Deliverable 6.3 – Carbon footprint

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Deliverable 6.3 – Carbon footprint measurement and mitigation

TwInSolar

(Improving Research and Innovation to achieve a massive integration of Solar renewables)

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This document has been developed as part of the project titled "**TwInSolar – Improving research and innovation to achieve a massive integration of solar renewables**"

The TwInSolar project (September 2022 - November 2025) has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 10107647

Document information

Deliverable:	D 6.3
Work Package:	WP6 – Project management
Task:	Task 6.1 Project coordination
Author:	Mathieu DAVID
Document type:	Report
Dissemination level:	Public
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Revision

Version	Date	Author	Description of changes
V1	16-07-2025	Nora Czako	Drafting
V2	24-11-2025	Charles Voivret	Adding content to TwInSolar key impact pathways (WP4)
V3	24-11-2025	Josselin La Gal La Salle	Update content
V4	25-11-2025	Mathieu David	Typo corrections, layout formatting and minor modifications

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Executive summary

TwInSolar aims to strengthen the research and innovation capacities of the public laboratory PIMENT of the University of La Reunion (UR), located in one of the outermost regions of Europe. The project focuses on creating new opportunities within and outside Europe, particularly in areas surrounding Reunion Island and other insular territories facing similar challenges. It will achieve its objectives through collaborations with the Technical University of Denmark (DTU), the Fraunhofer Institute for Solar Energy Systems (Fraunhofer), and regional partners such as the Conference of Peripheral Maritime Regions (CPMR) and Nexa, a regional R&I agency of Reunion Island. The main goal of the project is to address challenges related to the large-scale integration of solar energy production in these territories.

Given the global emphasis on sustainability and the environmental impact of projects, understanding the carbon footprint of the TwInSolar project is vital for assessing its contribution to sustainability goals. This document outlines the estimated carbon footprint of the project, focusing on key activities, emissions and potential mitigation strategies. It also includes the expected impacts associated to the microgrid designed in WP4 as a result of research activities.

1. Carbon footprint estimation

To estimate the carbon footprint of TwInSolar, the primary sources of emissions will be identified, which may include:

Travel emissions

Estimation approach

Travel undertaken by project staff and researchers to attend meetings, missions, conferences and other project-related events—primarily between Reunion Island and Europe—represents a significant source of emissions. These journeys were mainly carried out by air, with limited use of ground transportation and other logistical mobility. Emissions from train travel and other forms of public transport were not estimated, as their contribution was negligible.

TwInSolar project events attended by the partners

University of La Réunion

No.	Mission	Place	No of the travellers	Date	Mode of travel	Round trip	Path	Participant	Partner	Emission kg
1	**WP1 - Task 1.1** ------ 1. Kick-off meeting Freiburg, Germany 19-20 Sept, 2022 2. Site visit#1 DTU Roskilde, Denmark 15-16 Sept, 2022 3. Site visit#2 Faunhofer Freiburg, Germany 19-20 Sept, 2022	Freiburg, Germany Roskilde, Denmark	1	13/09/2022-24/09/2022	Flight	Yes	St-Denis/Paris/Copenhagen/ Frankfurt/Freiburg	Josselin LE GAL LA SALLE	UR	1247,93
			2	17/09/2022-24/09/2022	Flight	Yes	St-Denis/Paris/Strasbourg/Freiburg	Philippe LAURET	UR	
			3		Train	Yes	Freiburg/Paris CDG		UR	1042,30
			4	13/09/2022-24/09/2022	Flight	Yes	St-Denis/Paris/Copenhagen/ Frankfurt/Freiburg	Delphine BARBARY	UR	1247,99
			5	13/09/2022-24/09/2022	Flight	Yes	St-Denis/Paris/Copenhagen/ Frankfurt/Freiburg	Jean CASTAING-LASVIGNOTTES	UR	1247,99
			6	13/09/2022-24/09/2022	Flight	Yes	St-Denis/Paris/Copenhagen/ Frankfurt/Freiburg	Mathieu DAVID	UR	1247,99
			7	13/09/2022-24/09/2022	Flight	Yes	St-Denis/Paris/Copenhagen/ Frankfurt/Freiburg	Vanessa DIJOUX	UR	1247,99
			8	13/09/2022-24/09/2022	Flight	Yes	St-Denis/Paris/Copenhagen/ Frankfurt/Freiburg	Jérôme VIGNERON	UR	1247,99

