GUGGENHEIM BILBAO

Guggenheim Museum Bilbao
Greenhouse Gas (GHG) Inventory Report

November 2021

TABLE OF CONTENTS

1. INTRODUCTION AND PURPOSE

The Guggenheim Museum Bilbao Foundation is a cultural foundation that manages, directs, maintains, preserves and promotes the Guggenheim Museum Bilbao.

Since its inauguration in October 1997, the Museum has collected, preserved and exhibited 20th century art within a singular architectural context. It is now a prominent cultural symbol of the economic revitalization of the Basque Country and of the international orientation of the Guggenheim Constellation of museums, thus fulfilling its foundational objectives.

Likewise, the contribution towards environmental betterment has become central to the Foundation's objectives. Its Environmental Policy establishes environmental conservation as a fundamental aim in all of its activities, consistent with the nature, magnitude, and environmental impact of the Museum.

In 2004, the Museum obtained the ISO 14001 standard certification for its environmental management system and has subsequently implemented measures to reduce its environmental impact, in line with the commitment to preserving the environment and carrying out its activities in accordance with the principles of sustainable development.

The Guggenheim Museum Bilbao's 2021–2030 Strategic Plan sets out ten strategic commitments. Among these, importantly, is its commitment to the environment, through which the Museum pledges to continue working to minimize its environmental impact with the development and implementation of sustainable energy solutions and non-polluting processes, and by promoting activity that is oriented to ecoefficiency.

This report is published by the Guggenheim Museum Bilbao Foundation to facilitate the verification of the Greenhouse Gas Inventory and to inform its stakeholders in a transparent manner on the Museum's emissions, in fulfilment of the Environmental Policy approved by Management in the 2017 financial year.

The greenhouse gas (GHG) emissions inventory has been calculated in accordance with the requirements of international standard UNE-EN ISO 14064-1:2019 "Greenhouse gasses. Part 1: Specification with guidance, at the organization level for quantification and reporting of greenhouse gas emissions and removals". The present report, as the main communication tool for the inventory, has the following objectives:

- To know the scope of the Guggenheim Museum Bilbao's GHG emissions.
- To report internally and externally on the emissions generated by the activities of the Guggenheim Museum Bilbao.
- To identify opportunities for improvement in the area of energy efficiency.

- To continue as a pioneering organization in sustainable management.
- To be able to reduce or optimize the organization's energy consumption and therefore reduce GHG emissions.

This report contains the inventory data for the year 2021.

The Maintenance and Facilities Department of the Guggenheim Museum Bilbao has overseen the preparation of the inventory and the publication of this report.

2. ORGANIZATIONAL BOUNDARIES

The GHG inventory presented in this report has been done using an "Operational Control" approach, as this is the approach that best represents the organization's activity.

The Guggenheim Museum Bilbao takes into account all quantified GHG emissions and/or removals in the facilities over which it has control as well as the quantified GHG emissions in the transportation of artworks for the exhibitions in which it participates.

The following facilities are therefore included in the GHG inventory:

Organizational boundaries			
Tag	**VAT ID**	**Designation**	**Description**
A	G-48832240	GUGGENHEIM MUSEUM BILBAO	Includes the generation of GHG derived from the overall activity of the museum and the "Red Arches" sculpture.
B	G-48832240	EXTERNAL STORAGE	Auxiliary warehouse facility for artwork packaging material

3. REPORT LIMITS

In accordance with the requirements of the UNE-EN ISO 14064-1:2019 standard, the direct and indirect GHG emissions and removals associated with the organization's operations are identified based on the categories and subcategories contained in the following categories:

CATEGORIZATION	TYPE	PROCESS / ACTIVITY	GEIS GENERATED OR REMOVED	INSTALLATION
Category 1: Direct emissions and removals	Stationary-fossil fuel combustion	Heating: natural gas	CO_2, CH_4, N_2O	Museum (A)
	Stationary-fossil fuel combustion	Heating. Diesel oil C	CO_2, CH_4, N_2O	Museum (A)
	Stationary-fossil fuel combustion	Generating sets and pressure washers. Diesel oil A	CO_2, CH_4, N_2O	Museum (A) and External storage (B)
	Direct fugitive emissions	Air conditioning: refrigerant gasses	HFCs	Museum (A)
	Direct fugitive emissions	High voltage cells: sulfur hexafluoride.	SF6	Museum (A)
	Direct fugitive emissions	Fire extinguishing agents	FE-13, CO_2[1]	Museum (A) and External storage (B)
	Biogenic removals	Existing trees	CO_2	Museum (A)
	Biogenic removals	*Puppy* ornamental flowers	CO_2	Museum (A)
Category 2: Indirect emissions from imported energy	Imported electricity	Electricity consumption	CO_2, CH_4, N_2O	Museum (A) and External storage (B)
	-	Daily commuting to and from the work site	CO_2 e	Museum (A)

