LIFE15 CCA/ES/000058

LIFE SUSTAINHUTS: SUSTAINABLE MOUNTAIN HUTS IN EUROPE

C7.5 Final guideline: "LIFE SUSTAINHUTS project results report"

Status: F

(D: Draft, FD: Final Draft, F: Final)

Dissemination level: PU

(PU: Public, CO: Confidential, only for members of the consortium (including the Commission Services))

This project has received funding from Programme for the Environment and Climate Action (LIFE) and repealing Regulation (EC) No 614/2007.

Document Change Control

Version Number	Date of issue	Author(s)	Brief description of changes
Draft	15/10/2021	Sabina Fiorot (ENVIPARK)	
Final	14/01/2022	Pedro Casero (FHa)	final revision

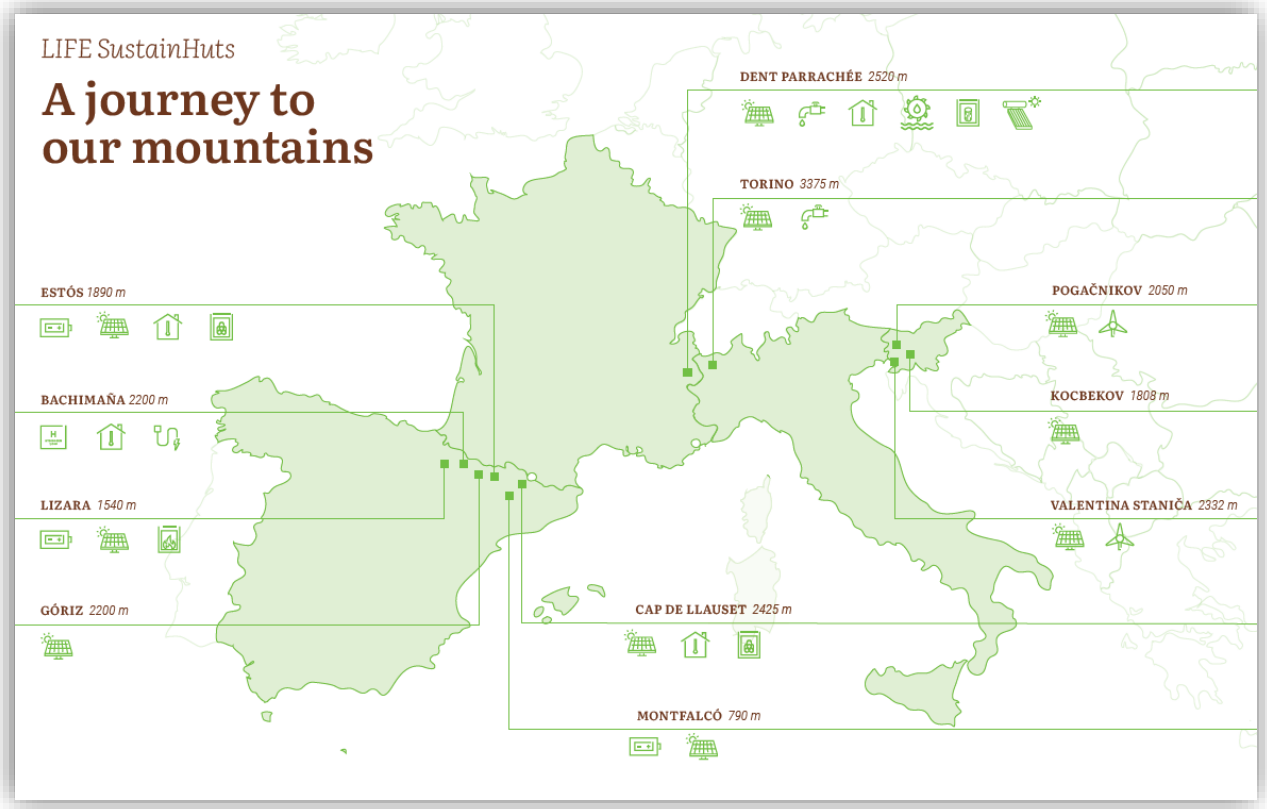
This document is a **final guide containing all the results obtained in SUSTAINHUTS project**, with the aim of being useful for its replication in other facilities, to publicise the technologies installed and potentially applicable, as well as the expected results depending on the type of facility and the particularities of each mountain hut.