2	**WP2 - Task 2.3** --- Summer School DTU, Roskilde, Denmark 21-25 Aug 2023 **WP3 - Task 3.2** --- Fraunhofer Workshop#1 Roskilde, Denmark 21 Aug 2023	Rosklide, Denmark	9	18/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Béatrice MOREL	UR	1205,95
			10	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Mirhado ANDRIAMANDROSO	UR	1315,3
			11	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Johann FRANCOU	UR	1315,3
			12	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Michel BENNE	UR	1315,3
			13	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Jean CASTAING-LASVIGNOTTES	UR	1315,3
			14	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Chloé DURIF	UR	1315,3
			15	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Mathieu DAVID	UR	1315,3
			16	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Paulisimone RASOAVONJY	UR	1315,3
			17	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Nour MURAD	UR	1315,3
			18	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Faly RAMAHATANA	UR	1315,3
			19	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Jonhatan LANGE	UR	1315,3
			20	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Josselin LE GAL LA SALLE	UR	1315,3

3	**KPI (GA 2.1.2)** **------** Scentific - communication in international conferences: SOLAR WORD CONGRESS INDIA 2023	New Delhi, India	21	28/10/2023-05/11/2023	Flight	Yes	Réunion/Maurice/New Delhi	Mirhado ANDRIAMANDROSO	UR	838,65
4	**KPI (GA 2.1.2)** ------ Scentific - communication in international conferences: IEA PVPC TASK 16 + Workshop MSFWDES	Roskilde, Denmark	22	06/04/2024-15/04/2024	Flight	Yes	Réunion/Copenhague	Mathieu DAVID	UR	1265,19
			23	06/04/2024-14/04/2024	Flight	Yes	Réunion/Copenhague	Philippe Lauret	UR	1265,19
5	**WP4** ------ Meetings with Fraunhofer to discuss research projects (01 - 20 Sept 2024)	Freiburg, Germany	24	28/09/2024	Flight	One way	Paris/Réunion	Lionel TROVALET	UR	515,72

6	**KPI (GA 2.1.2)** --- Scentific - communication in international conferences: EU PVSEC 2024 Conference	Vienne, Austria	25	20/09/2024-28/09/2024	Flight	Yes	Réunion/Paris/Vienne	Josselin LE GAL LA SALLE	UR	1292,16
7	**KPI (GA 2.1.2)** --- Scentific - communication in international conferences: SASEC2024 conference	Johannesburg, South-Africa	26	12/11/2024-16/11/2024	Flight	Yes	St-Denis/Maurice/CapeTown/ Johannesburg	Béatrice MOREL	UR	779,03
8	**WP4** --- Meetings with Fraunhofer to discuss research projects (11 May - 15 June 2025)	Freiburg, Germany	27	11/05/2025-16/06/2025	Train	one way	Nice/Paris/Freiburg	Vincent BARBERA	UR	
			28		Train	one way	Freiburg/Bale			0
9	**KPI (GA 2.1.2)** --- Scentific - communication in international conferences: JNES 2025	Anglet, France	29	01/07/2025-23/07/2025	Flight	Yes	St-Denis/Paris/Biarritz	Philippe LAURET	UR	1309,41

10	**WP5 - Task 5.4** ------ International Workshop	Brussels, Belgium	30	30/09/2025	Flight	Yes	St-Denis/Paris/Brussels	Mathieu DAVID	UR	1074,19
			31	25/09/2025-04/10/2025	Flight, train	Yes	St-Denis/Paris/Brussels	Charles Voivret	UR	1074,19
11	**KPI (GA 2.1.2)** ------ Scentific - communication in international conferences: SWC2025	Fortaleza, Brazil	32	02/11/2025-10/11/2025	Flight	Yes	St-Denis/Johannesburg/Sao Paulo/Fortaleza	Mathieu DAVID	UR	2158,39
			33	02/11/2025-10/11/2025	Flight	Yes	St-Denis/Johannesburg/Sao Paulo/Fortaleza	Philippe LAURET	UR	2158,39
TOTAL									**UR**	**37934,94**