[1] *The extinguishing agent Novec 1230 is not included as its global warming potential is less than 1*

CATEGORIZATION	TYPE	PROCESS / ACTIVITY	GEIS GENERATED OR REMOVED	INSTALLATION
Category 3: Indirect emissions from transportation	-	Business travel in a museum-owned vehicle or employee vehicle	CO_2 e	Guggenheim Museum (A)
	-	Business travel by public transportation (train, plane, bus, cab)	CO_2 e	Guggenheim Museum (A)
	-	Transportation of artworks	CO_2 e	Guggenheim Museum (A) and External storage (B)
	-	In-person accompaniment of artworks (couriers)	CO_2 e	Guggenheim Museum (A)
	-	Daily travel for Guggenheim service staff: restaurant and cafeteria	CO_2 e	Guggenheim Museum (A)
	-	Transportation of products purchased by Guggenheim services: restaurant and cafeteria	CO_2 e	Guggenheim Museum (A)
	-	Customer and visitor travel	CO_2 e	Guggenheim Museum (A)
Category 4: Indirect emissions from products used by the organization	Caused by goods purchased by the organization	Artworks: creation and conservation	CO_2 e	Guggenheim Museum (A) and External storage (B)
	Caused by goods purchased by the organization	Artworks: scenery material	CO_2 e	Guggenheim Museum (A) and External storage (B)
	Caused by goods purchased by the organization	Other goods purchased: packaging, etc.	CO_2 e	Guggenheim Museum (A) and External storage (B)
	Caused by goods purchased by the organization	Capital goods: manufacturing and transportation of equipment and machinery located at the facilities	CO_2 e	Guggenheim Museum (A) and External storage (B)
	Caused by goods purchased by the organization	Purchased energy: electricity and gas production and transportation	CO_2 e	Guggenheim Museum (A) and External storage (B)
	Caused by goods purchased by the organization	Water consumption	CO_2 e	Guggenheim Museum (A)
	Caused by goods purchased by the organization	Merchandising purchases	CO_2 e	Guggenheim Museum (A)

CATEGORIZATION	TYPE	PROCESS / ACTIVITY	GEIS GENERATED OR REMOVED	INSTALLATION
	Caused by services purchased by the organization	Waste transportation	CO_2 e	Guggenheim Museum (A)
	Caused by services purchased by the organization	Waste management	CO_2 e	Guggenheim Museum (A)
	Caused by services purchased by the organization	Maintenance and cleaning of facilities: transportation of personnel, products	CO_2 e	Guggenheim Museum (A)
	Caused by services purchased by the organization	Consulting and advisory services	CO_2 e	Guggenheim Museum (A)
	Caused by services purchased by the organization	Financial services and investments	CO_2 e	Guggenheim Museum (A)
Category 5: Indirect emissions associated with the organization's use of products	-	No GHG generating processes have been identified for this category.	-	-
Category 6: Indirect emissions from other sources	-	No GHG generating processes have been identified for this category.	-	-

In the quantification of emissions the following GHGs have been taken into account, in keeping with ISO 14064-1: CO_2, CH_4, N_2O, SF_6, NF_3, PFCs and HFCs.

The scope of the inventory in regard to indirect emissions, however, has been established according to the following criteria:

- **Magnitude/volume**: indirect emissions or removals understood to be quantitatively substantial.
- **Level of influence on sources/sinks**: extent to which the organization has the capacity to track and reduce emissions and increase removals (energy efficiency, eco-design, etc.).
- **Access to information**: the organization's ability to access information/activity data to calculate emissions and removals from activities over which it has no operational or financial control. This criterion will be prioritized as it is considered to be a limiting factor with the greatest opportunity for improvement to arrive at a more comprehensive calculation of carbon footprint.

