Methodology for estimating the impact of the Green Bond

The extent of the impact generated by CDP's Green Bond 2023 was analysed and estimated from an environmental and socio-economic point of view, using well established assessment methodologies[1].

More specifically, two types of impact estimates were made:

- environmental, in terms of the reduction in CO2 equivalent and absolute physical indicators, specific to each *eligible category*;
- socio-economic, in terms of value added and employment, estimated for the entire portfolio, excluding the investments that generate impacts abroad.

Environmental impact assessment of projects

The environmental impact assessment of the initiatives included in the Green Bond portfolio was carried out starting from the Eligible Green Categories of the Framework; the disbursed resources were divided for all categories[2], and an analysis of the specific environmental impacts was carried out for each one, through the identification and valuation of the related indicators, in accordance with the ICMA guidelines[3].

Bond	Eligible Green Categories	Disbursed (€/mln)
Green Bond 2023	Renewable Energy	26
	Energy Efficiency	126
	Green Buildings	123
	Clean Transportation	153
	Circular Economy	27
	Sustainable Water and Wastewater Management	45
Portfolio Total		500

[1] The analyses and assessments were carried out internally within the CDP organisation, in particular by the 'Monitoring and Impact Analysis' area. With reference to the assessments relating to some initiatives within the Energy Efficiency and Clean Transportation categories, the methodology used was developed by the 'Technical Competence Centres' department.

[2] Information relating to the investment by category was found in the documents relating to loans and/or projects. As regards the investment plans that provide for actions to be implemented in several categories of the Framework, the total CAPEX was divided between the relevant categories, through the available data or, in the absence thereof, with estimates; in particular, for the Renewable Energy category, in some cases the investment in photovoltaic sources was estimated starting from the physical data of the installed capacity, through a value for average market cost per MW of installed solar panels, based on data from industry reports. IEA, International Energy Agency: https://www.iea.org/reports/cost-of-capital-observatory/tools-and-analysis.

[3] ICMA, 2022, "Harmonised-Framework-for-Impact-Reporting-Green-Bonds".

For all the projects financed by the Bond, the environmental impact was estimated, through calculations based on physical data produced by the beneficiaries, linked to the performance of production processes, infrastructures, energy efficiency measures and other types of financed projects, as provided for in the investment plans and corporate business plans.

In particular, the reduction of CO_2e emissions was calculated as a result of the financed interventions in the Renewable Energy, Energy Efficiency, Green Buildings and Clean Transportation categories. It was thus possible to quantify precisely the reduction in CO_2e for operations corresponding to 428 million euro of loans, equal to 86% of the total value of the portfolio.

In accordance with the "Global GHG Accounting and Reporting Standard for the Financial Industry", developed by the PCAF Global Core Team, the reduction of GHG emissions is:

- reported in CO_2 equivalent (CO_2e), which is the standard unit of measurement used internationally to express the impact on the climate of the various greenhouse gases and hydrofluorocarbons with a global warming potential in a 100-year time interval[4], as identified in the IPCC Assessment Reports. The most important greenhouse gases, apart from carbon dioxide (CO_2), are methane (CH_4) and nitrous oxide (N_2O);

- calculated considering the technical specifications of each plan/project, where available, or estimated based on data on expected production levels and national emissions factors provided by the Italian Institute for Environmental Protection and Research (ISPRA) or the available literature;

- calculated using a counterfactual method, that is, evaluating the reduction in emissions that the financed investment produces compared to that which would have been emitted in the absence of the project or implementing the investments without the project specifications that achieve the green objectives and generate the related environmental impacts (baseline or counterfactual scenario). In the case of projects in the 'Renewable Energy' category, for example, the emissions avoided thanks to the zero-emission energy generation and replacement were measured, assuming that, in the absence of the project, the same amount of energy would have been produced using a mix of fossil fuel sources[5]. In the case of the efficiency-enhancing measures, the energy savings, and the consequent emissions avoided, were estimated as compared to the consumption prior to the implementation of said measures or, in the case of a simultaneous increase in production capacity, to the situation in which the same projects were carried out with the technologies previously used by the enterprise;

- estimated, for the installation of renewable energy sources, considering the useful life cycle of the plants, even residual, and taking into account the technological degradation that is the progressive

[4] In other words, it is the amount of CO_2 that, over a given time period, would cause the same integrated radiative forcing (a measure of the strength of the drivers of climate change) of an emitted amount of another greenhouse gas or mixture of greenhouse gases. In this respect, the PCAF recommends using 100-year global warming potentials.

