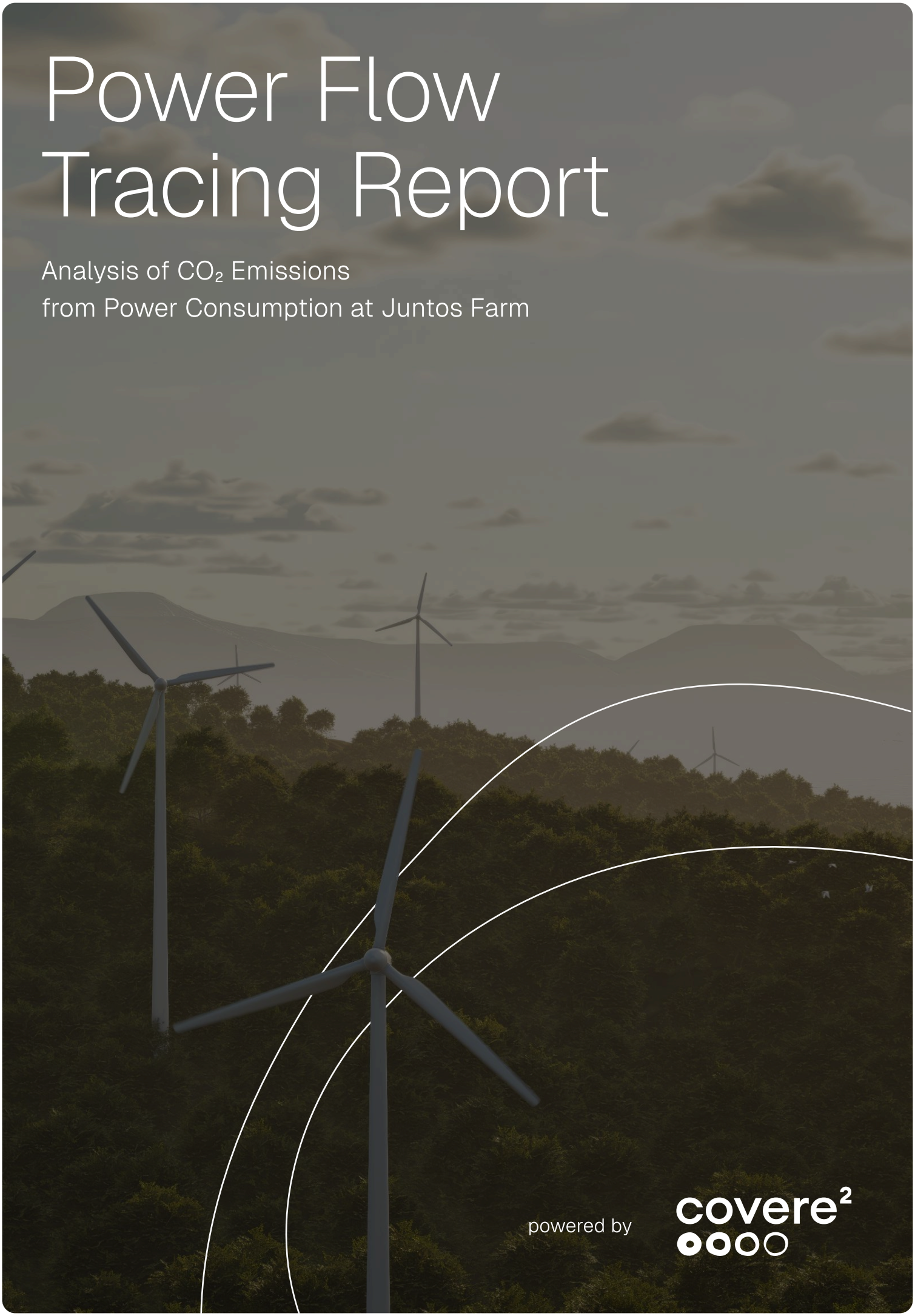
Power Flow Tracing Report

Analysis of CO_2 Emissions
from Power Consumption at Juntos Farm



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Power Flow Tracing Report

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Report for

Juntos Farm

Date

14.06.2025

Industry

Food

Location

Ibiza

Coordinates

39.02186, 1.44464

Table of Content

What is Power Flow Tracing?