Fraunhofer ISE

No.	Mission	Place	No of the travellers	Date	Mode of travel	Round trip	Path	Participant	Partner	Emission kg
1	**WP1 - Task 1.1** --- 1. Site visit #3 UR La Réunion, 13-17 February, 2023 2. Round table with energy stakeholders #1 February 17, 2023 **WP1 -Task 1.2** --- 1.Best practise Workshop#1 February 14, 2023 **WP2 - Task 2.2.** --- Workshop#1 Part2 16 February, 2023	La Reunion	1	11/02/2023-18/02/2023	Train	Yes	Freiburg/Paris	Elke LORENZ	Fraun-hofer	1042,30
					Flight	Yes	Paris/St-Denis			
			2	11/02/2023-18/02/2023	Train	Yes	Freiburg/Paris	David MELGAR	Fraun-hofer	1042,30
					Flight	Yes	Paris/St-Denis			
2	**WP3 - Task 3.2** --- Fraunhofer Workshop#1 Roskilde, Denmark 21 Aug 20233	Rosklide, Denmark	3	20/08/2023-23/08/2023	Train	Yes	Freiburg/Roskilde	Elke LORENZ	Fraun-hofer	0

3	**WP3 - Task 3.3** --- Fraunhofer Summer School La Réunion 18-22 November 2024	St-Pierre, La Réunion	4	16/11/2024-23/11/2024	Train	Yes	Freiburg/Paris	Elke LORENZ	Fraun-hofer	1042,30
					Flight	Yes	Paris/St-Denis			
			5	16/11/2024-23/11/2024	Train	Yes	Freiburg/Paris	David MELGAR	Fraun-hofer	1042,30
					Flight	Yes	Paris/St-Denis			
			6	16/11/2024-23/11/2024	Train	Yes	Freiburg/Paris	Nils STRAUB	Fraun-hofer	1042,30
					Flight	Yes	Paris/St-Denis			
4	**WP5 - Task 5.4** --- International Workshop Brussels, Belgium	Brussels, Belgium	7	29/09/2025-30/09/2025	Train	Yes	Freiburg/Brussels	Elke LORENZ	Fraun-hofer	0
TOTAL									Fraun-hofer	5211,50

DTU

No.	Mission	Place	No of the travellers	Date	Mode of travel	Round trip	Path	Participant	Partner	Emission kg
1	**WP1 - Task 1.1** ------ 1. Kick-off meeting Freiburg, Germany 19-20 Sept, 2022 3. Site visit#2 Faunhofer Freiburg, Germany 19-20 Sept, 2022	Freiburg, Germany	1	18/09/2022-21/09/2022	Flight	Yes	Copenhaguen/Stutgartt	Peter POULSEN	DTU	244,0
			2	18/09/2022-21/09/2022	Flight	Yes	Copenhaguen/Stutgartt	Sergiu SPATARA	DTU	244,0
2	**WP1 - Task 1.1** ------ 1. Site visit #3 UR La Réunion, 13-17 February, 2023 2. Round table with energy stakeholders #1 February 17, 2023 **WP1 -Task 1.2** ------ 1.Best practise Workshop#1 February 14, 2023 **WP2 - Task 2.2.** ------ Workshop#1 Part2 16 February, 2023	La Reunion	3	11/02/2023-21/02/2023	Fight	Yes	Copenhaguen//Paris/St-Denis	Peter POULSEN	DTU	1315,30
			4	11/02/2023-21/02/2023	Flight	Yes	Copenhaguen//Paris/St-Denis	Sergiu SPATARU	DTU	1315,30
			5	11/02/2023-18/02/2023	Flight	Yes	Copenhaguen//Paris/St-Denis	Nicolaos CUTULULIS	DTU	1315,30
			6	11/02/2023-21/02/2023	Flight	Yes	Copenhaguen//Paris/St-Denis	Rodrigp DEL PRADO SANTAMARIA	DTU	1315,30
			7	11/02/2023-21/02/2023	Flight	Yes	Copenhaguen//Paris/St-Denis	Lucas MORINO	DTU	1315,30
			8	11/02/2023-21/02/2023	Flight	Yes	Copenhaguen//Paris/St-Denis	Martin BARTHOLOMAUS	DTU	1315,30