[5] ISPRA, "Emission factors for the production and consumption of electricity in Italy", 2024.

reduction in performance and efficiency during the useful life[6]. As regards the other categories of the Framework, it was not possible to carry out the same operation, given the heterogeneity of the technologies used in each project (consider, for example, the energy efficiency measures implemented for buildings and production plants), each with different dynamics and rates of degradation;

- calculated, for the Renewable Energy category, in terms of net emissions, considering the additional emissions (compared to the counterfactual scenario) linked to the installation of photovoltaic panels, thus incorporating the LCA principles into the assessment[7]. Always proceeding with a prudent approach, for the remaining categories of the Framework, the emission reduction was calculated without taking into account the additional emissions deriving from the implementation of the interventions in the short term (in particular, the work carried out in the construction phase of a plant or the adaptation of buildings to the most recent energy efficiency standards), in other words, using "gross data", due to the lack of information on all the individual projects and of data from the companies that would allow an estimate of the impact in terms of greater emissions related to these interventions;

- not estimated for the 'Circular Economy' and 'Sustainable Water and Wastewater Management' categories - it was not possible to estimate, using physical indicators, a reduction in the emissions of these categories. The measure, provided in terms of greenhouse gas emission reductions, therefore considers the categories of 'Renewable Energy,' 'Energy Efficiency,' 'Green Buildings,' and 'Clean Transportation' (86% of the total Green Bond portfolio). It does not consider the additional potential emissions avoided through investments in the 'Circular Economy' and 'Sustainable Water and Wastewater Management' categories.

- assessed by category, in relation to the value invested in the portfolio for the specific category, obtaining an indicator of the intensity of the reduction of greenhouse gas emissions per million euro invested (tCO2e/€ million); this was possible for the four categories for which the emissions avoided were valued, while the reduction intensity was not calculated for the value of the total portfolio, since the value of the total investment also refers to two categories for which the value of the emissions avoided had not been estimated;

- allocated on a pro rata basis, in other words, by assigning an environmental impact attribution factor to CDP's Green Bond, based on the ratio between the eligible amount of the loan disbursed and the total amount of the company's investment plan;

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[6] Degradation factors based on the literature were used: "LCA di un impianto fotovoltaico piano con moduli ad etero-giunzione" (LCA of a flat photovoltaic system with heterojunction modules), RSE, 2019.
[7] Operation carried out in the phase of estimating the reduction of CO2e emissions with a prudent approach, which attempts to provide an accurate figure, also considering a measure of the additional emissions necessary for the implementation of the interventions. Literature reviews formed the basis upon which these higher emissions were calculated. Salibi, Schönberger, Makolli, Bousi, Almajali, Friedrich; 2021: "Energy payback time of photovoltaic electricity generated by passivated emitter and rear cell (PERC) solar modules: a novel methodology proposal".

- estimated directly by the companies for certain specific actions; nevertheless, it was verified that these values comply with the methodological conditions illustrated above [8].

Taking an even more detailed look at the individual categories:

- for the Renewable Energy category, the calculation of CO_2e reduction was carried out taking into account: the expected annual energy production of each plant, calculated as a product of their installed capacity, multiplied by the expected unit production capacity (function of geographical location, and therefore of the specific climate conditions and solar power potential[9]) and finally corrected for technological degradation estimated over the useful life of the plant[10]; the national atmospheric emissions factor of carbon dioxide for the generation and consumption of electricity in Italy, calculated in relation to the mix of fossil fuels in 2023[11];

- or the Energy Efficiency and Green Buildings categories, the measurement of CO_2e reduction was obtained using the same methodology used by the Bank of Italy in the 2024 Environmental Report[12]: the annual energy savings expected from actions taken to enhance efficiency were measured and then converted into CO_2e through the ISPRA emissions factors;

- For the "Clean Transportation" category, the estimate of saved CO_2 emissions is based on the development of counterfactual scenarios, one for each type of vehicle (e.g., passenger cars, LDVs, HDVs, buses). These scenarios simulate the evolution of the vehicle fleet in the absence of the financed projects. The scenarios take into account several crucial factors, including: (i) the number of vehicles in circulation in 2023, categorized by European emission standard class (Euro) and fuel type[13]; (ii) projections of the total number of vehicles in the coming decades[14], considering the development of electric and hybrid vehicles, as well as the natural turnover of the fleet due to the end of vehicles' useful life, (iii) regulatory restrictions on circulation, which influence the composition of the vehicle fleet over time due to the phase-out of obsolete and non-compliant vehicles[15], (iv) the allocation of CO_2e emissions to each vehicle class, using the most up-to-date available data[16].

