The Cobeal Combustion Workbench

An emissions-accounting engine for waste-to-value project systems

DOCUMENT
Preprint · Technical

SERIES
Waste-to-Value Stack

MODULE
01 · Combustion

ABSTRACT

Module 01 · Emissions Accounting Engine

The Cobeal Combustion Workbench is the first emissions-accounting module in a modular waste-to-value project system. It receives facility-level combustion inputs, classifies them by fuel and activity category, converts fuel consumption into energy, applies emission factors, calculates gross and net emissions, and produces structured data for integration into displacement, economics, MRV, and reporting modules.

CORE CALCULATION CHAIN

THE FOUR-STEP CHAIN

Fuel quantity × net calorific value = energy consumed

Energy consumed × emission factor = gas-specific emissions

CO_2 + CH_4 (as CO_2e) + N_2O (as CO_2e) = gross CO_2e

Gross CO_2e − captured CO_2 = net CO_2e

1 System Definition

The Cobeal Combustion Workbench is a structured emissions-accounting engine for fuel combustion activities. It converts facility-level fuel consumption into standardized energy and emissions outputs.

The module records each combustion activity as an inventory entry, applies fuel-specific calculation factors, classifies the activity by sector and fuel class, and generates gross and net carbon dioxide equivalent emissions.

2 Functional Framework

The workbench performs four core functions:

01 Records fuel-use activity by entry, period, fuel, unit, and category.

02 Converts physical fuel consumption into energy consumed.

03 Applies emission factors for carbon dioxide, methane, and nitrous oxide.

04 Produces gross emissions, captured carbon dioxide, and net fossil carbon dioxide equivalent.

3 Calculation Logic

The calculation chain is:

$$\textit{Fuel quantity} \times \textit{net calorific value} = \textit{energy consumed}$$

$$\textit{Energy consumed} \times \textit{emission factor} = \textit{gas-specific emissions}$$

$$CO_2 + CH_4\ (CO_2e) + N_2O\ (CO_2e) = \textit{gross } CO_2e$$

$$\textit{Gross } CO_2e - \textit{captured } CO_2 = \textit{net } CO_2e$$

The live calculation panel displays the result immediately as the user enters or modifies the data.

4 Architecture

The system has three operating layers.

I. INVENTORY LAYER

- entry label
- reporting period
- IPCC activity category
- fuel type
- energy consumed
- gross CO_2e
- net CO_2e

II. ENTRY LAYER

- metadata
- fuel selection
- quantity consumed
- units
- net calorific value
- emission factors
- captured CO_2
- notes and references

III. CALCULATION LAYER

- energy consumed
- CO_2 emissions
- CH_4 emissions
- N_2O emissions
- total gross CO_2e
- captured CO_2
- net fossil CO_2e

5 Data Model & Classification Logic

Each entry is structured around five data groups.

Metadata

The metadata defines the identity and timing of the entry: entry label, period start, period end, IPCC activity category.

Fuel Data

The fuel data defines the physical combustion source: fuel type, fuel class, quantity consumed, unit, net calorific value.

Emission Factor Data

The emission factor data defines the conversion from energy to emissions: CO_2, CH_4, and N_2O emission factors.

Accounting Data

The accounting data defines adjustments at the source level: captured CO_2, gross emissions, net fossil CO_2e.

Reference Data

The reference data preserves context: calculation notes, source references, methodology notes, assumptions.

6 User Inputs & System Outputs

Inputs are captured at entry time. Outputs are rendered live and persisted to the inventory ledger.

USER INPUTS

- fuel consumed
- reporting period
- activity category
- fuel type
- fossil or biomass classification
- physical unit
- quantity consumed
- calorific value
- CO_2 factor
- CH_4 factor
- N_2O factor
- captured CO_2
- notes and references

SYSTEM OUTPUTS

- energy consumed in terajoules
- carbon dioxide emissions
- methane emissions
- nitrous oxide emissions
- gross CO_2e
- captured CO_2
- net fossil CO_2e
- entry-level inventory records
- sortable combustion ledger
- category-level combustion data

7 Role in Waste-to-Value Systems

In a waste-to-value system, the Combustion Workbench provides the fuel-combustion accounting layer. It can quantify existing facility fuel use before a project is introduced, and also quantify fuel use after a project replaces part or all of the original fuel with biogas, biomethane, biomass, recovered heat, renewable electricity, or other substitute energy pathways.

Worked Scenarios

WHEY-TO-BIOGAS

The system records natural gas used by the dairy plant boiler, calculates the baseline fossil emissions, then records the post-project biogas or biomethane combustion profile.

MANURE-TO-BIOGAS

The system calculates fossil-fuel displacement when recovered methane replaces diesel, LPG, natural gas, or fuel oil.

BIOMASS OR RECOVERED FUEL

The module separates fossil combustion from biomass combustion while preserving total energy and emissions data.

8 Integration Pathway

The Combustion Workbench is Module 01 of a larger waste-to-value application stack.

MODULE	NAME	FUNCTION
01	**Combustion**	Fuel use, energy consumed, combustion emissions.
02	**Waste Conversion**	Feedstock intake; biological or thermal conversion; biogas, biomethane, digestate, char, oil, heat, electricity.
03	**Displacement**	Links project energy output to displaced fossil-fuel use.

04	**Project Economics**	CAPEX, OPEX, energy savings, avoided disposal, carbon revenue, payback, financing metrics.
05	**MRV**	Monitoring, reporting, verification; baseline, project, leakage, audit trail.
06	**Reporting**	Lender, investor, internal management, and project-development reports.

9 Preprint Summary

The Cobeal Combustion Workbench is the first emissions-accounting module in a modular waste-to-value project system. It receives facility-level combustion inputs, classifies them by fuel and activity category, converts fuel consumption into energy, applies emission factors, calculates gross and net emissions, and produces structured data for integration into displacement, economics, MRV, and reporting modules.

COLOPHON

This document is a preprint technical report describing Module 01 of the Cobeal waste-to-value stack. It is intended for internal review, partner discussion, and pre-feasibility screening. It is not a bankability study or a project finance prospectus.