Emissions whose assessed significance do not reach the established thresholds on the basis of these criteria have been excluded.

The emission sources excluded on this basis are:

- Direct emissions and removals:
  - Biogenic removals: ornamental flowers
- Indirect emissions from transportation:
  - Indirect emissions derived from the daily commute of Guggenheim services staff: restaurant and cafeteria.
  - Indirect emissions derived from the transportation of products purchased by Guggenheim services: restaurant and cafeteria.
  - Emissions caused by the transportation of customers and visitors.
- Indirect emissions from products used by the organization:
  - By goods purchased by the organization: artwork (creation and conservation), other goods purchased, capital goods, energy purchased, water consumption and merchandising purchases.
  - By services used by the organization: final waste treatment, maintenance and cleaning of facilities, consulting and advisory services, and financial and investment services.

- Indirect emissions associated with the use of products by the organization: no GHG-generating processes have been identified for this category.

- Indirect emissions from other sources: no GHG generating processes have been identified for this category.

Due to limitations in the availability of data, indirect transportation emissions related to work travel by public transportation, cab and bus are not included. Likewise, due to the lack of available data on the weight of certain works of art for maritime and air transport, the respective indirect emissions have not been included.

4. BASE YEAR

The base year is a period of time that is specified for the purposes of comparing emissions in a time series.

The base year that has been chosen is 2021, because it is the most recent year that is representative of the museum's regular activity.

The base year emissions were 2,573.47 tCO_2e, broken down below by type of emission:

2021 GHG emissions		
Category	**Description**	**GHG emissions (tCO_2e)**
1	Stationary combustion	1,145.95
	Direct fugitive emissions	0
	Direct removals	2.79
TOTAL Category 1 - Direct GHG emissions:		**1,145.95**
2	Power consumption	1,058.64
TOTAL Category 2 - Indirect GHG emissions from imported energy:		**1,058.64**
3	Daily commuting to and from the work site	39.55
	Business travel in a museum vehicle or employee vehicle	2.73
	Staff commuting by public transport (train, plane, bus, cab, etc.)	10.86
	Transport of artworks	116.22
TOTAL Category 3 - Indirect GHG emissions from transportation:		**169.51**
4	Waste transportation	2.03
	Use and transport of museography material	157.29
	Use of new artwork packaging	40.20
TOTAL Category 4 - Indirect GHG emissions by products used by the organization		**199.51**
TOTAL GHG emissions		**2,573.47**

5. QUANTIFICATION OF EMISSIONS

Emissions have been quantified for the calculation period: the year 2021.

5.1 CATEGORY 1: DIRECT EMISSIONS AND REMOVALS

Direct GHG emissions and removals for the year 2021 are as follows:

Direct GHG emissions							
Tag	**Installation**	**Description**		**Partial CO_2 emissions (tCO_2e)**	**Partial CH_4 Emissions (tCO_2e)**	**Partial N_2O emission (tCO_2e)**	**Total emissions (tCO_2e)**
1.1	A	Stationary combustion	Natural gas: heating	1,143.06	0.11	0.0023	1,143.17
1.2	A		Diesel oil C: heating	0.21	0	0	0.21
1.3	A and B		Diesel oil A: generating sets and pressure washers	2.57	0	0.0001	2.5679
TOTAL Stationary combustion (tCO_2e): 1,145.95							
Tag	**Installation**	**Description**		**SF_6 emissions (tCO_2e)**	**HFC emissions (tCO_2e)**	**FE-13 emissions (tCO_2e)**	**Total emissions (tCO_2e)**
1.3	A	Direct fugitive emissions	Refrigerant gasses (air conditioning leaks)		0		0
1.4	A		Sulfur Hexafluoride: High Voltage Cells	0			0
1.5	A and B		Fire extinguishing agents – FE-13			0	0
1.6	A and B		Fire extinguishing agents – CO_2				0
TOTAL direct fugitive emissions (tCO_2e): 0							
TOTAL Category 1 - Direct GHG emissions (tCO_2e): 1,145.95							

Direct GHG removals				
Tag	**Installation**	**Description**		**Total absorption (tCO_2e)**
1.6	A	Removal of existing trees at the Museum	Orange trees	2.78
1.6	A		Privets	0.01
TOTAL direct GHG removals (tCO_2e): 2.79				