3	**WP3 - Task 3.3** --- Fraunhofer Summer School La Réunion 18-22 November 2024	St-Pierre, La Réunion	9	16/11/2024-23/11/2024	Flight	Yes	Copenhaguen//Paris/St-Denis	Jacop Krum Thorning	DTU	1315,30
TOTAL									DTU	9695,10

Nexa

No.	Mission	Place	No of the travellers	Date	Mode of travel	Round trip	Path	Participant	Partner	Emission kg
1	**WP1 - Task 1.1** ------ 1. Kick-off meeting Freiburg, Germany 19-20 Sept, 2022 2. Site visit#1 DTU Roskilde, Denmark 15-16 Sept, 2022 3. Site visit#2 Faunhofer Freiburg, Germany 19-20 Sept, 2022	Freiburg, Germany	1	18/09/2022-21/09/2022	Flight	Yes	St-Denis/Paris/Freiburg	Evelyne TARNUS	Nexa	1042,30
2	**WP2 - Task 2.3** ------ Summer School DTU, Roskilde, Denmark 21-25 Aug 2023 **WP3 - Task 3.2** ------ Fraunhofer Workshop#1 Roskilde, Denmark 21 Aug 2023	Rosklide, Denmark	2	20/08/2023-27/08/2023	Flight	Yes	St-Denis/Paris/Copenhague	Evelyne TARNUS	Nexa	1315,30
TOTAL									**Nexa**	**2357,60**

CPMR

No.	Mission	Place	No of the travellers	Date	Mode of travel	Round trip	Path	Participant	Partner	Emission kg
1	**WP1 - Task 1.1** ------ 1. Kick-off meeting Freiburg, Germany 19-20 Sept, 2022 3. Site visit#2 Faunhofer Freiburg, Germany 19-20 Sept, 2022	Freiburg, Germany	1	18/09/2022-21/09/2022	Train	Yes	Lyon/Freiburg	Nidaa BOTMI	CPMR	0
2	**WP1 - Task 1.1** ------ 1. Site visit #3 UR La Réunion, 13-17 February, 2023 2. Round table with energy stakeholders #1 February 17, 2023 **WP1 -Task 1.2** ------ 1.Best practise Workshop#1 February 14, 2023 **WP2 - Task 2.2.** ------ Workshop#1 Part2 16 February, 2023	La Reunion	2	11/02/2023-21/02/2023	Fight	Yes	Brussels/Paris/St-Denis	Claire HELLY	CPMR	1074,19

3	**WP2 - Task 2.3** --- Summer School DTU, Roskilde, Denmark 21-25 Aug 2023 **WP3 - Task 3.2** --- Fraunhofer Workshop#1 Roskilde, Denmark 21 Aug 2023	Rosklide, Denmark	3	18/08/2023- 27/08/2023	Flight	Yes	Brussels/Copenhaguen	Claire HELLY	CPMR	178,00
TOTAL									CPMR	1252.19

Carbon footprint analysis for TwInSolar project

The table below gives an overview of direct CO_2 emissions from the project TwInSolar. They are all estimated with online tools easily and publicly available. As expected, the travels represent almost 99.5% of the total CO_2 emission. The organisation of numerous events using online possibilities allows limiting significantly the carbon footprint of the project.

