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AutoECoMo: A Software Framework for Automated Energy Community Modeling with Built-In CO_2 Emission Analysis

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Abstract:

The **Auto**matic **E**nergy **Co**mmunity **Mo**deler (AutoECoMo) is a software framework designed to automate the modeling and simulation of Energy Communities operating under collective self-consumption schemes. The tool is implemented in MATLAB and Simulink and converts a high-level community specification into a fully executable, modular simulation model without manual block level construction. AutoECoMo imports metered or synthetic demand and generation profiles from spreadsheets, assigns participants as consumers or prosumers, and encodes community parameters such as self-consumption factors, contracted limits, and energy sharing coefficients. From this specification, the framework automatically generates a structured Simulink model that integrates member level components, a data management layer, and an allocation layer implementing configurable energy sharing rules. The simulation reproduces intra community exchanges and interactions with the external grid, enabling rapid scenario analysis across different participation structures and operational configurations. This paper extends AutoECoMo with a built in CO_2 emissions analysis module that quantifies operational emissions attributable to community operation using traceable energy flow accounting. At each simulation time step, electricity consumption is decomposed by supply origin, distinguishing grid import and locally produced photovoltaic energy. These energy flows are mapped to source specific emissions intensity factors in grams of CO_2 per kilowatt-hour to compute total operational emissions, emissions intensity, and avoided emissions relative to a selected reference scenario. The module also reports emissions aware key performance indicators alongside standard community metrics, including self-consumption, self-sufficiency, surplus exports, and grid import dependency, supporting joint interpretation of technical, economic, and environmental outcomes. An energy community case study in Spain is employed to demonstrate the tool's capabilities and the added value of integrated emissions analytics. Results illustrate how AutoECoMo enables consistent and reproducible comparisons of allocation strategies and flexibility options while providing transparent CO_2 accounting suitable for research, planning, and policy evaluation. The framework is designed to be extensible and transferable to regulatory contexts beyond Spain, offering a practical benchmark environment for the systematic assessment of energy community operation with environmental performance as a first-class output.

Keywords:

Energy communities modeling, benchmark modeling framework, Software Tool, CO_2 emissions analysis, collective self-consumption.

1. Introduction

Energy Communities have emerged as a relevant organizational and technical mechanism for advancing the energy transition, since they enable end users to move from passive consumption to more active roles based on local generation, self-consumption, storage, and energy exchange within a collective structure [1]. Within this broader context, Collective Self-Consumption (CSC) has become a particularly important implementation pathway in the European countries, where the regulatory framework has opened practical opportunities for shared photovoltaic (PV) deployment and coordinated local use of distributed renewable generation [2]. Under

CSC schemes, the way locally produced energy is assigned among participants is not a secondary detail, but a central operational decision that affects economic outcomes, individual incentives, and the overall attractiveness of participation [3]. Consequently, the evaluation of CSC energy communities requires modeling environments able to represent not only demand and generation profiles, but also the operational consequences of alternative allocation coefficients or allocation strategies under realistic community configurations. From a research perspective, the analysis of Energy Communities is inherently multidisciplinary, since it involves the interaction of energy system modeling, operational objectives, business logic, and regulatory constraints [4].

Recent reviews have also emphasized the importance of open data, models, and software tools to accelerate the design and operation of energy communities, while pointing out that practical implementation is often hindered by fragmented workflows and limited reproducibility across studies [5], [6]. In parallel, recent tool-oriented developments have proposed configurable environments for Renewable Energy Communities that support scenario generation and environmental assessment, showing the value of accessible and structured computational frameworks for community analysis [7]. Besides technical and economic indicators, environmental performance is becoming an increasingly relevant assessment dimension. Recent studies have shown that community composition, load configuration, and energy management decisions can substantially affect costs, emissions, and grid exchanges in Energy Communities [8]. Likewise, the integration of technologies such as PV generation, electric loads, and community storage modifies internal energy flows and can lead to different environmental outcomes depending on how the community is operated [9], [10]. This makes transparent and traceable emissions accounting especially valuable when comparing alternative allocation settings or flexibility options.

In this context, this paper presents the Automatic Energy Community Modeler (AutoECoMo), a MATLAB/Simulink-based software framework for the automated modeling and simulation of Energy Communities operating under CSC schemes. The tool converts a high-level community specification into a modular and executable simulation model without requiring manual block-level construction. Building on this framework, the paper introduces a built-in CO_2 emissions analysis module that quantifies operational emissions from source-resolved electricity flows, distinguishing grid imports and locally generated PV energy. In this way, AutoECoMo enables consistent and reproducible comparisons of alternative allocation coefficients or allocation strategies by jointly reporting technical, operational, and environmental indicators within the same simulation workflow.