5.2 CATEGORY 2: INDIRECT EMISSIONS FROM ENERGY IMPORTS

Indirect GHG emissions from energy imports for the year 2021 are as follows:

Indirect GHG emissions from energy imports			
Tag	**Installation**	**Description**	**Total emissions (tCO_2e)**
2.1	A	Electricity consumption	985.58
2.2	B		73.07
TOTAL indirect GHG emissions from imported energy (tCO_2e): 1,058.64			

5.3 CATEGORY 3: INDIRECT EMISSIONS FROM TRANSPORTATION

Indirect GHG emissions from transportation for the year 2021 are presented below:

Indirect GHG emissions from transportation			
Tag	**Installation**	**Description**	**Total emissions (tCO_2e)**
3.1	A	Daily commuting to and from the work site	39.55
3.2	A	Work travel in the employee's own vehicle	2.73
3.3	A	Work travel by public transportation (train, plane, bus, cab, car...) of museum staff and couriers	10.86
3.4	A and B	Transport of artworks	116.22
TOTAL Indirect GHG emissions from transportation (tCO_2e): 169.37			

5.4 CATEGORY 4: INDIRECT EMISSIONS FROM PRODUCTS USED BY THE ORGANIZATION

Indirect GHG emissions from products used by the organization for the year 2021 are as follows:

Indirect GHG emissions from products used by the organization			
Tag	**Installation**	**Description**	**Total emissions (tCO_2e)**
4.1	A	Waste transportation	2.03
4.2	A	Use and transport of museography material	157.29
4.3	A	Use of new packaging for artworks	40.20
TOTAL indirect GHG emissions by products used by the organization (tCO_2e): 199.51			

5.5 TOTAL EMISSIONS

Total GHG emissions for the year 2021, broken down by type of emission, are as follows:

2021 GHG emissions		
Category	**Description**	**GHG emissions (tCO_2 e)**
1	Stationary combustion	1,145.95
	Direct fugitive emissions	0.00
	Direct removals	2.79
TOTAL Category 1 - Direct GHG emissions:		**1,145.95**
2	Power consumption	1,058.64
TOTAL Category 2 - Indirect GHG emissions from imported energy:		**1,058.64**
3	Daily commuting to and from the work site	52.05
	Work travel in the employee's own vehicle	2.73
	Work travel by public transport (train, plane, bus, cab, car...) of museum staff and couriers.	10.86
	Transport of artworks	116.22
TOTAL Category 3 - Indirect GHG emissions from transportation:		**181.87**
4	Emissions caused by waste transportation	2.03
	Use and transport of museography material	157.29
	Use of new packaging for works of art	40.20
TOTAL Category 4 - Indirect GHG emissions by products used by the organization		**199.51**
TOTAL GHG emissions		**2,585.97**

6. QUANTIFICATION METHODOLOGY

Two calculation methodologies are used to quantify reportable GHG emissions (direct and indirect emissions from imported energy) and significant indirect emissions, depending on the type of the emissions source:

1. Emission sources in which there is a chemical transformation process (stationary or mobile combustion, process emissions or emissions from organic matter degradation) and indirect emissions from the generation of consumed electricity.

CO_2 emissions (tCO_2e) = activity data x emission factor

with the following:

a) Activity Data: quantitative measure of the activity that produces an emission.

In the case of combustion in stationary sources, it is usually expressed in units of energy (TJ) and is calculated as the product of the fuel consumption (in mass or volume) and the Lower Calorific Value (LCV).

In the case of mobile combustion sources, if fuel consumption is not available to operate in a manner similar to that described for stationary sources, activity data on distance traveled (km) can be used.

In the case of electricity, the activity data is the electricity consumption of the facility (expressed in kWh).

b) Emission Factor: expressed in tons of CO_2e /unit (with the unit depending on the activity data units) and dependent on the type and characteristics of the chemical transformation process (and type of fuel) used in each case.

For each fuel there is a specific CO_2e emission that is closely linked to the carbon content of that fuel.

Each electricity retailer has its own grid emission factor for each kWh of electricity sold.