Power Flow Tracing (PFT) encompasses a set of methodologies designed to calculate power transfers from individual generation points to specific consumption points or branches. Initially developed to allocate costs associated with transmission losses, PFT has become highly relevant in the field of sustainability, particularly for determining the fuel mix of power consumption at specific points on the power grid. Knowing the fuel mix of consumed power in turn enables to determine the specific carbon footprint arising from power consumption at a certain point of the power grid.

Why is Power Flow Tracing Essential to achieve Net-Zero Goals?

Europe's certification frameworks, such as Guarantees of Origin (GO) and Renewable Energy Certificates (REC), provide mechanisms for tracing and certifying electricity and its characteristics. However, these schemes are decoupled from the physical flow of electricity and often lack the temporal and locational granularity needed for precise tracking.

Power Flow Tracing fills this gap by offering a more granular and accurate approach. It enables stakeholders to trace the movement of electricity across the grid while incorporating emissions data, making it a critical tool for organizations striving to meet Net-Zero commitments.

ELEKS DAKAR Technology: Certified Excellence

The PFT functionality of ELEKS' power grid simulation tool DAKAR features an approach that is deeply rooted in foundational PFT scientific literature. As one of ELEKS' oldest and most sophisticated products, DAKAR's importance has grown significantly due to the combined pressures of geopolitical challenges and the global Net-Zero agenda.

In 2024, the renowned Fraunhofer Institute for Applied Information Technology FIT thoroughly examined the scientific foundation of ELEKS DAKAR PFT and compared it to other methods in practice. The research provides a comprehensive assessment of its effectiveness and its scientific underpinning. The publication of this research is available open source.

Power Flow Tracing: Results from Juntos Farm

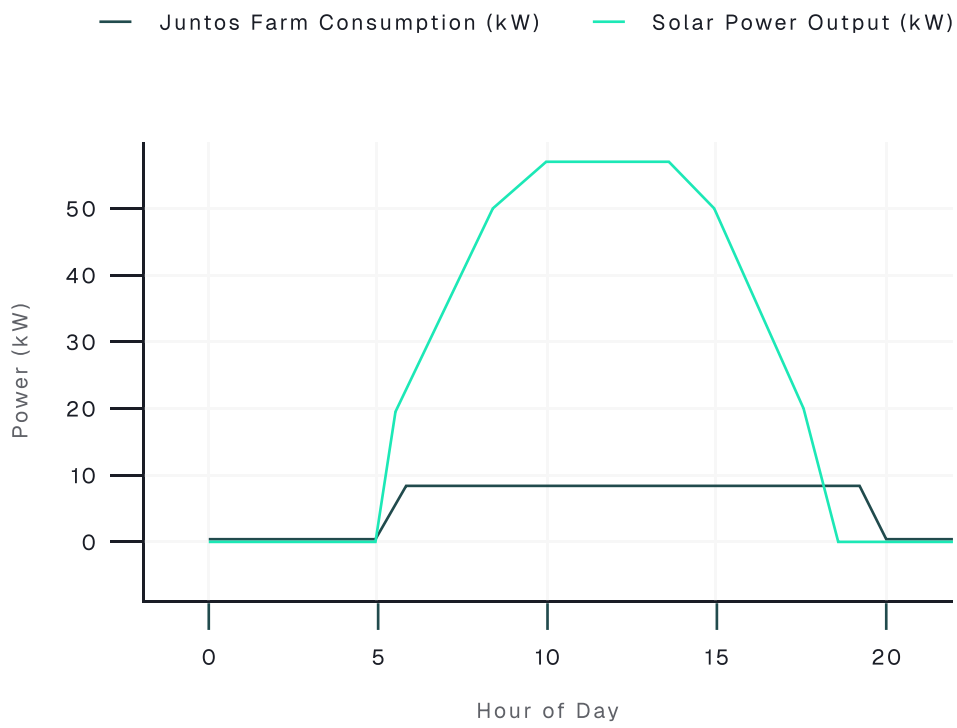
A Power Flow Tracing (PFT) analysis was conducted in June 2025, at the request of Juntos Farm, located at the coordinates **39.02186°N, 1.44464°E.** The objective was to assess the carbon intensity of electricity consumed at the farm under grid-connected conditions and with considering the farm rooftop Solar Power Plant.