1.1 Contributions

The main contributions of this work are:

1. An automated software framework for CSC community simulation, capable of transforming structured user inputs into a modular and executable MATLAB/Simulink model of an Energy Community.
2. An integrated CO_2 emissions analysis module, based on traceable energy-flow accounting, that computes operational emissions, emissions intensity, and avoided emissions alongside standard community performance indicators.
3. A scenario-based demonstration of tool capabilities, showing how AutoECoMo can be used to compare alternative allocation coefficients or allocation strategies and interpret their impact from both operational and environmental perspectives.

The rest of the paper is organized as follows. Section 2 presents the AutoECoMo framework, including its purpose, architecture, and automated workflow. Section 3 describes the implementation of the CSC simulation model and the representation of configurable allocation rules. Section 4 introduces the CO_2 emissions analysis module and the environmental indicators computed by the tool. Section 5 presents the demonstration scenarios used to evaluate the framework. Finally, Section 6 summarizes the main conclusions and outlines future developments of the framework.

2. AutoECoMo Software Framework

The AutoECoMo is a MATLAB/Simulink-based software framework designed to automate the modeling and simulation of energy communities operating under CSC schemes. The tool transforms a high-level community specification into a modular and executable simulation model, avoiding manual block-level construction and reducing the effort required to evaluate alternative community configurations. In this way, AutoECoMo provides a reproducible environment for the analysis of community operation under different participant structures, demand and generation profiles, and allocation settings.

The framework is intended for electricity-focused Energy Communities composed of consumers and prosumers, and it supports the use of both metered and synthetic time-series data. Community information is introduced through structured spreadsheet templates containing demand and, when applicable, PV generation data, together with participant roles and contractual parameters. These inputs are processed by the tool to automatically create a Simulink model that reproduces community energy exchanges, including internal allocation of locally generated energy, grid imports, and surplus exports. In its current version, the framework follows a CSC formulation aligned with the Spanish context, while preserving a modular structure that facilitates future adaptation to other regulatory settings.

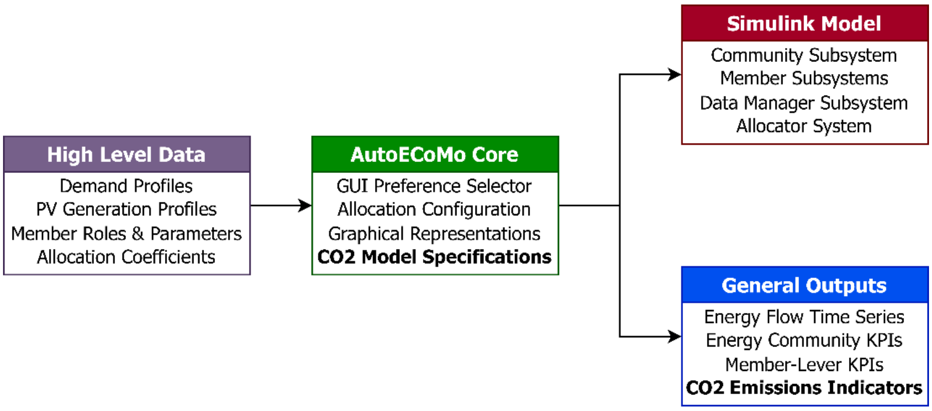


Figure 1. *Input-output workflow diagram of AutoECoMo software tool.*

From a software perspective, AutoECoMo is organized around three main functional layers. The first is the data and input layer, responsible for importing and validating time-series profiles and participant information. The second is the model generation layer, which programmatically builds the community model in Simulink by creating the required member-level subsystems, signal-routing elements, and aggregation blocks. The third is the simulation and post-processing layer, where the generated model is executed and the resulting time-series are converted into community-level and member-level indicators. This layered organization improves readability, extensibility, and reproducibility, while allowing new functionalities such as storage modeling or environmental assessment modules to be added without altering the overall workflow. Fig. 1 illustrates this input-output workflow, showing how structured community inputs are transformed into an executable Simulink model and, subsequently, into technical and environmental outputs.

