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GECO 2.2

WP2 – UPGRADING OF THE GECO2 PROJECT TOOLS

D.2.2.1 – Calculators Upgrading

Activity 2.2 Ugrading of project calculators

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ABSTRACT

This deliverable presents the activities carried out to upgrade the calculation component integrated within the **GECO 2.2** platform, available at **https://geco2.iamb.it**. The work focused on strengthening the technical infrastructure supporting the execution of the Carbon Calculator rather than modifying its scientific methodology. The implemented improvements concern the complete calculation lifecycle, including data preparation, validation, normalisation, execution management, result persistence and traceability.

The document describes the architecture adopted to integrate the external calculation engine into the application workflow, highlighting the services responsible for generating calculation inputs, managing isolated execution environments, importing results and preserving processing evidence. Particular attention is devoted to data quality assurance through validation procedures, consistency checks and dataset normalisation before execution.

The upgrading activities also introduced mechanisms for auditability and integrity verification based on cryptographic hashing and traceability records, ensuring that each calculation can be reproduced and verified within a controlled operational environment.

Overall, the implemented solution provides a more robust, maintainable and transparent calculation workflow, improving the reliability of the integration between the GECO 2.2 platform and the external Carbon Calculator while preserving the scientific integrity of the calculation model.

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D.2.2.1 - CALCULATORS UPGRADING

Executive Summary

This deliverable presents the activities carried out to upgrade the calculation component integrated within GECO 2.2. The intervention did not entail a rewrite of the engine's scientific model; instead, it strengthened the technical environment responsible for supplying the engine with data, triggering its execution and preserving the resulting outputs. From this perspective, the calculator is treated as an external engine integrated into a broader application pipeline governed by the GECO platform.

The work mainly addressed the workflow leading from the data collected through the questionnaire to the generation of the carbon accounting result: input preparation, consistency checks, normalisation, job execution, output acquisition and processing traceability.

The upgraded calculation services are deployed within the GECO 2.2 (**https://geco2.iamb.it**), where authorised users can access the complete workflow for data collection, calculation execution and result consultation.

Objective and Scope

The objective of Deliverable D.2.2.1 is to describe the activities actually carried out to make the calculator operational within the platform. The scope is intentionally limited to the calculation component and the technical services supporting it; workflow

management, dashboards and APIs are referred to only where necessary to explain how the engine is prepared or invoked.

- integration of the CPP Calculator as an external executable;
- generation and validation of calculation input data;
- normalisation of datasets originating from surveys and application tables;
- execution of the engine in isolated job directories;
- import of results and preservation of supporting evidence;
- hashing and audit trail of the calculation lifecycle.

The upgraded calculator operates as part of the GECO 2.2 platform, accessible through **https://geco2.iamb.it**, which provides the operational environment for questionnaire management, calculation execution and result visualisation.

In other words, the present deliverable assesses the quality of the infrastructure supporting the calculation rather than any change to the mathematical model itself. This distinction is important, as it prevents modifications relating to the integration software and its operational governance from being incorrectly attributed to the scientific calculation model.

Technical Architecture of the Calculation Process

The calculation component is embedded in a chain of services that prepare the data, launch the external binary and collect the results. Within the project codebase, this logic is mainly implemented in the services dedicated to calculation and execution queue management: `SellerCalculatorService` and `BuyerCalculatorService` orchestrate the run, while the source data are obtained from the survey tables and from the sanitised outputs generated following validation.

At the operational level, each calculation job is executed in a dedicated directory under `carbon_jobs`. This keeps execution contexts separate, reduces side effects and facilitates diagnosis in the event of an error.

Element	Function	Technical reference
External engine	Performs the scientific calculation	CPP Calculator invoked as an executable binary
Orchestration service	Prepares the input and starts the job	SellerCalculatorService / BuyerCalculatorService
Input data	Collects and normalises the values	survey_csv_row, buyer_survey_csv_row
Result persistence	Stores outputs and processing status	application database and audit records

Input Preparation

Before the calculation is performed, the system builds a consistent input from the survey data. This stage is essential because the external engine does not operate directly on the form or on the domain tables, but on a data row that has already been transformed into

the expected format. The project therefore placed particular emphasis on the quality of this preparation stage, reducing the risk of non-reproducible executions.

Questionnaire data, obtained in JSON format, are normalised, sanitised and validated before being converted into a CSV row, stored in a file and persisted in the database.