	Unitary emission kg CO_2/unit	Quantity	Total emission kg CO_2	Comments
Online workshops/webinars	2	13	26	Average 30 participants with video and audio
Online meetings	1.5	40	60	Average 5-10 participants with audio and video
Emails	0,01	10,000	100	With 1Mo attachment
Website (visits)	0,00041	1500	0,615	
Online repository (TEAMS)	0,00066	75000	49,5	25 GO of storage for 3 years
Travels	Destination dependant	54	56.451,33	See tables above
TOTAL			**56.687,45**	

1. **Coordinator: University of La Réunion**

The TwInSolar project, which aimed to enhance visibility and strengthen partnerships, involved multiple trips both within Europe and beyond. Over the 39-month project period, **33 staff members from the University of La Réunion** travelled to the project partners at **DTU** or **Fraunhofer** or attended conferences to present project results.

Given that **La Reunion is geographically distant from Europe**, the associated travel-related emissions were higher than those of a project based entirely within Europe. Over the course of the project, a total of **37,934.94 kg CO_2** was emitted, calculated based on **air travel**, which was the primary mode of transport.

Only minimal travel by train or other public transport occurred, and **emissions from these modes were not included in the calculation**.

Analysis:

- The high CO_2 emissions are primarily attributable to long-haul flights.
- The emissions reflect the geographical constraints of conducting a European-funded project from a remote overseas region.
- While air travel was necessary for effective collaboration, project visibility and presenting results, many of our events, workshops and other activities were made accessible online or held virtually, following our mitigation strategy. **Only 11 missions required university staff to travel**, which represents less than half of all events and trainings organized during the project.
- Overall, the carbon footprint highlights the **trade-off between international collaboration and environmental impact**, underlining the importance of integrating sustainability measures into project planning.

The TwInSolar travel-related CO_2 emissions (cca. 37,9 tonnes over the project period) **are not particularly high**, especially for a project requiring multiple international trips and events.

The per-person emissions (approx. 1,15 tonnes over 39 months → cca. 0,37 t/year) are lower than the annual travel emissions of many academic conference participants at certain institutions.

Only 11 missions required university staff to travel, while many events, workshops and activities were accessible online, helping to keep the total emissions **relatively controlled**.

Overall, the analysis shows that TwInSolar has already implemented **sustainability strategies**, but there remains potential for further reduction (e.g., more virtual participation, optimizing necessary travel).

2. **Partners: Fraunhofer ISE, DTU, Nexa, CPMR**

For key project events, such as the kick-off meeting, study visits, some workshops, summer schools and the final event in Brussels, partners participated in person. These participations, mainly in La Reunion resulted in 21 long-haul flights, resulting in a total emission of **18.516,39 kg CO_2**.

Energy consumption for research and infrastructure

Throughout the entire project duration, energy consumption remains a relevant factor in the carbon footprint, as the developments achieved within the project will not have an impact on energy use during the project period, neither for the coordinating institution nor for the project partners.

At the same time, project members are mindful of energy-saving practices within their respective institutions, acting responsibly and making efforts to reduce consumption wherever possible, in line with the available infrastructure and internal sustainability measures.

Material and resource use

The materials required for project activities, such as solar panels, instruments, tools and other related resources can contribute to the carbon footprint. However, no new equipment purchases, or infrastructure investments were funded during the project, existing equipment was used.

Project members consciously focus on reducing resource use within their own institutions, to the extent possible, promoting responsible consumption.

Waste generation

Waste generated from research activities, events, and dissemination efforts (conferences, workshops, meetings) can theoretically contribute to indirect emissions, including paper waste and other materials.
However, in the TwInSolar project, no detailed measurement or estimation of emissions from waste was carried out, as the amount of waste generated was negligible, and no additional waste was produced as a direct result of the project's outcomes.

2. Carbon footprint calculation methodology

Scope of emissions

Emissions generated by the project are classified according to the internationally recognized GHG Protocol (Greenhouse Gas Protocol) into three main categories: Scope 1, Scope 2, and Scope 3. This section explains which emissions were considered in the TwInSolar project and which were not.