A central feature of AutoECoMo is its GUI-driven workflow, which enables users to move from data loading to simulation and KPI computation in a structured sequence. First, member data is imported from spreadsheets, and the simulation horizon is selected from the available timestamps. Next, the allocation settings are defined through user-provided allocation coefficients, either static or time-varying. The tool then automatically generates the corresponding Simulink model and runs the simulation over the selected period. Finally, post-processing routines compute standard community indicators such as self-consumption, self-sufficiency, surplus exports, and grid import dependence, which constitute the technical basis for the additional CO_2 emissions analysis introduced in this paper. Overall, AutoECoMo is conceived as an automated benchmark environment for CSC-based Energy Communities. Its main added value lies in combining model generation, simulation, and indicator computation within a unified workflow, so that scenario comparisons can be performed consistently and transparently from the same input structure.

3. Automatic Modeling of CSC Energy Communities

While Section 2 introduced AutoECoMo from a software and workflow perspective, this section focuses on the way a CSC Energy Community is formally represented and automatically instantiated in the generated simulation model. The aim is to show how the community specifications provided by the user is translated into a structured set of signals, subsystems, and allocation routines that reproduce the logic of the CSC scheme.

AutoECoMo models an Energy Community as a set of N members observed over a discrete time horizon $\mathcal{T}$. Each member is characterized by its role within the community, namely **consumer** or **prosumer**, together with the corresponding time-series data and contractual parameters. In the current implementation, all members are associated with an electrical demand profile, while prosumers additionally include a local PV generation profile. The community specification is completed with the CSC parameters required to determine how locally generated energy is assigned among members, including the self-consumption factor α and the vector of allocation coefficients $\boldsymbol{\beta}(t)$.

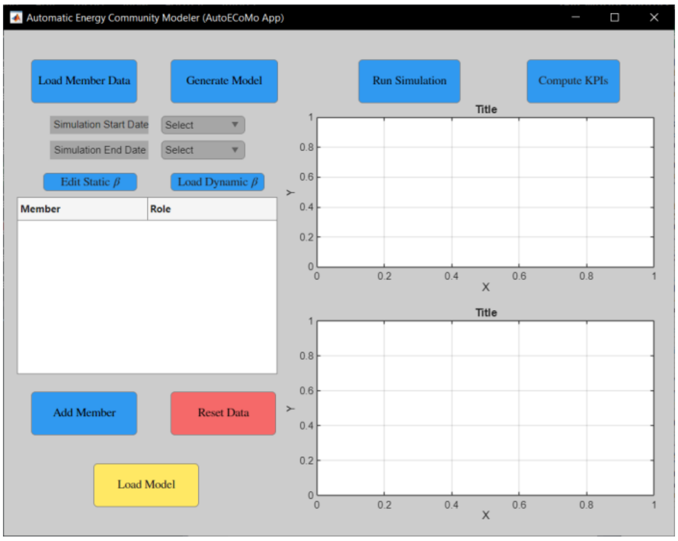


Figure 2. *AutoECoMo tool graphical interface.*

This information is loaded into the tool through structured spreadsheet templates and configured through the graphical interface shown in Fig. 2. From the modeling viewpoint, the role of the interface is not merely operational: it defines the set of member entities to be represented, the simulation horizon to be evaluated, and the allocation configuration to be applied. In this way, the user-provided specification becomes a high-level description from which the executable CSC model is automatically generated.

3.1 CSC Operational Model

The current version of AutoECoMo implements the CSC formulation adopted in the Spanish framework. Let $TEG(t)$ denote the total electricity generated by the community at time t, and let α be the fraction of that generation designated for CSC. The energy available for CSC is given by:

$$G(t) = TEG(t)\alpha \qquad (1)$$

This quantity represents the portion of local generation that is internally available for virtual allocation among the community members, while the remaining share is treated according to the applicable surplus mechanism. The distribution of $G(t)$ among the members is governed by the allocation coefficients $\beta_n(t)$ collected in the vector $\boldsymbol{\beta}(t)$. The amount of CSC energy assigned to member n at time t is defined by:

$$D_n(t) = \beta_n(t)G(t) \qquad (2)$$

subject to the conservation condition:

$$\sum_{n \in N} \beta_n(t) = 1 \qquad (3)$$

This formulation allows both static and time-varying allocation coefficients to be considered. Static coefficients reproduce the most common contractual arrangement currently found in operational CSC schemes, whereas time-varying coefficients allow the framework to evaluate more flexible allocation settings. When several prosumers or shared generation units are present, the same logic is applied to each contribution and aggregated at member level before the final allocation results are processed. At community level, the simulated CSC operation yields the core energy-balance quantities used throughout the framework. Let $L_n(t)$ denote the electrical demand of member n and let $L(t)$ be the total community demand. The self-consumed energy, grid imports, and grid exports at time $t$are then obtained as:

$$SC(t) = \min\{G(t), L(t)\} \qquad (4)$$

$$I(t) = \max\{L(t) - G(t), 0\} \qquad (5)$$

$$E(t) = \max\{G(t) - L(t), 0\} \qquad (6)$$

These expressions provide the energy-accounting backbone of the automatically generated model and later serve as the basis for both KPI computation and CO_2 emissions analysis.

3.2 Automatic Simulink Instantiation

Once the community specification has been defined, AutoECoMo automatically constructs the corresponding Simulink representation. This instantiation is based on a modular structure that separates member-level signal generation, data aggregation, and CSC allocation. At the lowest level, each participant is represented by a role-specific subsystem, as illustrated in Fig. 3. A consumer subsystem provides the member demand signal, whereas a prosumer subsystem provides demand, local generation, and the associated α signal required to determine the fraction of generated energy designated for CSC. This role-based representation keeps the individual member models simple while preserving the distinction between consumption-only and generation-capable participants.

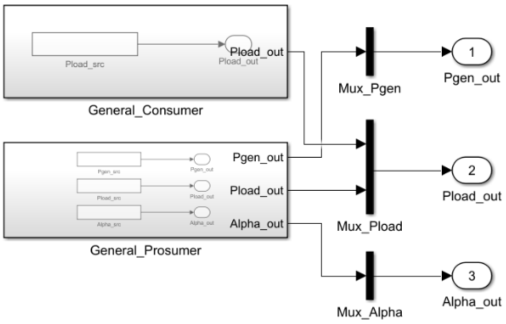


Figure 3. *AutoECoMo representative member subsystems.*

The outputs of all member subsystems are grouped within the community block and passed to the general model shown in Fig. 4. In this model, the **Data Manager** block receives the raw member-level signals, aligns them, reshapes them into a common format, and prepares them for community-level processing. In parallel, the allocation coefficients are introduced as a dedicated input so that the allocation layer can be modified independently of the underlying demand and generation data. The **Allocator** block then implements the CSC allocation logic described above and produces the main time-series output required for analysis, including allocated energy, effectively self-consumed energy, excess generation, and residual unserved demand.

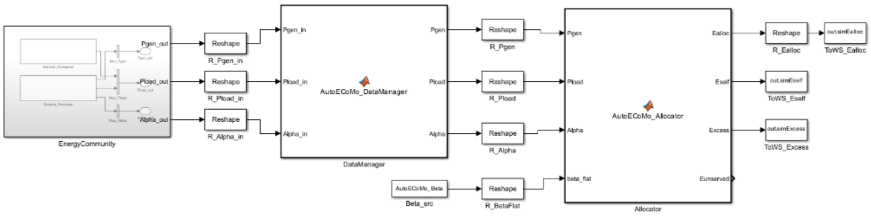


Figure 4. *General automatic generated Simulink model.*

3.3 Simulation Outputs and Standard KPIs

After simulation, the generated time series are post-processed to compute standard technical indicators at both community and member level. Over the time horizon, the aggregated self-consumed energy, imported energy, and exported energy are used to derive the self-consumption ratio (SCR) and self-sufficiency ratio (SSR), defined as:

$$SCR = \frac{\sum_{t \epsilon T} SC(t)}{\sum_{t \epsilon T} G(t)} \qquad (7)$$

$$SSR = \frac{\sum_{t \epsilon T} SC(t)}{\sum_{t \epsilon T} L(t)} \qquad (8)$$

In the current implementation, these outputs are mainly energy-based technical indicators, which are sufficient to characterize the operational behavior of the modeled community and to compare alternative allocation settings. Moreover, because they are derived from explicit time-series accounting rather than from aggregated assumptions, they provide the basis for the environmental calculations introduced in the next section.