In all cases, emission factors that already include the fuel oxidation factor (a factor that takes into consideration the existence of inefficiencies in any combustion process that result in unburned or partially oxidized carbon content such as soot or ash) are used.

2. Emission sources where there is no chemical transformation process (fugitive emissions), or in cases where emission data is available in units other than tons of CO_2e (e.g., tons of CH_4)

CO_2 emissions (tCO_2e) = emission data x global warming potential

with the following:

a) emission data: quantitative measure of the emission produced. This data may be available either because the mass of fugitive emissions is known (such as in the case of refrigerant fluid recharges) or because a measurement is available (e.g. because continuous measurement of emitted CH_4 is done).

b) global warming potential: factor describing the impact of the radiation force of a unit based on the mass of a given GHG, relative to the equivalent unit of CO_2 in a given period. Expressed in tons of CO_2e /t GHG (there is a factor for each type of GHG).

Lastly, once the unit calculation of emissions from each source is available in units of tons of CO2e, all emissions in the same category (direct emissions, indirect emissions from energy and other indirect emissions) are added together.

a. Methodology for the quantification of removals

The methodology for calculating CO2 removals is similar to the one used to calculate emission sources where there is a chemical transformation process. It is based on the number of trees (equivalent to activity data) and absorption rates (equivalent to emission factors).

CO_2 removals (tCO_2e) = number of trees x absorption rate

Being:

a) Number of trees: number of trees by type of species.

b) Absorption rate: expressed in tons of CO2e /units per tree per year. There is an absorption rate for each tree species.

In cases where direct emission data is not available, emission factors from recognized sources have been used. The emission factors used and their sources are specified in the table below:

Emission factors						
Emission source		**Value**	**Greenhouse gas**	**Unit**	**Source**	
Stationary combustion	Natural gas	0.182	CO_2	kg CO_2/kWh	Spanish National Greenhouse Gas Inventory 1990–2018 (ed. 2020). IHOBE carbon footprint calculation tool, 2020.	
		0.00002	CH_4	kg CO_2/kWh	(DEFRA 2020) UK Government greenhouse gas conversion factors for company reporting	S1 Fuels: Gaseous fuels - Natural gas
		0.0000004	N_2O	kg CO_2/kWh	(DEFRA 2020) UK Government greenhouse gas conversion factors for company reporting	S1 Fuels: Gaseous fuels - Natural gas
	Diesel C	2.881	CO_2	kg CO_2/l	Spanish National Greenhouse Gas Inventory 1990–2018 (2020 ed.)	
		0.000389	CH_4	kg CO_2/l	Spanish National Greenhouse Gas Inventory 1990–2018 (2020 ed.)	
		0.000023	N_2O	kg CO_2/l	Spanish National Greenhouse Gas Inventory 1990–2018 (2020 ed.)	
	Diesel A	2.469	CO_2	kg CO_2/l	Spanish National Greenhouse Gas Inventory 1990–2018 (2020 ed.)	
		0.000028	CH_4	kg CO_2/l	Spanish National Greenhouse Gas Inventory 1990–2018 (2020 ed.)	
		0.000114	N_2O	kg CO_2/l	Spanish National Greenhouse Gas Inventory 1990–2018 (2020 ed.)	
Electricity consumption	Electricity mix 2021	0.232	CO_2	kg CO_{2e}/kWh	Comisión Nacional de los Mercados y la Competencia, 2021 (Iberdrola, w/o GO)	
Transportation	Car	0.17021	CO_2	kg CO_2/km	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Average car - Unknown fuel
		0.00017	CH_4	kg CO_2/km	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Average car - Unknown fuel
		0.00110	N_2O	kg CO_2/km	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Average car - Unknown fuel
	Hybrid car	0.11825	CO_2	kg CO_2/km	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Average car - Hybrid
		0.00017	CH_4	kg CO_2/km	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Average car - Hybrid
		0.0011	N_2O	kg CO_2/km	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Average car - Hybrid
	Cab	0.14742	CO_2	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Taxi - Regular cab
		0.00000296	CH_4	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Taxi - Regular cab