- Scope 1 Direct emissions:
  The project did not own or control vehicles or facilities, so no direct emissions arose from project-owned sources.
- Scope 2 Indirect emissions from energy consumption:
  This includes emissions from electricity used for project-related activities at partner institutions. The project's development activities did not affect energy consumption during the project period, as partners used existing facilities and equipment.
- Scope 3 Other indirect emissions:
  This includes emissions from the broader supply chain, primarily air travel for meetings, missions, conferences, and events. Train, bus, or other forms of transportation were not included, as they occurred only in negligible amounts. Emissions from material production and logistics were negligible because no new equipment or infrastructure was purchased, and waste generation was minimal.

Importance of the categorization:

For the TwInSolar project, this classification provides a transparent overview of the project's carbon footprint, enabling comparison with other research projects or institutions. It also highlights the areas where the most significant impact on emission reduction can be achieved. The Scope framework helps organize the direct and indirect emissions generated during TwInSolar and supports sustainability-focused decision-making throughout the project's implementation.

3. Mitigation measures

To reduce the carbon footprint, several mitigation measures can be implemented:

Reduction in travel emissions

Actions:

- **Encourage virtual meetings and use of online collaboration tools:**
  We organised 13 online or hybrid events where physical presence was not necessary (virtual alternative). The total number of people reached through these events approached 600. We promoted hybrid participation options to reduce the need for participants to travel, offering remote access to selected workshops and meetings.
- **Plan and combine trips:**
  Whenever possible, multiple meetings, workshops, or other project tasks were planned and combined into a single trip. This approach helped reduce the total number of flights while ensuring that travel for project activities was efficient and aligned with other ongoing tasks.
- **Prioritise local venues and regional participation:**
  Whenever in-person meetings or events were required, we prioritised local venues and suppliers and encouraged participants from nearby institutions or regional partners to attend. This approach helped minimise travel-related emissions and reduce the need for long-distance travel.
- **Encourage sustainable commuting for local staff:**
  For travel within the same city or region, staff were encouraged to use public transport, walking or shared options such as rented buses instead of private cars. Particular attention was paid when organising events to ensure that venues were easily, conveniently, and sustainably accessible.
- **Conduct project meetings online:**
  All internal project meetings were conducted online, and coordination was managed through email communication.
- **Opt for more sustainable travel modes when necessary:**
  When travel was unavoidable, we preferred more sustainable options such as shared transport.
- **Reduce the overall number of trips:**
  The total number of trips undertaken as part of the project was carefully limited to what was strictly necessary.
- **Travel tracking and awareness:**
  Keep a record of all trips and raise awareness among participants about the carbon impact of each journey, motivating conscious travel decisions.

Energy efficiency and renewable energy use

Although the TwInSolar project did not directly affect energy consumption during its implementation, partner organizations were conscious of their energy use and sought to adopt responsible practices within their existing facilities.

Actions:

- **Use existing infrastructure and equipment:**
  Partners relied on existing laboratories, offices, and equipment, avoiding new purchases that could increase energy demand.
- **Energy-conscious operation:**
  Staff were encouraged to switch off lights and devices when not in use and to schedule lab and office work efficiently to minimise unnecessary energy consumption.
- **Adoption of energy-saving measures:**
  Where possible, partners applied energy-saving technologies already available in their institutions.
- **Promotion of renewable energy:**
  The University of La Reunion and other partners continued to explore the use of renewable energy sources, including potential solar energy solutions, to support sustainability goals.
- **Awareness and responsible behaviour:**
  Partners actively promoted energy-conscious behaviour among project members, ensuring responsible consumption within the limits of the project's operations.

Sustainable material choices

In the TwInSolar project, **no new equipment purchases, or infrastructure investments were funded**, and existing materials and resources were used wherever possible. As such, the project's direct impact on material-related carbon emissions was minimal. Nevertheless, the project promoted **responsible and sustainable use of materials** within partner institutions.

