **The function.** Contain, protect, dispense, inform, transport.
- **The quantity.** One liter, 16 ounces, twelve units.
- **The quality or service level.** Product arrives without leakage, with the oxygen barrier the shelf life requires, surviving three tiers of stacking.
- **The duration.** Twelve months of shelf life, or an 800-mile haul, or twenty return trips.

A properly written functional unit looks like this:

> *Package, protect and deliver 1 liter of tomato sauce to the consumer in the Southeast, with 12 months of shelf life, surviving three tiers of stacking and 400 miles of truck freight.*

It is deliberately long. Every element you strip out is a door through which a rigged comparison walks in.

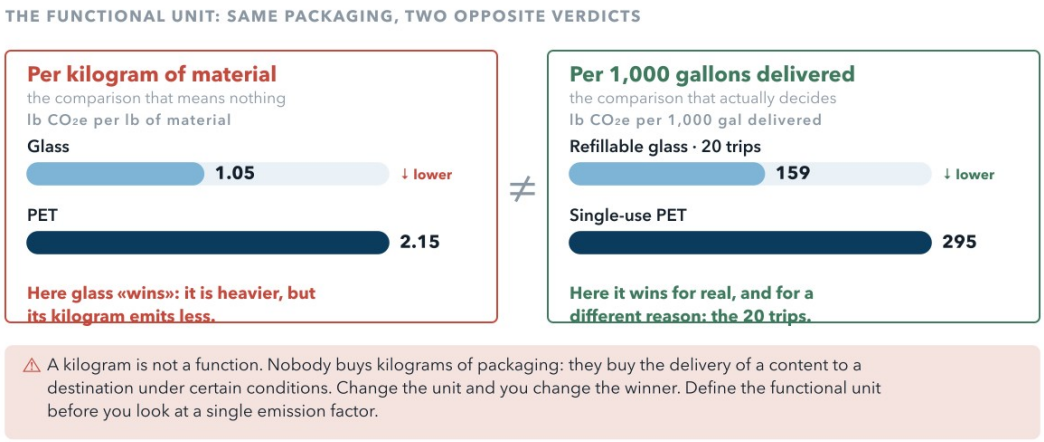


Figure 4. *The functional unit: same packaging, two opposite verdicts.*

The example worth seeing once

Glass against PET, for one liter. Factors are the reference values from Annex B, and to isolate the effect of the unit the exercise assumes the same plant and the same grid.

Per kilogram of material, glass looks like the comfortable winner: around 1.20 kg CO2e per kg, against 2.70 for virgin PET. More than double, in glass's favor.

Now the same comparison by function. A one-liter glass bottle weighs on the order of 400 grams. A PET bottle for the same liter weighs about 30.

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Glass: 0.400 kg x 1.20 = 0.48 kg CO2e per liter packaged
PET:   0.030 kg x 2.70 = 0.081 kg CO2e per liter packaged
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Glass, which was winning by more than double, now loses by nearly six times. Not one emission factor changed. The question changed.

And that is still only half the story, because glass is heavy. That container travels, and in Chapter 20 you will see that 400 grams moving 400 miles is not the same thing as 30. The gap widens.

But before you close the book convinced that plastic always wins, look at the other side: if that glass bottle is **refillable** and makes twenty trips, its manufacturing footprint is spread across twenty uses.

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Refillable glass: 0.48 / 20 trips = 0.024 kg CO2e per liter packaged
                  (plus washing, which uses hot water and is not
trivial)
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And it wins again. Three different answers, none of them dishonest, depending on how the functional unit is written. Whoever defines it defines the result.

> ⚠ **Accounting trap**
>
> Comparing materials per kilogram is the most common error in this field and the easiest to spot: if a chart's axis says "per kg of material" and the conclusion is about