Emission factors						
Emission source		**Value**	**Greenhouse gas**	**Unit**	**Source**	
		0,00134	N_2O	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Taxi - Regular cab
	Bus (city)	0,10144	CO_2	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Bus - Average local bus
		0,00001	CH_4	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Bus - Average local bus
		0,00082	N_2O	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Bus - Average local bus
	Bus (coach)	0,02629	CO_2	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Bus - Coach
		0,00001	CH_4	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Bus - Coach
		0,00054	N_2O	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: Bus - Coach
	Metro	0,033	CO_2	kg CO_{2e}/PKM (passenger kilometer)	Bilbao Metro 2019 Greenhouse Gasses Report	
	Train (commuter rail)	0,02832	CO_2	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: rail - light rail and tram
		0,00011	CH_4	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: rail - light rail and tram
		0,00018	N_2O	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: rail - light rail and tram
	Train (medium/long distance)	0,0351	CO_2	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: rail - national rail
		0,00007	CH_4	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: rail - national rail
		0,00032	N_2O	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: rail - national rail
	Tramway	0,02832	CO_2	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: rail - light rail and tram
		0,00011	CH_4	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: rail - light rail and tram
		0,00018	N_2O	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- land: rail - light rail and tram
	Truck	0,85049	CO_2	kg CO_2/km	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: HGV - All HGVs Average Laden

Emission factors						
Emission source		**Value**	**Greenhouse gas**	**Unit**	**Source**	
		0.00014	CH_4	kg CO_2/km	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: HGV - All HGVs Average Laden
		0.01344	N_2O	kg CO_2/km	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: HGV - All HGVs Average Laden
	Truck (cargo)	0.5733	CO_2	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: HGV - Rigid (>3.5 - 7.5 tons)
		0.0001	CH_4	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: HGV - Rigid (>3.5 - 7.5 tons)
		0.0605	N_2O	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: HGV - Rigid (>3.5 - 7.5 tons)
	Van (cargo)	0.59795	CO_2	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: Vans - Average (up to 3.5 tons) (Diesel)
		0.00001	CH_4	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: Vans - Average (up to 3.5 tons) (Diesel)
		0.00465	N_2O	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: Vans - Average (up to 3.5 tons) (Diesel)
	Ship	0.05095	CO_2	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: Cargo ship - RoRo Ferry - Average
		0.000015	CH_4	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: Cargo ship - RoRo Ferry - Average
		0.000694	N_2O	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: Cargo ship - RoRo Ferry - Average
	Aircraft (cargo)	1.01381	CO_2	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: Freight flights - International
		0.00004	CH_4	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: Freight flights - International
		0.00505	N_2O	kg CO_2/tkm	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Freighting goods: Freight flights - International
	Aircraft	0.1827	CO_2	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- air: Flights - International - average passenger
		0.00001	CH_4	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- air: Flights - International - average passenger
		0.00091	N_2O	kg CO_2/PKM (passenger kilometer)	(DEFRA 2021) UK Government greenhouse gas conversion factors for company reporting	S3 Business Travel- air: Flights - International - average passenger

CO_2 absorption rate by tree species			
Tree	**Scientific name**	**CO absorption rate (tCO_2e/year)**	**Source**
Orange tree	*Citrus aurantium*	0.555	"Nuevas metodologías para la enseñanza de la biodiversidad y el cambio climático en la Enseñanza Segundaria," Real Jardín Botánico de Madrid-CSIC, Real Jardín Botánico Juan Carlos I Universidad de Alcalá.
Privet	*Ligustrum ovalifolium*	0.0013	"Nuevas metodologías para la enseñanza de la biodiversidad y el cambio climático en la Enseñanza Segundaria," Real Jardín Botánico de Madrid-CSIC, Real Jardín Botánico Juan Carlos I Universidad de Alcalá.

7. IMPACT OF UNCERTAINTY

The statistical uncertainty of the main activity data of tertiary sector activities such as gas, electricity and fuel consumption are subject to legislation on the control of measuring equipment involved in commercial operations. Royal Decree 889/2006 establishes the maximum errors that this measuring equipment can have, which are as follows:

Minimum accuracy requirements	
Meter type	**Maximum percentage of error**
Gas meter	3%
Electric energy meter	4%
Fuel meter	2.5%

For "direct emissions", "indirect emissions caused by imported energy", "emissions from transport of waste and artwork" where the activity data is subject to commercial operations, the organization considers that the uncertainty is very low and will simply ensure compliance with the legislation by requiring the supplier to provide current calibration certificates for the equipment when the emissions from the source are higher than 20%.