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[8] Limited to a single operation, in the absence of any further data, the value of the emissions reduction was estimated from the company's Sustainability Report 2022, comparing the 2021-2022 emissions data. Since the result obtained in 2022 was due to the actions previously financed by CDP, of which the disbursement through the Green Bond constitutes a refinancing, it was assumed that the impact obtained during 2022 would remain constant in subsequent years.

[9] To calculate the expected unit production capacity of the photovoltaic systems, the tools made available by the European Union were used: European Commission, Photovoltaic Geographical Information System (PVGIS), EU Science Hub.

[10] The useful life of photovoltaic systems has been estimated at 25 years, scenario supported by studies and analyses and consistent with most of the current evaluations in the sector; please note that this figure is conservative, given that technological development is increasing the useful life of the systems, bringing it towards 30 years for those with the best performance. ENEA 2021, "Il fine vita del fotovoltaico in Italia" (The End-of-life of Photovoltaics in Italy); Sodhi, Banaszek, Magee, Rivero-Hudec, 2022, "Economic Lifetimes of Solar Panels".

[11] "Emission factors for the production and consumption of electricity in Italy'', 2024.

[12] Bank of Italy, "2024 Environmental Report".

[13] Italian Association of the Automotive Industry (Associazione Nazionale Filiera Industria Automobilistica - ANFIA).

[14] Energy & Strategy della School of Management of the Politecnico di Milano.

[15] Regulatory restrictions on vehicle circulation based on Euro standards and fuel type were taken into account. Starting from the national regulatory limit set for 2030 on Euro 3 gasoline and Euro 6 diesel cars, an estimate was made of when a similar ban could be applied to other Euro classes and fuel types. This estimation exercise was necessary because, except for the 2030 regulation on Euro 3 gasoline and Euro 6 diesel vehicles, circulation restrictions vary at the regional or municipal level and are therefore not suitable for the purposes of this analysis.

[16] Emissions of the Italian fleet by Euro class and fuel type: INEMAR; Average annual BEV consumption per km: ChargeUp Europe; Average annual LDV, HDV, and bus consumption per km: Motus-E VGI (assuming the same technological progress trend as BEVs); Emissions of LDV, HDV, and buses: estimate based on INEMAR data.

By analyzing the composition and evolution of the circulating fleet, it was thus possible to determine the emissions associated with a "typical vehicle" representative of the circulating fleet for each year considered.

Subsequently, depending on the specific funded intervention, the following methodologies have been adopted[17]:

- For operations related to the purchase of new low-emission vehicles, the reduction in CO_2 emissions was calculated by considering the number and type of vehicles purchased. Specifically, a counterfactual analysis was conducted by comparing the emissions of a new alternative fuel-powered vehicle of the same category with those of a low-emission vehicle, taking into account the average kilometres travelled annually by that specific vehicle category.
- For operations involving the replacement of existing vehicles with low-emission models, the difference in CO_2 emissions was calculated between a new low-emission vehicle and a representative vehicle from the counterfactual circulating fleet, based on the average annual kilometres travelled by that specific vehicle category.
- For the installation of charging points for electric vehicles, a correlation was assumed between the number of charging points and the stimulation to the electric vehicle market. The analysis considered the kilometres that could be travelled by electric vehicles enabled by the increased number of charging stations, due to a broader network coverage effect. Subsequently, a comparative analysis of CO_2 emissions was conducted between an electric vehicle and a representative vehicle from the counterfactual circulating fleet, both evaluated based on the typical average annual mileage for their respective vehicle categories.
- In all analyses, the CO_2 savings were calculated net of the CO_2 emitted during the production of the electricity used to power the new low-emission vehicles.

- as regards the Sustainable Water and Wastewater Management category, for each financed assets the indicator that measures the reduction in the consumption of water used in the company's production cycles or in relation to the infrastructure projects in the integrated water system has been reported;

- as regards the Circular Economy category, specific impact indicators have been valued in relation to the financed investments, in order to assess the circularity objectives pursued, in particular relating to the production of fuels (secondary solid fuel and biogas) and the recycling and reintroduction of scrap and production waste into the production cycles, based on data provided by the companies.

[17] CDP internal models of the Technical Competence Center.