4. Built-in CO_2 Emissions Analysis Module

The technical outputs produced by the CSC simulation provide the basis for an additional environmental assessment layer in AutoECoMo. In the current version of the tool, operational CO_2 emissions are quantified by combining the simulated energy flows with source-specific emissions factors defined by the user. This allows the framework to evaluate not only how much energy is imported, self-consumed, or exported, but also the carbon implications of the supply mix used to satisfy the community demand under a given allocation setting. The implemented approach follows source-based accounting logic. Rather than assigning a single average carbon factor to total community consumption, AutoECoMo distinguishes the origin of the electricity that effectively serves the demand and attributes emissions according to that origin. In this way, differences in environmental performance between scenarios arise from differences in the simulated energy flows and their source composition, not from changes in the emissions factors themselves.

4.1 Operational CO_2 Emissions Model

The CO_2 module is built on the source-resolved energy flows obtained from the simulation results. At each time step, AutoECoMo identifies the portion of the served demand supplied by the grid and the portion supplied by PV generation. In the notation used by the implementation, these quantities are denoted by $E_g(t)$ and $E_p(t)$, respectively. Based on them, the hourly operational CO2 emissions are computed as:

$$TE(t) = E_g(t)\gamma^g + E_p(t)\gamma^p \qquad (9)$$

In where γ^g and γ^p are the CO2 emissions factors for the grid and PV energy indicated by the user in AutoECoMo, then the total community operational emissions over the simulation horizon are:

$$CTE = \sum_{t \in T} TE(t) \qquad (10)$$

This formulation is consistent with the source-based accounting perspective adopted in the tool. Since the community demand can be served by a combination of grid imports and locally allocated PV energy, the total emissions result from the weighted contribution of each source according to its corresponding emissions factor. At member level, the same logic is applied individually. Let $E_g^n(t)$and $E_p^n(t)$denote the grid-supplied and PV-supplied energy attributed to member n at time t by the equivalent equations 9 and 10 the member level emissions can be computed.

4.2 CO2 Emissions-based Indicators

Based on the previous formulation, AutoECoMo reports a set of environmental indicators alongside the technical KPIs of the CSC simulation. The main global indicator is the total operational CO2 emissions, CTE, expressed in gCO2 and also reported in kgCO2. In addition, the tool computes the separate contributions of the grid and the PV source to total emissions, which helps interpret whether a given scenario is dominated by external grid dependence or by local renewable use.

To complement the absolute emissions results, the framework also computes an emissions intensity factor, defined as the operational emissions per unit of electricity demand over the horizon:

$$IF = \frac{CTE}{\sum_{t \in T} E_L(t)} \qquad (11)$$

where $E_L(t)$denotes the total community electricity demand at time t. This indicator, expressed in gCO2/kWh, is useful for comparing scenarios with different demand levels or different energy supply mixes on a normalized basis. At participant level, AutoECoMo reports the CO2 emissions attributable to each member, both in grams and kilograms, together with a member-specific emissions intensity. This makes it possible to assess whether a given allocation setting improves the environmental performance of the community while also revealing how the associated emissions burden is distributed across members.

In addition to these CO2-specific indicators, the module retains direct links to the technical results of the simulation, such as self-consumed energy and surplus energy. This is useful for joint interpretation, since lower grid dependence or higher effective PV use typically translates into lower operational emissions under fixed source-specific emissions factors.

4.3 Integration with the AutoECoMo KPI Dashboard

The CO2 analysis is fully integrated into the post-processing stage of AutoECoMo and is configured directly from the main graphical interface. As shown in Fig. 5, the tool includes a dedicated Set CO2 Factors button, through which the user manually defines the source-specific emissions factors employed in the environmental calculations. In the current implementation, these inputs correspond to the carbon intensity of electricity imported from the grid and the carbon intensity associated with photovoltaic energy, both expressed in

gCO_2/kWh. This design gives the user direct control over the environmental assumptions adopted in the analysis, making the framework flexible enough to represent different regulatory contexts, datasets, or scenario hypotheses.