In order for this document to make sense in itself and so that it is not necessary to consult the other guides produced in the project, the following is presented throughout the document:

- The table of the huts included in the project together with their location
- The table with the technologies installed in each hut, giving a total of 29
- The results of CO_2 emissions avoided, fuel savings and renewable energy produced both accumulated during the entire execution of the project and normalised to a standard year
- Results obtained for other parameters that in some way reflect the environmental impact obtained, such as energy efficiency, reduction in the number of helicopter trips, as well as a specific assessment of such a novel technology as the storage of seasonal renewable energy in the form of hydrogen.
- Finally, the main outcomes of the project are presented.

It can be concluded that **the technologies implemented in the project have been successful, achieving to a large extent the planned objectives**, and clearly improving both the energy management and the sustainability of all the huts.

	Hut	Country	Altitude [m]	In the project since
#1	Lizara	Spain	1650	2016
#2	Bachimaña	Spain	2200	2016
#3	Estós	Spain	1890	2016
#4	Cap de Llauset	Spain	2400	2016
#5	Torino	Italy	3375	2016
#6	Kočbekov	Slovenia	1808	2016
#7	Pogačnikov	Slovenia	2050	2016
#8	Montfalcó	Spain	800	2018
#9	Góriz	Spain	2200	2018
#10	Valentina Staniča	Slovenia	2332	2019
#11	Dent Parrachée	France	2520	2019



Hut	Action	Description of the technology installed
Lizara	Automation and efficiency	Automation for the optimisation of battery charging and generator start-up management, in order to increase the service life of the battery bank.
	Photovoltaic	Renovation of part of the existing photovoltaic system and expansion of the installed peak power.
	Thermo-Chimney	High efficiency chimney installation that allows heat recovery from combustion for use in heating and reduction of fuel gas consumption.
Bachimaña	Electrification	Replacement of diesel boilers with electric heaters so that renewable electricity is harnessed in periods of surplus.
	Insulation and energy efficiency	Application of thermoprotective paint on the interior walls of rooms where damp is more frequent, as well as providing greater thermal insulation.
	H2 storage	Seasonal renewable energy storage using hydrogen, using surpluses at various times of the year for use at other times of the year.
Estós	Automation and efficiency	Exploitation of the surplus of the hydraulic turbine available in the hut for battery charging.
	Photovoltaic	Renovation of part of the existing photovoltaic system, and expansion of the installed peak power.
	Pellet stove	Installation of a biomass (pellet) stove for heating, improving the efficiency of thermal energy use and reducing the consumption of fossil gas.
	Insulation and energy efficiency	Installation of innovative and ecological insulation in several areas of the hut (ground floor, stairs, rooms) facing north to improve the efficiency of the heating system.
Llauset	Photovoltaic	Expansion of the installed peak power of photovoltaic panels by using the entire available roof area.
	Pellet stove	Installation of a biomass (pellet) stove for heating, improving thermal energy efficiency and reducing fossil fuel consumption.
	Insulation and energy efficiency	Installation of innovative and environmentally friendly insulation in the battery room to condition the temperature of the batteries and extend their service life.
Kocbekov	Photovoltaic	Installation of a complete photovoltaic system consisting of photovoltaic panels, a lead-acid battery bank, and the control and energy management systems.
Pogačnikov	Photovoltaic	Installation of a complete photovoltaic system consisting of photovoltaic panels, a bank of lithium-ion batteries, and the control and energy management systems.
	Micro-Wind	Installation of a micro wind turbine at a certain distance from the hut to support the photovoltaic system for battery charging.
Torino	Photovoltaic	Installation of a photovoltaic array suitable for extreme climates at altitudes above 3000m.
	Water treatment plant	Installation of a plant to collect water from the environment, and another plant to reuse water from the hut to reduce the need for external water supply to the hut.
Montfalcó	Photovoltaic	Renovation of part of the existing photovoltaic system, and expansion of the installed peak power.
	Automation and efficiency	Modification of the water supply installation to the hut, replacing the existing water pump with a more efficient one, and optimising its operation.
Góriz	Photovoltaic	Extension of the photovoltaic installation of the hut, as well as the renovation of the existing battery bank.
Dent Parrachée	Photovoltaic	Renovation of part of the existing photovoltaic installation, and extension of the installed peak power, as well as installation of a lead acid battery bank.
	Hydro turbine	Installation of a low-power hydraulic turbine to exploit a stream of water.
	Wood stove	Installation of two wood stoves with air recirculation to reduce fossil fuel consumption.
	Solar Thermal Panels	Installation of solar thermal panels for heating and HSW and to reduce fossil fuel consumption.
	Insulation	Several actions to improve thermal insulation in various rooms of the facility.
	Water Treatment Plant	Connection of the hut to the water discharge network.
Valentina Staniča	Photovoltaic	Installation of a complete photovoltaic system consisting of photovoltaic panels, a lead-acid battery bank, and the control and energy management systems.
	Micro-Wind	Installation of a micro wind turbine at a certain distance from the hut to support the photovoltaic system for battery charging.