The main functionalities include:

- persistence of the raw survey JSON for subsequent checks;
- generation of the CSV row or normalised array;
- association of the data with the relevant field or company;
- preparing the set of files required for the calculator job.

These steps are not ancillary details: they represent the point at which data quality determines the quality of the final result. If the input is inconsistent, the external engine may produce an output that is formally valid but operationally unreliable.

Validation and Normalisation

Validation was one of the most important areas of work. Before executing the calculation, the system checks questionnaire completeness, field consistency, alignment with the CSV mappings and the presence of required values. Where necessary, the data are sanitised or recalibrated according to a defined set of rules.

For both sellers and buyers, the workflow moves from a pre-analysis stage that reports errors and warnings separately to the subsequent formal validation performed before

the final calculation. This makes it possible to clearly distinguish data-related issues from calculation-related issues.

The main functionalities include:

- verification of the presence of mandatory fields;
- verification of consistency rules between values and units of measurement;
- identification of blocking errors as distinct from non-blocking warnings;
- generation of a normalised representation of the dataset;
- alignment between a completed survey and a processable status.

The outcome of this stage is a more robust pipeline: the calculator is launched only after the data have been filtered and made compatible with the external engine. In this respect, the upgrading activities mainly concern error prevention and the transparency of the process.

Execution of the External Engine

The CPP Calculator is launched through dedicated services that create the job folder, copy the input templates and invoke the external executable. `SellerCalculatorService` and `BuyerCalculatorService` manage this sequence in a similar manner, differing only in the source of the initial data.

Each calculation is executed within an isolated working directory. Each run operates on its own files, uses a dedicated working directory and subsequently reconciles the output with the corresponding application record. This approach prevents interference between consecutive executions and simplifies the inspection of intermediate artefacts.

For the purposes of the present deliverable, it is important to note that the end user does not interact with the calculator binary directly; rather, the user sees the effects of its execution through the results stored in the platform. For this reason, the process is described as a set of coordinated services rather than as a single system call.

Output Import and Persistence

Once the run has been completed, the outputs are imported into the application database and made available to the consultation component. At this stage, the focus is no longer on launching the calculation but on its information outputs: the result, process status, any intermediate indicators and references to the executed job.

The main functionalities include:

- storage of the engine results in the relevant application fields;
- updating of processing and confirmation statuses;
- preservation of intermediate data for ex-post verification;
- linking the technical processing stage with the data available for consultation.

This persistence mechanism is particularly important because it makes it possible to reconstruct the context of each processing operation without having to rerun the calculation. In practical terms, the system separates the execution phase from the consultation phase while preserving the information link between them.

Traceability, Hashing and Audit

To strengthen the calculation lifecycle, the project introduced traceability mechanisms based on cryptographic hashes and an audit trail. The underlying principle is straightforward: each input and output can be associated with a verifiable payload, allowing the calculation result to be inspected and compared over time.

The audit records refer to company, field, budget and user data and are associated with hashes of the serialised content. In this way, the system preserves not only the numerical result but also the technical accountability chain that generated it.

The main functionalities include:

- hashing of input data to detect unexpected changes;
- recording of the execution and of the user responsible for the process;
- alignment between the job, the application record and the final result;
- support for integrity checks and internal audits.

This aspect is essential, as it demonstrates that the value produced by the calculation derives from a controlled and verifiable workflow.

Results of the Upgrading Activities

The upgrading of the calculator resulted in a more reliable environment that is less vulnerable to data inconsistencies. Pre-validation functions, job separation and output persistence made the overall process more transparent and more suitable for repeated use across a large number of fields or companies.

Area	Result achieved

Data preparation	More consistent inputs compatible with the external engine
Execution	Isolated runs that are improved diagnosability
Persistence	Results available without rerunning the calculation
Traceability	Improved verifiability of inputs, outputs and jobs

The overall result is not a change to the calculator algorithm, but rather a more mature integration of the calculator into the GECO 2.2 application lifecycle.

Conclusions

The present deliverable therefore describes the calculator as an external component that is prepared, executed and controlled by the GECO platform. The references to the `SellerCalculatorService` and `BuyerCalculatorService` classes are intended to clarify how the engine was integrated into the project, not to redefine its calculation model.

The upgraded calculation workflow is currently deployed within the GECO 2.2 platform (**https://geco2.iamb.it**), where it supports the complete lifecycle of carbon assessment, from data acquisition to calculation execution and result management. The implemented architecture also provides the foundation for integrating future calculation

engines while preserving the separation between scientific methodologies and application services.