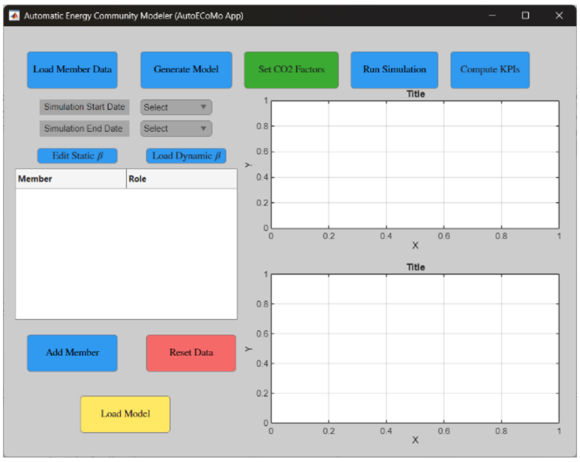
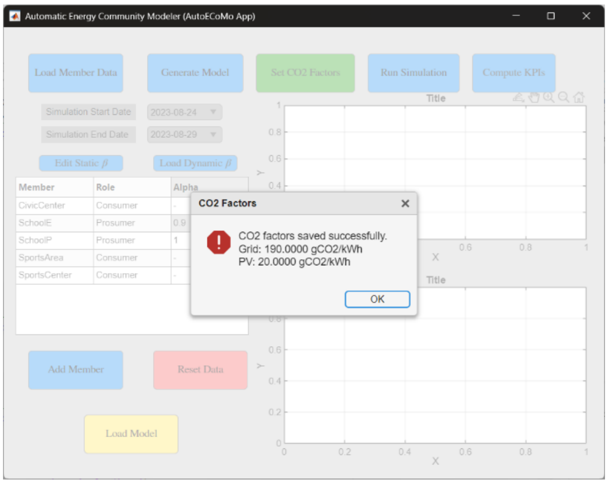


Figure 5. *Main AutoECoMo graphical interface including the* ***Set CO_2 Factors*** *option.*

Once the factors are entered, the tool stores them and confirms the selected values through a dedicated dialog window, as illustrated in Fig. 6. In the example shown, the user-defined factors are $190 gCO_2/kWh$ for grid electricity and $20 gCO_2/kWh$ for photovoltaic energy. These values are then used internally during KPI computation, so that the environmental indicators remain fully consistent with the simulated energy flows of the evaluated CSC case.



Simulation Start Date 2023-08-24
Simulation End Date 2023-08-29

Member	Role	Alpha
CivicCenter	Consumer	-
SchoolE	Prosumer	0.9
SchoolP	Prosumer	1
SportsArea	Consumer	-
SportsCenter	Consumer	-

CO2 Factors

CO2 factors saved successfully.
Grid: 190.0000 gCO2/kWh
PV: 20.0000 gCO2/kWh

Figure 6. *Confirmation dialog displayed after entering the CO_2 emissions factors in AutoECoMo.*

After simulation, AutoECoMo reconstructs the relevant member-level and community-level flows, computes the corresponding emissions quantities, and displays the results through dedicated KPI tables in the dashboard. In the current implementation, the output is organized into separate views for global technical KPIs, global CO_2 KPIs, energy indicators by member, CO_2 indicators by member, and prosumer-to-member allocation matrices. This organization allows the user to move from raw operational behavior to environmental interpretation within the same interface and without requiring external calculations. This integration is important because it preserves traceability between the CSC simulation and the environmental assessment. The reported CO_2 metrics are not obtained from an external calculator, but directly from the same time-series accounting used to compute self-consumption, self-sufficiency, imports, exports, and member coverage. As a result, AutoECoMo supports consistent scenario comparison in which technical and environmental outcomes are evaluated within a unified workflow.

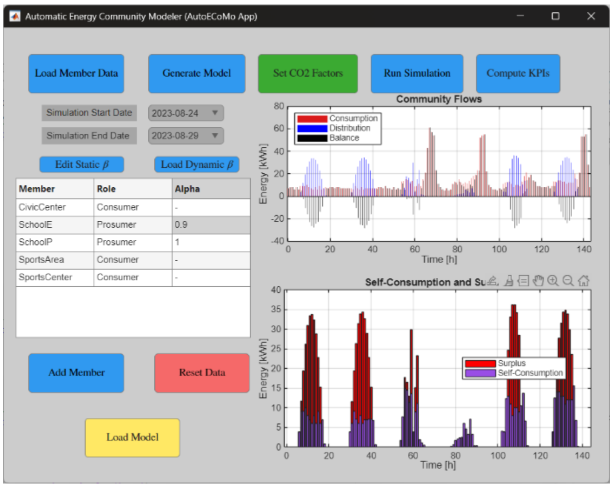
Finally, although the present version of the tool does not yet include storage-related CO_2 accounting, the adopted structure is readily extensible. The same source-based framework can incorporate additional terms, such as electricity discharged from a community storage system, once these flows are explicitly modeled and linked to their corresponding emissions factors.