The results indicate that the carbon footprint of electricity supplied to Juntos Farm from the grid is **549.7 g CO_2/kWh**. This value is markedly higher than the national average electricity carbon intensity of **293 g CO_2/kWh**, as publicly reported. The discrepancy suggests that the specific energy mix delivered to the farm, based on real-time grid conditions and location, has a significantly higher carbon content, nearly double the national average.

This granular, location-specific footprint - enabled by Power Flow Tracing - provides a critical reference point for evaluating the impact of local renewable energy deployment. When utilizing the full production capacity of the on-site **67.2 kW** solar power plant, the carbon footprint of electricity consumption at the farm is reduced to **26 g CO_2/kWh**.

During the assessment period (June), the integration of solar energy resulted in an approximate **95% reduction in emissions** associated with electricity use.

Furthermore, daytime solar generation consistently exceeded the farm's electricity consumption, **presenting opportunities for energy storage or feed-in to the grid**.



Solar Panel Output

Assumptions & Data Transparency

The carbon footprint results presented in this report are based on a calculation valid exclusively for the month of June 2025. The analysis assumes the scheduled power output of a rooftop solar installation located in Ibiza and relies on a simplified model of the farm's electricity consumption patterns (see Additional Data and Figures section on page 12).

These assumptions were made to enable a preliminary estimation of the impact of solar energy integration at Juntos Farm. As such, results should be interpreted as indicative rather than definitive, and further data collection across different time periods and operating conditions is recommended for comprehensive assessment.

In this report, when referring to data obtained from publicly available or open sources, this specifically denotes information retrieved from the reference platform Electricity Maps, which provides data on electricity generation and associated emissions primarily at the national level. (source: https://app.electricitymaps.com/map/72h/hourly)

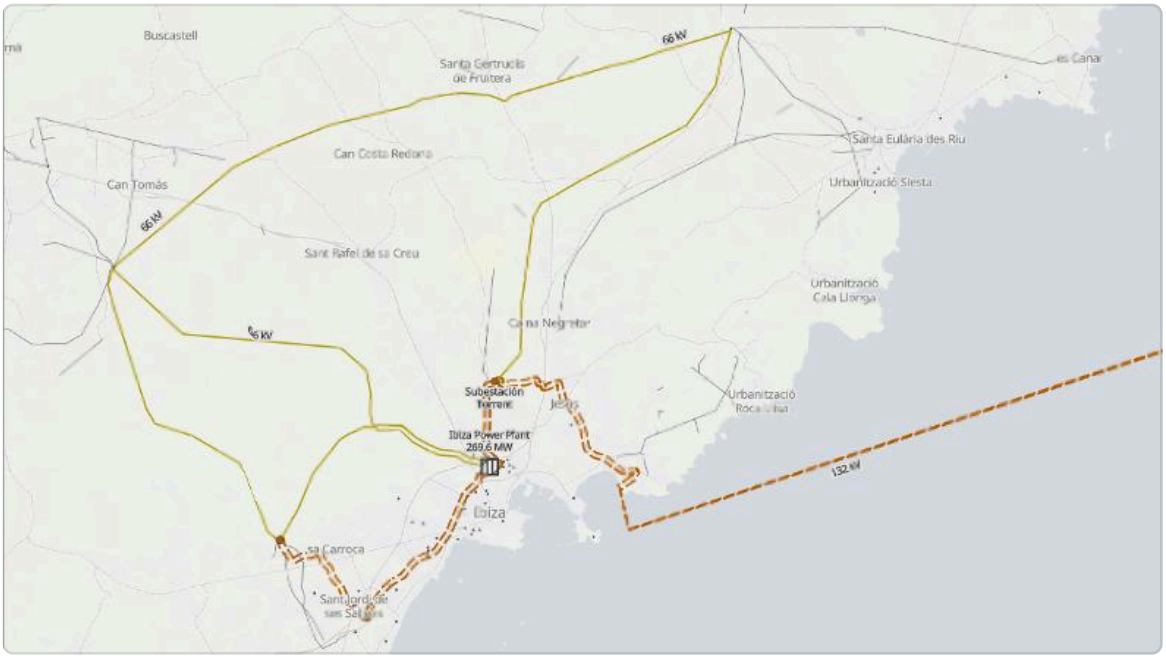
Power Flow Tracing: Mapping the Ibiza Power System