Socio-economic impact assessment of the portfolio

With regard to the assessment of socio-economic impact, several variables have been considered, namely i) production, ii) value added, iii) jobs and iv) private income and consumption. About these variables of interest, the total impact generated by the Green Bond includes:

- the *direct impacts*, relating solely to the sector affected by the issuance;
- the *indirect impacts*, relating to the processes activated in other business sectors (Leontief multiplier);
- the *induced impacts*, deriving from the increase in income stimulated by the social bond (Keynesian multiplier).

The passage from the allocated 500 million euro to the approximately 400 million euro of resources used as input for the estimate of the socio-economic impact was made by excluding the activities from the scope of the analysis that, despite having deployed resources, do not have the characteristics to generate a direct impact on the national aggregate demand. Therefore, investments that generate an impact abroad have been excluded. The vector of resources obtained at purchase prices was converted into basic prices, considering only the effects produced by the deployed resources allocated, with no carryover effects on the economic system. For construction, the estimate brings forward to 2023 the demand impacts generated by the resources deployed during the year, even if these impacts may occur over a longer time frame.

The estimates were carried out using a Multi-Regional Input-Output (MRIO) model, which, through the study of the interdependencies between the regional economic systems, estimates how the total impacts are distributed across the local area which has been invested in. The model[18] is broken down into four macro-areas (North-East, North-West, Central, South and Islands) and 54 production sectors. The interdependencies between the different areas represent the peculiarity of the MRIO models, as they make it possible to determine the ability of the local area to internalise (retain) the multiplier effect of both domestic final demand and that coming from the other macro areas.

The model’s ability to correctly assess the effect on the national economic system and employment of the investments made with the funds raised through the Bond clearly depends on the ability to correctly attribute the expenditure flows to the various product items in the input-output matrix classification and to the geographic areas of destination of the investments.

With regard to impacts on employment, jobs are measured in Annual Work Units (AWU), Units of work equivalent to full-time employment; this is the amount of work performed by one employee working full-time for one year, a unit of measurement for the volume of work employed in the production of goods and services included in the estimates of Gross Domestic Product used by ISTAT[19]. Please note that impacts

[18] Developed by the Regional Institute for Economic Planning of Tuscany (IRPET).
[19] Homogeneous unit of measurement for the volume of work carried out by employees. The unit of work represents the amount of work performed in the year by a full-time employee and provides the unit of measurement for the amount of work performed by part-time employees, by employees with reduced hours (for example, because they receive the earnings supplement fund or because they perform a double job), and by employees with a work duration of less than one year. Glossary, ISTAT.

on employment represent the jobs created and/or maintained, linked to the workforce needs for production set in motion as a result of the investments.

Input-Output tables and multiregional matrices

The IO tables or tables of interdependencies by sector are a schematic-accounting representation of the different value flows in a given economic system and over a given time frame (normally one year, known as the base year). The reference unit consists of economic sectors grouped together in branches (production units characterised by similar cost structure, production processes and products), each of which carry out two types of transactions: i) purchases from other sectors of goods and services that they use for their own production activities (use branches); ii) sales of goods and services they produce to other sectors and end consumers (supply branches).

The accounting structure of the tables underlying the MRIO model consists of two sets of accounts: the single region supply and use table[20] (SUT) and a multi-regional trade matrix.

Starting from the standard formulation of the IO models and the basic theory of perfect competition and an economic equilibrium between supply and demand, total production (domestic and imported) in sector *m* is equivalent to that which is reused locally (intermediate goods or final goods) and that which is exported. Formally[21], it is necessary that:

$$X^m + J^m = \sum_n K^{mn} + Y^m \qquad (1)$$

Where X^m corresponds to total production of sector *m*; J^m are the imports of sector *m*; $\sum_n K^{mn}$ represents the intermediate demand of the production in sector *m* necessary to satisfy the production in sector *n* in the area considered and Y^m corresponds to the final demand of the sector.

The assumptions underlying the IO model can be summarised as: i) the economic system is initially in equilibrium and the increase in demand is met by an increase in production (and not in stocks); ii) linear production technology, that is, the input quantity used for each production activity is proportional to the volume of output X^m; ii) assumption of fixed economies of scale in all production sectors, i.e. the unit input need is assumed to be constant regardless of changes in production volumes; iii) no external effects, i.e. the effect deriving from economic activity outside the market transactions is not considered and hourly wages, hours worked, relative intensity of domestic production and imports are kept fixed (i.e. exogenous); and iv) the Leontief production function is used, which assumes no substitutability between production factors (capital and labour).