5. Demonstration Case

To illustrate the practical use of AutoECoMo, a demonstration case distributed with the tool is considered. This case can be downloaded directly from the MATLAB File Exchange repository of MathWorks together with the AutoECoMo package. In particular, the current implementation of the framework, including the demonstration files and supporting material, is available at:

https://es.mathworks.com/matlabcentral/fileexchange/182734-automatic-energy-community-modeler-autoecomo

The demonstration case represents a five-member Energy Community located in Spain, configured under a CSC scheme. The case includes both consumers and prosumers and is evaluated over a predefined simulation horizon using the workflow described in the previous sections. In addition to the member demand and generation profiles, the case is simulated using the source-specific CO_2 emissions factors introduced in Section 4, namely the user-defined grid and photovoltaic emissions intensities. This allows the tool to simultaneously quantify the operational energy balances and the associated environmental indicators within the same execution.



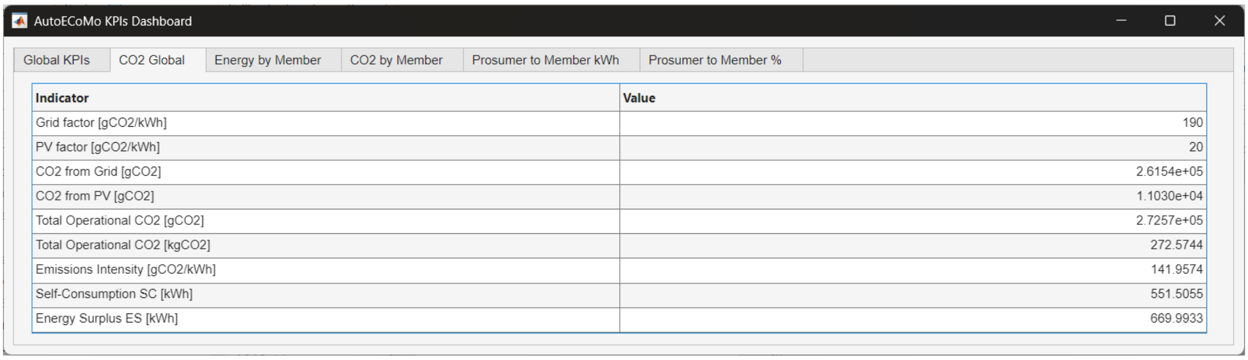
Simulation Start Date 2023-08-24
Simulation End Date 2023-08-29

Member	Role	Alpha
CivicCenter	Consumer	-
SchoolE	Prosumer	0.9
SchoolP	Prosumer	1
SportsArea	Consumer	-
SportsCenter	Consumer	-

Figure 7. *AutoECoMo main interface of the five-member Spanish Energy Community demonstration case.*

From the user perspective, the case can be loaded and executed directly from the main AutoECoMo graphical interface. As shown in Fig. 7, the community configuration, selected simulation dates, and resulting time-series plots are displayed after running the model. The upper plot summarizes the community-level flow behavior over the selected horizon, including total consumption, distributed energy, and the resulting balance. The lower plot provides a complementary representation of self-consumed and surplus energy, which helps interpret the relationship between local generation availability and the amount of energy effectively used within the community. In this way, the demonstration provides an immediate visual overview of the operational behavior reproduced by the generated model.

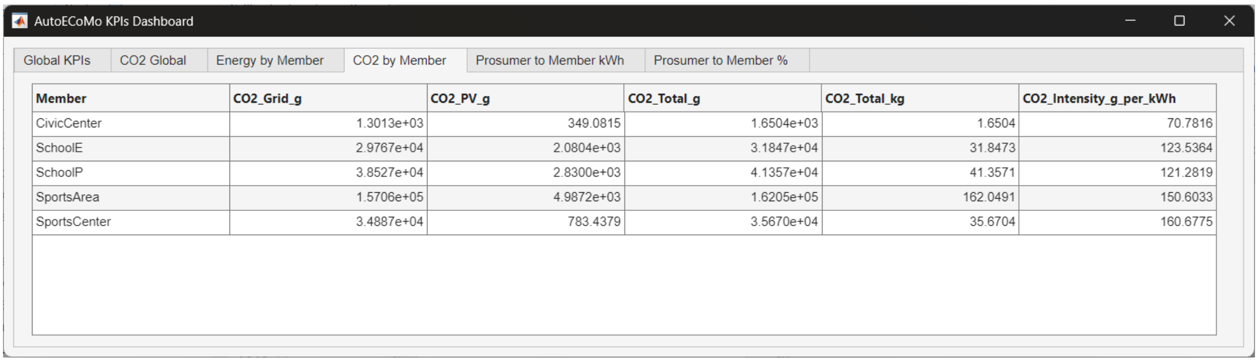
Once the simulation has been completed, AutoECoMo computes the corresponding CO_2 emissions indicators through the integrated KPI dashboard. The community-level global CO_2 indicators are shown in Fig. 8, where the tool reports the grid and photovoltaic emissions factors, the emissions attributable to each source, the total operational emissions of the community, the equivalent value in kilograms of CO_2, the emissions intensity, and complementary energy-related quantities such as self-consumption and surplus energy. These results provide a compact environmental summary of the evaluated CSC scenario and allow the user to assess the overall carbon implications of the simulated operation.