To initiate the Power Flow Tracing (PFT) analysis, the structure of the electricity supply system serving the island of Ibiza was mapped to identify relevant sources of power. Electricity reaching Ibiza originates from two primary sources:

Local Generation: Ibiza Power Plant

Ibiza hosts a local thermal power plant with an installed capacity of **269.6 MW**, operating primarily on natural gas.

The average carbon intensity of electricity generated by this plant is approximately **691 g CO_2/kWh**, based on publicly available emissions data.



Map of the Power Network around Ibiza Power Plant

Electricity Imports from Mainland Spain via Mallorca

In addition to local generation, Ibiza receives electricity through an interconnection with mainland Spain, routed via the island of Mallorca.

According to publicly available data, the carbon intensity of electricity transmitted from Spain to Mallorca is approximately **109 g CO_2/kWh**.

The subsequent transmission from Mallorca to Ibiza results in a higher estimated carbon intensity of **293 g CO_2/kWh**, reflecting both the regional energy mix and transmission-related losses.

These values were integrated into the Power Flow Tracing model to accurately represent the imported electricity's contribution to the overall carbon footprint at the point of consumption on Ibiza.

Map of the Power Network in Mallorca

This foundational mapping provides the basis for the Power Flow Tracing model used to determine the location-specific carbon footprint of electricity consumed at Juntos Farm.

Power Flow Tracing: CO_2 Emissions Calculation and Comparison with National Average

As part of the Power Flow Tracing (PFT) analysis, CO_2 emissions were calculated for electricity transmitted from mainland Spain to a substation in Mallorca receiving approximately **190 MW** of power. The calculation was performed using the ELEKS DAKAR simulation tool and is based on actual grid topology and energy flow dynamics.

The results indicate that electricity delivered to Mallorca via interconnection with the Spanish mainland has a carbon intensity of **452.2 g CO_2/kWh**. This figure **is 4.15 times higher** than the national average emission factor of **109 g CO_2/kWh**, as reported in publicly available sources on Spain's energy system.

Load (MW)	Generation Summary (MW)	Emission Summary (kg/h)
189,2	189,2	189,2

Generation Type Name	Power (MW)		Average Emission (g/kWh)	Emission (kg/h)
61 Gas-fueled TPPs, natural gas	164,589	86.74%	520,000	85586.2
80 nuclear power plants, enriched uranium	17,059	8.99%	5,000	85.3
03 SolarPP Photovoltaics	4,658	2.45%	26,000	121.1
06 GAPP	3,233	1.70%	4,000	12.9
01 WindPP onshore	0.176	0.09%	13,008	2.3
05 HPP (without GAPP)	0.028	0.01%	11,006	0.3
452.2 g CO_2/kWh				

Power generation mix and associated CO_2 emissions for electricity supplied to Mallorca (Node Name: HVDC Son Bugadelles). Power generation mix and associated CO_2 emissions for electricity supplied to Mallorca (189.2 MW total load), based on Power Flow Tracing using ELEKS DAKAR. Gas-fueled thermal power plants account for the majority of power generation (86.74%), contributing significantly to the total emissions. The resulting average carbon intensity is calculated at 452.2 g CO_2/kWh.