Actions:

- **Use existing equipment and materials:**
  All project activities relied on existing laboratories, instruments and office equipment, avoiding additional carbon emissions from production and transport.
- **Responsible resource management:**
  Partners were encouraged to minimise waste, reuse materials where possible and ensure proper disposal according to environmental guidelines.
- **Local sourcing when necessary:**
  If any materials were needed, preference was given to locally available resources to reduce transportation-related emissions.
- **Promote awareness:**
  Project members were informed about sustainable material choices and encouraged to apply environmentally conscious practices in their institutions.
- **Using recyclable and biodegradable materials** where possible.

Although TwInSolar did not involve large-scale material procurement, the project maintained a **low material-related carbon footprint** by relying on existing resources and promoting **responsible, sustainable practices**.

Waste management practices

The TwInSolar project generated **no additional waste** as a direct result of project activities, as most activities relied on existing materials and resources and no new equipment or infrastructure was purchased. Nevertheless, the project aimed to maintain responsible and sustainable waste practices during organizational activities and events.

Actions:

- **Digital-first approach:**
  Documents, reports and communication materials were shared digitally to reduce printing and physical distribution.
- **Dedicated project website:**
  A project website was created where all documents and event-related materials were available for easy access by participants and other interested parties.
- **No printed marketing or promotional materials:**
  No flyers, brochures or branded merchandise were produced, minimizing additional waste.
- **Event planning with sustainability in mind:**
  Particular attention was paid to ensure that event venues were accessible in an environmentally friendly way and physical events were organised to generate minimal waste.
- **Waste sorting and recycling:**
  At physical events, clearly marked recycling and compost bins were available to encourage proper waste separation.
- **Sustainable catering and event management:**
  For any in-person workshops or events, choose local and seasonal catering, reduce single-use plastics and encourage waste separation and recycling.
- **Reduction of printed materials:**
  Event agendas, presentations and handouts were provided in digital format whenever possible.
- **Electronic dissemination of project outputs:**
  All dissemination activities were carried out exclusively via electronic channels, including newsletters, direct emails, the project website and LinkedIn posts.
- **Digital availability of training materials:**
  Training materials were made available through multiple digital platforms, such as the project YouTube channel, website or via email, ensuring no paper copies were needed.
- **Digital workflows and archiving:**
  All internal work processes and document archiving were conducted exclusively in digital form.
- **Awareness among participants:**
  Participants were encouraged to adopt responsible waste practices, such as using digital resources over paper and properly disposing of any unavoidable waste.

The TwInSolar project **maintained a very low waste footprint**, as all activities relied on existing resources and no new equipment or materials were purchased. By prioritising digital workflows, electronic dissemination and responsible event planning, the project successfully minimized any environmental impact related to waste while promoting sustainable and conscious practices among all participants.

4. Carbon footprint reporting and monitoring

During the TwInSolar project, the carbon footprint was **assessed retrospectively**, based on actual activities carried out over the project period. The focus was on emissions from key sources, particularly **air travel, energy use in partner facilities and minimal material consumption**.

- **Travel emissions:** Calculated based on flights undertaken by project staff for missions, meetings, workshops and conferences. Other forms of transport, such as train or bus were negligible and not included in the calculations.
- **Energy and material use:** Only existing equipment and infrastructure were used, so **no additional emissions** were associated with new resource consumption.
- **Waste:** The project did not produce additional waste as a direct result of its activities; all workflows, archiving and dissemination were carried out digitally.

The assessment provides a **clear overview of the project's environmental impact** and allows the TwInSolar team to **identify the main sources of emissions** and potential mitigation strategies. Furthermore, the **positive environmental contribution** of the project (through promoting solar energy solutions in insular regions) is highlighted, demonstrating that TwInSolar contributes to broader sustainability objectives by supporting **clean energy integration**.

5. Conclusion

The TwInSolar project has carefully integrated **sustainability considerations** into its operations, research activities and dissemination efforts, with the goal of **minimising its carbon footprint**.

The primary source of emissions during the project was **air travel**, necessary for staff missions, meetings, workshops and conferences.