Indicator	Value
Grid factor [gCO2/kWh]	190
PV factor [gCO2/kWh]	20
CO2 from Grid [gCO2]	2.6154e+05
CO2 from PV [gCO2]	1.1030e+04
Total Operational CO2 [gCO2]	2.7257e+05
Total Operational CO2 [kgCO2]	272.5744
Emissions Intensity [gCO2/kWh]	141.9574
Self-Consumption SC [kWh]	551.5055
Energy Surplus ES [kWh]	669.9933

Figure 8. *Global CO_2 emissions indicators reported by the AutoECoMo KPI dashboard.*

A more detailed decomposition is provided in Fig. 9, where the dashboard reports the member-level CO_2 indicators. For each participant, the tool separates the emissions attributable to grid electricity and photovoltaic supply, together with the total emissions and the specific emissions intensity in gCO_2/kWh. This member-level breakdown is especially useful for interpreting how the adopted allocation settings affect the environmental outcome of each participant, complementing the community-level indicators presented previously.



Member	CO2_Grid_g	CO2_PV_g	CO2_Total_g	CO2_Total_kg	CO2_Intensity_g_per_kWh
CivicCenter	1.3013e+03	349.0815	1.6504e+03	1.6504	70.7816
SchoolE	2.9767e+04	2.0804e+03	3.1847e+04	31.8473	123.5364
SchoolP	3.8527e+04	2.8300e+03	4.1357e+04	41.3571	121.2819
SportsArea	1.5706e+05	4.9872e+03	1.6205e+05	162.0491	150.6033
SportsCenter	3.4887e+04	783.4379	3.5670e+04	35.6704	160.6775

Figure 9. *Member-level CO_2 emissions decomposition for the demonstration case.*

In addition to the baseline case, AutoECoMo version 1.1.0 also includes an Excel file containing dynamic allocation coefficients, which can be directly loaded into the tool through the corresponding interface option. This file is distributed together with the downloadable version of the framework and allows the user to evaluate alternative time-varying allocation settings under the same community configuration. As a result, the demonstration case not only illustrates the nominal operation of a CSC-based Energy Community but also provides a ready-to-use benchmark for comparing static and dynamic allocation configurations from both technical and environmental perspectives.

Overall, this demonstration confirms the value of AutoECoMo as a reproducible simulation environment in which community operation, technical KPIs, and CO_2 emissions indicators can be evaluated jointly from a common input structure and without manual model construction.

6. Conclusions and Future Work

This paper presented AutoECoMo as an automated MATLAB/Simulink framework for the modeling and simulation of Energy Communities operating under CSC schemes and introduced a built-in CO_2 emissions analysis module as a new extension of the tool. The proposed workflow enables the user to move from a structured community specification to an executable simulation model and a consistent set of technical and environmental indicators without manual block-level implementation. Through the presented demonstration case, the framework showed its ability to reproduce the operational behavior of a CSC-based community, quantify standard KPIs such as self-consumption and self-sufficiency, and complement them with source-based CO_2 metrics at both community and member level. In this way, AutoECoMo provides a transparent and reproducible environment for comparing allocation settings from both operational and environmental perspectives.

Future work will focus on extending the environmental and operational scope of the framework. In particular, the next developments will aim to incorporate dynamic emissions factors evaluated on a time-step basis, so that the carbon intensity of imported electricity can vary over time instead of being treated as a fixed parameter. In parallel, the modeling structure will be expanded to include energy storage systems and their corresponding emissions accounting, as well as a richer representation of the community interaction with the external electricity market. These developments are expected to strengthen AutoECoMo as an extensible benchmark environment for more realistic and comprehensive assessment of Energy Communities under evolving technical, environmental, and regulatory conditions.

Acknowledgments

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