For emissions calculated on the basis of activity data that are not subject to commercial operations or for which it is not technically feasible to calculate the uncertainty, a qualitative assessment of the uncertainty is carried out as follows:

Direct and indirect emissions			
GHG emission/removal category	**Level of uncertainty**	**Description**	**Uncertainty reduction options**
Category 1: Direct emissions	Low	Activity data subject to commercial operation. The main uncertainty is one of method and scientific uncertainty.	None
Category 2: Power consumption	Low	Activity data subject to commercial operation. The main uncertainty is one of method and scientific uncertainty.	None
Category 3: Transportation	Medium	The main uncertainty is one of method and scientific uncertainty. Km traveled: Google Maps and worker survey.	None
Category 4: Use of products	Medium	Weight of transported waste according to logbook and museography material according to supplier invoice. Subject to legal commercial operation. Km traveled: Google Maps	None

8. MITIGATION ACTIVITIES

During 2021, the implementation of a number of reduction initiatives has allowed the organization to reduce electricity consumption and therefore reduce the indirect generation of GHGs per purchased energy. These include, in particular:

1. The replacement of fluorescent lamps with LEDs in emergency equipment. These luminaires have a power of 0.88 kW and 8760 hours of operation, and have led to a reduction of 7,708 kWh/year and 1.15 tons of CO_{2e}.

2. The completion of the replacement of the remaining cold water pumping units with new, more efficient pumps, allowing the elimination of the backflow preventer. Thanks to the installation of these pumps, the power consumption has been reduced by 16.9 kW, leading to a savings of 148,044.00 kWh/year and 22.21 tons of CO_{2e}.

3. The installation of motorized non-return valves and control loop in cold water pumps. With a power of 2.7 kW, electricity consumption is reduced by 23,652 kWh/year, and 3.54 tons of CO_{2e}.

4. The implementation of LED technology in exhibitions, which are intensive in electricity consumption. This type of more efficient luminaires, have a reduced consumption of 20 kW, thus contributing to savings of 66,000 kWh/year and 9.9 tons of CO_{2e}.

5. The modernization of the auditorium lighting with low consumption technology. The 3 kW reduction will mean a saving of 1,200 kWh/year, for the hours of use, and thus a reduction of 0.18 tons of CO_{2e}.

6. Installation of variable frequency drives on tower fans and condensation pumps, with an annual reduction of 148,920 kWh/year and therefore 22.34 tons of $CO_{2e.}$

Total avoided emissions from electricity consumption amount to 59tCO2e.

For the quantification of these results, the reduction of electrical power of the installations has been estimated based on direct measurements with ammeter clamp or by power difference of the replaced equipment and the length of operation of the equipment, through existing time meters, the museum calendar of opening hours or estimates made on the basis of the usual and continuous operation of the installations.

9. IMPROVEMENT ACTIONS

Furthermore, a number or actions are planned to reduce greenhouse gas emissions and improve the performance of the Guggenheim Museum Bilbao with a view to the year 2022.

These actions are articulated within the Guggenheim Museum Bilbao's Strategic Framework for Environmental Sustainability and along a series of strategic axes, the first of which is related to "climate change and energy efficiency".

The priority energy consumption reduction projects include modernizing the auditorium lighting with low energy consumption technology (LED), installing frequency variators in condensation pumps and replacing the backflow preventer system. The estimated annual savings from the modification of the auditorium lighting is 1,200 kWh, and the action on the condensation pumps will lead to an estimated annual saving of 87,600 kWh of electricity.

Also noteworthy is the project to ease the relative humidity control parameters from 2% to 5%, resulting in an estimated reduction of electricity and gas consumption of 10% and 30%, respectively.

Other planned actions include replacing the fluorescent lamps of the museum's downlighting equipment with LEDs. This action would not only contribute to the reduction of electricity consumption, it would also reduce the generation of hazardous waste, by reusing existing equipment. It is estimated that the replacement of these prototypes in the museum's luminaires will contribute to saving 38,880 kWh of electricity.

Lastly, and within a broader timeframe, we are studying alternatives for the installation of photovoltaic panels for the self-supply of electricity through renewable energy. Different locations for the installation are being evaluated, as well as its power capacity.