Subsequently, the Power Flow Tracing analysis was applied to calculate the carbon intensity of electricity consumed at **Juntos Farm** in Ibiza. Based on the modeled energy flows and grid configuration, the electricity supplied to the farm was found to result in **549.7 g CO_2/kWh**. This value is almost double (**88% higher**) than the national average carbon intensity of **293 g CO_2/kWh**, as reported in open-source.

The discrepancy highlights the importance of location-specific and real-time analysis, as aggregate national averages may significantly underestimate the actual carbon footprint of electricity at the point of consumption.

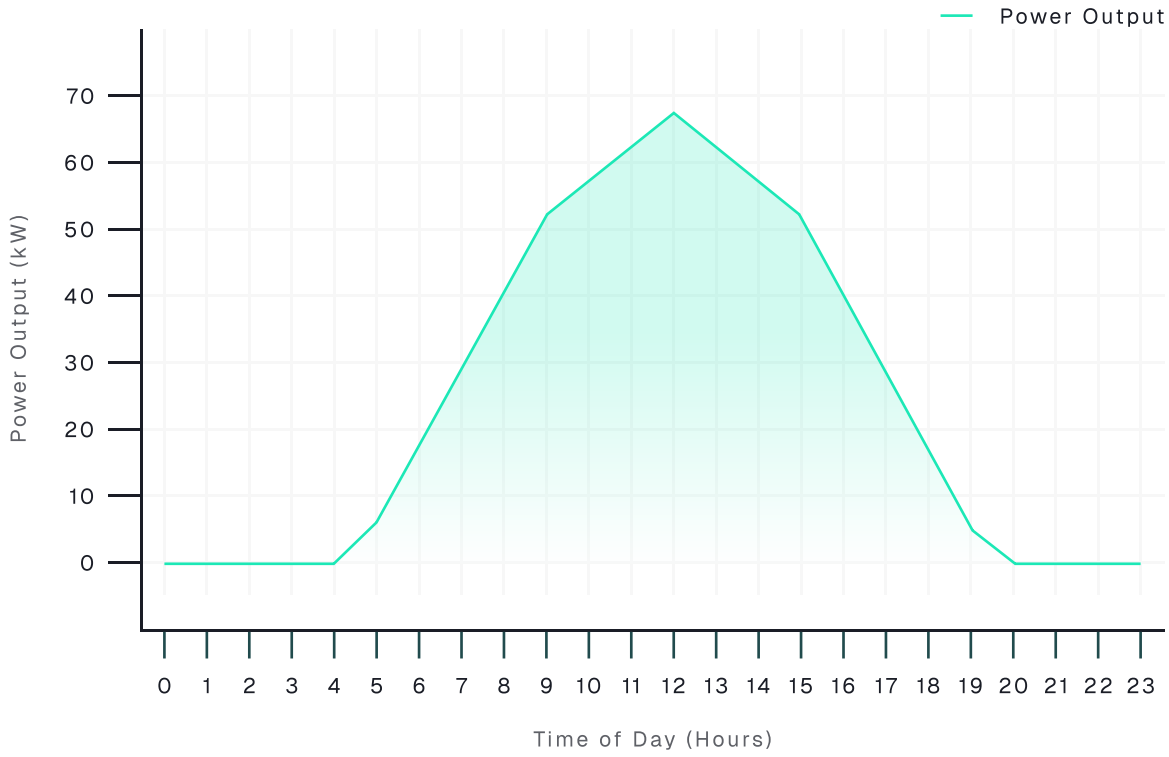
Load (MW)	Generation Summary (MW)	Emission Summary (kg/h)
0.01131	0.014160	7.7840