The key element of the IO models is the matrix of technical coefficients, whose individual elements a^{mn} determine the relationship between production levels and intermediate demand:

[20] For a detailed description of the IRPET building and balancing procedure for SUTs, see Paniccià R. & Rosignoli S., “A Methodology for Building Multiregional Supply and Use Tables for Italy”, IRPET, 2018.
[21] Adapted from Cherubini L., Ghezzi, L., Paniccià, R. and Rosignoli S, “Economic integration between the Mezzogiorno and the Centre North*”,* Bank of Italy, 2011*.*

$$a^{mn} = \frac{K^{mn}}{X^n} \qquad \Longrightarrow \qquad K^{mn} = a^{mn} \cdot X^n \qquad (2)$$

Where a^{mn} are the technical coefficients and represent the monetary value of the product in sector *m* (input) necessary for the production of a unit of value in sector *n* (output), K^{mn} is the intermediate demand of production in sector *m* necessary to satisfy production in sector *n* and, X^n represents the production value in sector *n*. It should be noted that the value assumed by the technical coefficients depends on the production technology of the area in question (under assumptions of linear production and, therefore, without considering economies of scale or learning). The matrix of technical coefficients, in addition to being calculated for production, is also calculated for imported inputs and primary inputs (wages and salaries, value added, etc.).

Once equation (2) has been defined, (1) can be rewritten as:

$$X^m + J^m = \sum_n a^{mn} \cdot X^n + Y^m \qquad (3)$$

And the basic IO model can be represented as follows in matrix form:

$$X = (I - A)^{-1} \cdot (Y - J) \qquad (4)$$

Where $(I - A)^{-1}$ is known in literature as the Leontief inverse matrix or multiplier matrix. The sum of the value columns represents the increase in production attributable to a unitary variation in final demand in the sector in question and makes it possible to estimate the impact of a change in external demand on production, intermediate import inputs and primary resources inputs. Finally, from Leontief's inverse matrix it is possible to compute the multipliers used to estimate the impact of the investments made on production, the intermediate import inputs and the primary resource inputs. From this matrix, it is also possible to derive demand multipliers that are used to estimate the impact of the investments made in terms of jobs created or maintained.

Starting from the basic IO model, the use of interregional matrices has made it possible to extend the accounting structure of the model (MRIO) used to estimate the impact of the Green Bond in order to consider trade flows between the macro regions, introducing an additional causal relationship (in addition to the Leontief-type technical relationship) of multiregional trade patterns, which distributes the total final demand among the various macro areas considered, to determine the production levels of each macro region [22].

The MRIO model used, compared to the basic model, therefore allows consideration of the (more realistic) assumption that the region j of consumption of intermediate production K_j^{mn} and final consumption Y_j^m may differ from the region *i* of production X_i^m and import J_i^m. In other words, it is possible to simulate monetary trade between different sectors of the economy and regions being analysed.

[22] Cherubini L., Ghezzi L., Paniccià R. and Rosignoli S (2011), "Economic integration between the Mezzogiorno and the Centre North", Seminars and conventions, Bank of Italy.

Formally, after the introduction of the *trade coefficient (T) matrix,* whose elements t_{ij}^{mn} (interregional trade coefficients[23]) represent the portion of product in sector *m* coming from region *i* and used by sector *n* in region *j*, equation (4) can be rewritten as:

$$X = (I - \mathbf{T} \cdot A)^{-1} \cdot (Y - J) \quad (5)$$

Finally, the vector of the investments attributable to the Green Bond was included in the model by way of a bridge matrix to categorise them in accordance with the classification envisaged in the multiregional IO matrices. More specifically, the use of a bridge matrix makes it possible to assign the variations in final demand generated by the Green Bond in a more precise and accurate manner, since they use the specific[24] categories of expenditure[25] which are then converted into the classification used by the IO matrices (NACE rev.2). In this case, which concerns investments, these have been converted from sector of origin to the proprietary sector (user).

[23] In particular, for the construction of the interregional trade coefficients, IRPET used the Chenery-Moses model (1970), where the underlying assumption is that the elements $tij\ mn$ are indifferent to the sector in which they are used.
[24] In particular, the following international standards defined by the United Nations Statistics Division were used; I) COICOP (Classification of Individual Consumption by Purpose), for household consumption, ii) COIFOG (Classification Of the Functions Of Government), for Public Administration expenditure; iii) Gross fixed capital formation by asset, for gross fixed investments.
[25] For example, if one considers spending intended for consumption in the form of Public Administration expenditure in infrastructure, the bridge matrix allows the amount of expenditure to be correctly allocated to the various economic sectors such as the construction, transport, machinery sectors, etc.