Other potential emission sources, including **energy use, material consumption, and waste generation**, were very limited due to the project's reliance on **existing equipment, digital workflows and electronic communication and dissemination**. No new infrastructure or equipment was purchased and all internal processes, archiving and sharing of project outputs were carried out digitally, further reducing environmental impact.

TwInSolar implemented a range of **mitigation measures** to limit its emissions. These included:

- **Digital-first communication** for newsletters, emails, social media and training materials;
- **Hybrid and online events** to reduce the need for physical travel;
- **Sustainable event planning**, prioritising venues accessible via public transport or shared transport options;
- **Responsible use of existing materials**, avoiding additional resource consumption;
- **Awareness-raising among participants** about energy-efficient and waste-conscious practices.

These actions demonstrate that, even for a project requiring international collaboration and travel, it is possible to **actively reduce environmental impact** through careful planning and sustainable practices.

Given TwInSolar's focus on **solar energy research and the promotion of renewable energy integration in insular and peripheral regions**, the project contributes positively to **broader sustainability objectives**. Beyond the project's limited direct emissions, it supports the transition to **clean energy**, provides knowledge and capacity for future renewable energy projects and sets a **practical example** for other international and inter-institutional research initiatives.

In conclusion, while the TwInSolar project did generate some unavoidable emissions, its comprehensive approach to **digitalization, responsible resource use and sustainable planning** ensured that its overall environmental footprint was minimized. By combining cutting-edge solar research with conscientious operational practices, TwInSolar demonstrates that research projects can **achieve scientific objectives while promoting sustainability** and can serve as a **benchmark for future initiatives** of similar nature.

6. TwInSolar developments and achievements: project outcomes in the context of carbon footprint

As described in the Work Package 4, the ERMESS algorithm identified a microgrid design that permit to reach 80% of electric self-sufficiency. This design is based on the installation of 692 kWp of new photovoltaic capacity, and on the installation of a lithium-ion battery of 3.18 MWh (capable of delivering a power of 305 kW), to better align production with consumption profiles.

The question of the comparison of the environmental performances between the two designs – with or without the installation of the systems recommended by ERMESS – is studied here.

On one hand, this installation of new systems leads to subsequent CO_2 emissions due to construction, importation and maintenance. On the other hand, these installations decrease the need for energy importation from the main grid. Yet, the main grid electricity in La Réunion is substantially produced from thermal power plants, emitting significant levels of CO_2. ERMESS can also assess the environmental performances of the recommended design. The reduction in CO_2 emissions is estimated to 488 tCO_2/year. With a lifetime expectancy of the storage and production systems of 17.5 years, we can evaluate the global reduction in CO_2 emissions of the new design to 8545 tCO_2.

7. Future strategy, continuous improvement and long-term sustainability

Building on the experiences and lessons learned during the TwInSolar project, the consortium is committed to **continuing sustainability and environmental awareness** in all future initiatives. While the project itself produced minimal emissions, it demonstrated that **research excellence and environmental responsibility** can go hand in hand. Future projects will integrate **eco-conscious practices** from the outset, ensuring that sustainability and carbon footprint reduction remain central objectives.

The **partnerships and networks** established during TwInSolar will be leveraged to develop further research initiatives in the field of **renewable energy**, expanding the consortium's impact in both European and global contexts. Future projects will continue to **promote solar energy integration**, support the **transition to clean energy** and explore innovative solutions for **energy efficiency and low-carbon technologies**.

By applying the practical experience, **digital workflows, mitigation strategies** and responsible practices developed in TwInSolar, future initiatives will aim to **maximize environmental responsibility** while maintaining high scientific and technical standards. This includes continuing **digital-first communication, sustainable event planning, responsible resource use and low-waste approaches**.

The project team is committed to ensuring that **sustainability becomes a core feature** of all research, dissemination and collaboration activities, serving as a **benchmark for environmentally conscious research projects** in the renewable energy sector. Lessons learned, best practices and research findings will continue to be **shared with policymakers, industry partners and the wider scientific community**, supporting the adoption of low-carbon strategies and renewable energy solutions, particularly in peripheral and insular regions.