Generation Type Name	Power (MW)		Average Emission (g/kWh)	Emission (kg/h)
61 Gas-fueled TPPs, natural gas	0.0072730	51.36%	520,0	3.8
61 Gas-fueled TPPs, natural gas (Ibiza)	0.0057780	40.81%	691,0	4.0
80 nuclear power plants, enriched uranium	0.0007540	5.32%	5,305	0
03 SolarPP Photovoltaics	0.0002060	1.45%	24,272	0
06 GAPP	0.0001430	1.01%	6,993	0
01 WindPP onshore	0.0000070	0.05%	0	0
05 HPP (without GAPP)	0.0000010	0.01%	0	0

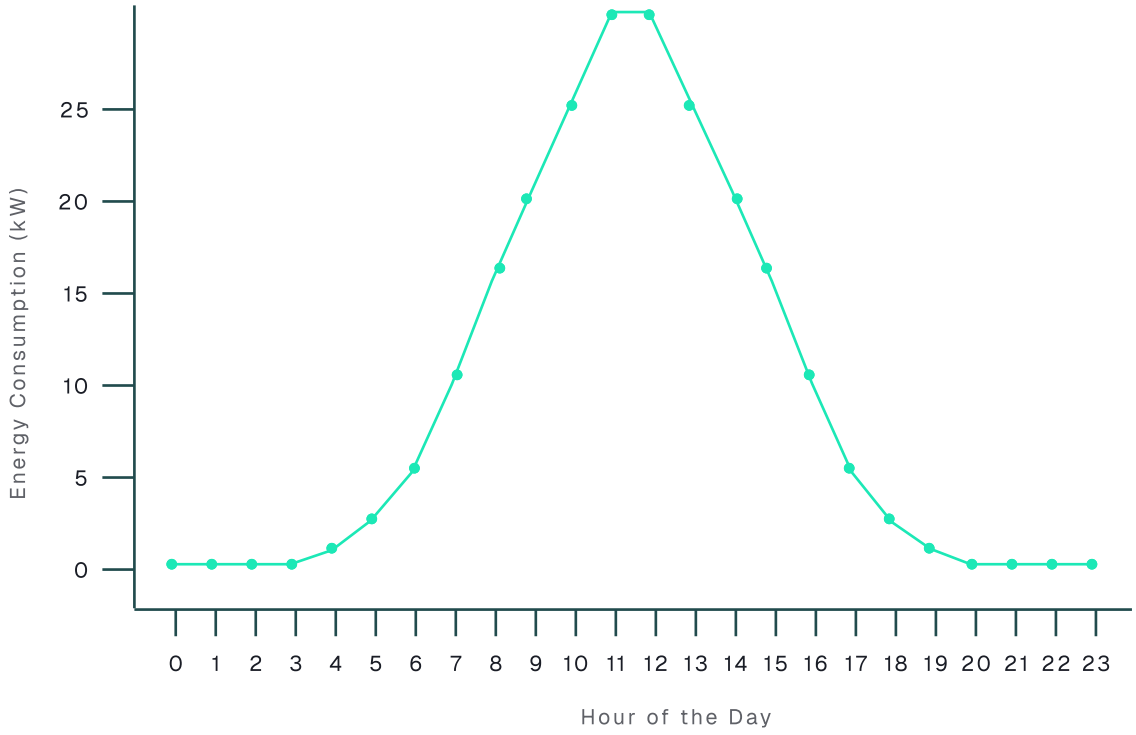
549.7 g CO_2/kWh

Power generation mix and associated CO_2 emissions for electricity consumed at Juntos Farm (Node Name: Juntos Farm). Power generation mix and associated CO_2 emissions for electricity consumed at Juntos Farm (0.01131 MW load), based on Power Flow Tracing using ELEKS DAKAR. The majority of power is supplied by gas-fueled thermal power plants, including local generation in Ibiza (40.81%) with a high carbon intensity of 691 g CO_2/kWh. The resulting average carbon footprint of electricity at Juntos Farm is 549.7 g CO_2/kWh, significantly higher than the national average.

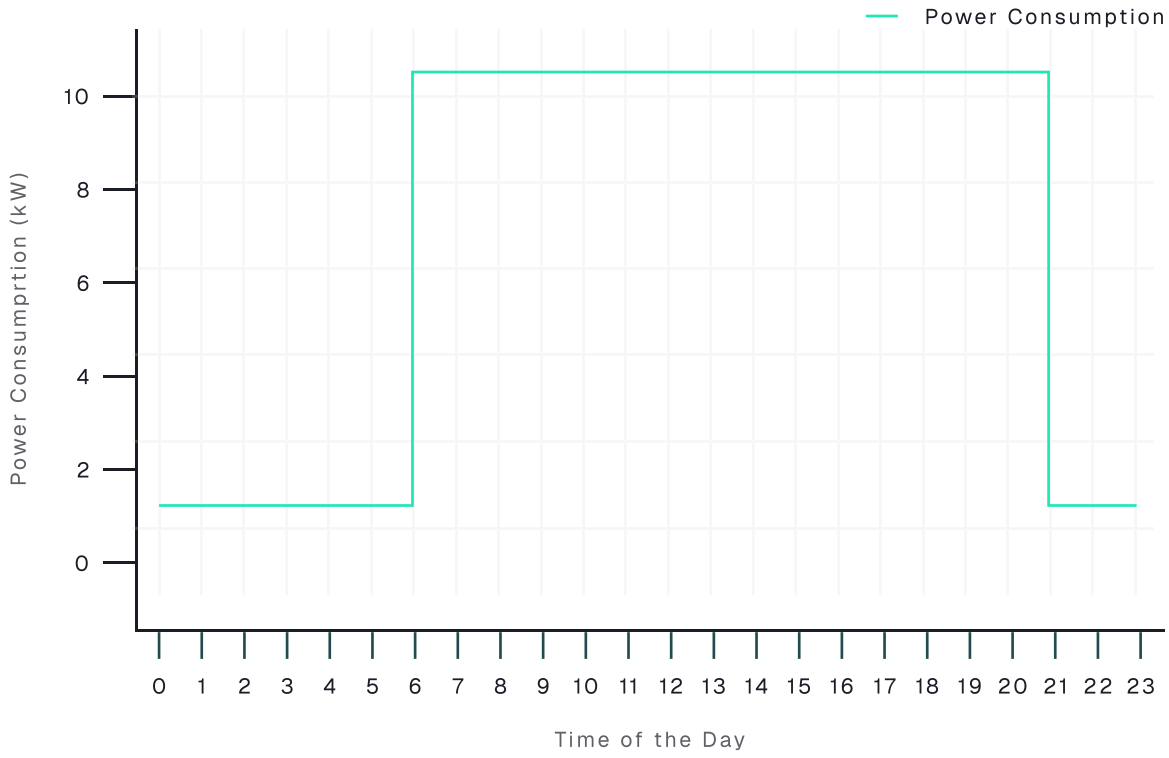
Additional Data and Figures



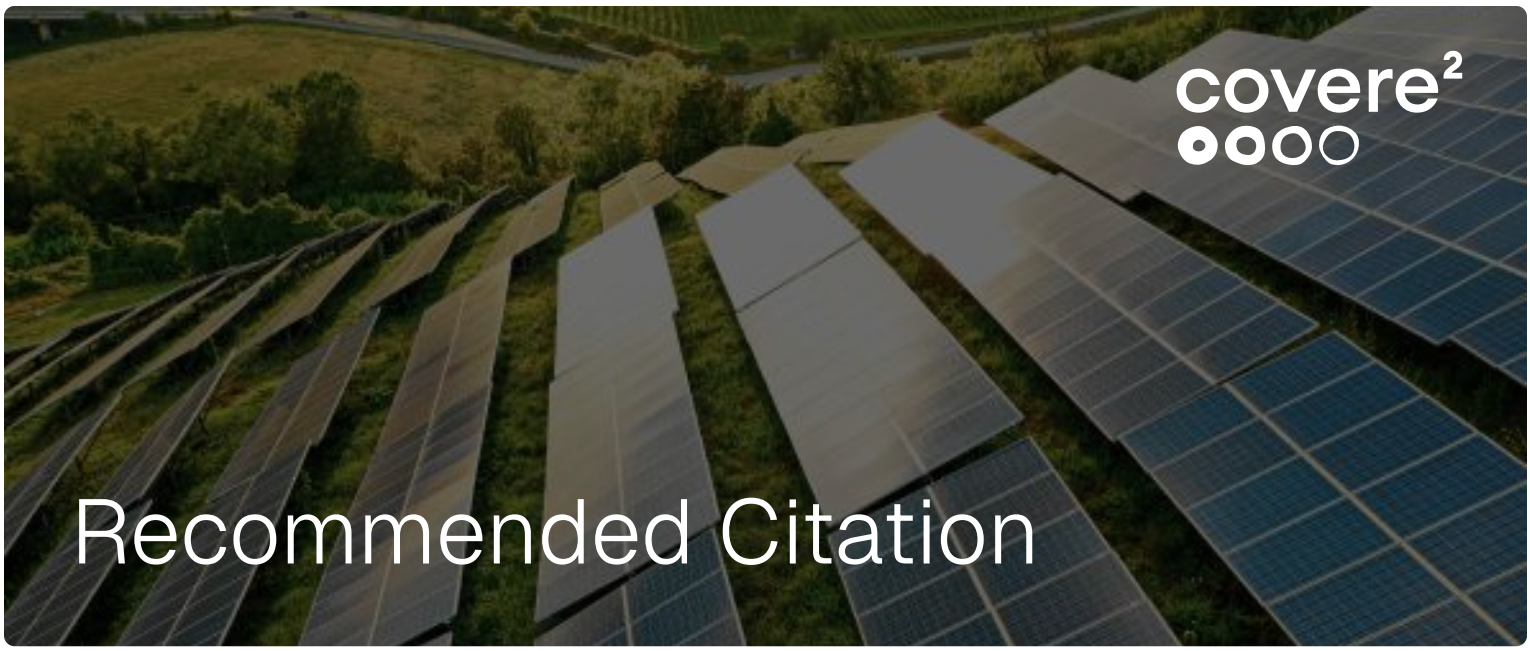
Juntos Farm Solar Power Plant Power Output



Typical daily electricity consumption for Juntos Farm in Ibiza



Simplified Power Consumption Model. Due to limited detailed data on power systems in Ibiza, Mallorca, and Spain, a simplified electricity consumption model is used assuming a monthly consumption of 6,000 kWh.



Recommended Citation

Fuel Mix and Emission Calculation Based on GPS Coordinates

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About ELEKS

ELEKS is a global leader in technology services, renowned for its expertise in data science, data management, and custom application development.

With over 30 years of experience, ELEKS empowers businesses across industries to harness the power of advanced analytics and innovative software solutions. In the energy and sustainability sectors, ELEKS delivers cutting-edge tools and platforms that enable precise data-driven decision-making, carbon emissions tracking, and optimization of resource use.

By combining deep technical knowledge with a commitment to driving sustainable progress, ELEKS helps organizations achieve their business and Net Zero goals.

About ELEKS DAKAR

DAKAR enables real-time power systems management for large power networks. It provides automated system stability analysis and optimized load flow calculation, for ultimate efficiency.

Centralized data storage and specialized data management tools help organizations minimize errors and prevent financial losses. And it's already enhancing the operational efficiency and performance stability of more than 20 Eastern European power systems.

About COVERE²

COVERE² solution streamlines reporting processes, ensures top-notch data quality, and guarantees compliance with relevant standards, all while equipping companies to pilot their sustainability agenda forward.

COVERE² has been developed thanks to the support from the European Union via the co-funding of the European Institute of Innovation and Technology. The project lasted for two years under the leadership of the University of Helsinki.

The Carbon Footprint of energy consumption powered by ELEKS DAKAR is a unique feature of COVERE² to increase the granularity and quality of energy-related emissions data.

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