Exhibit 1. Accumulated environmental impact of the huts of LIFE SustainHuts project during demonstration period

- Production of 144,404 kWh from renewable sources (sun, water, and wood)
- Savings of 29,433 litres of diesel
- Savings of 9,207 kg of natural gas
- Savings of 4,179 litres of propane gas
- Reduction of 145.64 tonnes of CO_2 into the atmosphere, which is the equivalent of the amount absorbed by more than 3600 trees or a 60 ha forest.

Exhibit 2. RES production, fuel savings and avoided CO_2 emissions accumulated during monitoring phase

This table shows the cumulative results for each hut during the entire demonstration phase, and for 5 parameters: renewable production, amount of fuel saved compared to the baseline, avoided CO_2 emissions (also compared to the baseline), fuel reduction normalised to person and night in hut, and amount of hydrogen produced. These parameters were defined at the beginning of the project in addition to others set out in the Grant Agreement.

ID Indicators	Renewable production	Litres of fuel saved	CO_2 Avoided
	kWh	Diesel (Litres) Natural Gas (kg) Propane (Litres)	Tonnes
Lizara	15,209	Diesel: 2,939 Natural gas: 9,207	35.68
Bachimaña	62,744	7,502	18.82
Estós	14,598	4,945	12.41
Llauset	20,525	4,973	10.46
Montfalcó	7,696	2,778	6.97
Góriz	12,536	4,246	10.65
Torino	6,427	1,745	44.94
Pogačnikov	3,680	890	3.74
Valentina Staniča	410	198	0.48
Dent Parrachée	579	Diesel: 10 Propane: 4,179	1.49
Total cumulative during monitoring	**144,404**	**Diesel: 29,433 Natural gas: 9,207 Propane: 4,179**	**145.64**

Exhibit 3. Average RES production, fuel savings and avoided CO_2 emissions per year and hut

This table presents the values of the aforementioned parameters normalised to one year for each hut, taking into account the usual opening period of the facility, the real demonstration period for which data is available, and an estimate has been made based on historical visitor numbers to the huts to compensate for the effect of the COVID pandemic. Finally, the last line shows the average value of these parameters.

ID Indicators	Renewable production	Litres of fuel saved	CO_2 Avoided	Number of helicopter trips avoided
	kWh	Diesel (Litres) Natural Gas (kg) Propane (Litres)	Tonnes	
Lizara	6,293	Diesel: 1,216 Natural gas: 3,809	14.76	*N/A (road)*
Bachimaña	32,736	3,914	9.81	4
Estós	12,513	4,239	10.63	4
Llauset	12,315	2,984	6.28	3
Montfalcó	6,597	2,381	5.97	*N/A (road)*
Góriz	8,849	2,997	7.52	3
Torino	2,921	793	20.42	*N/A (cableway)*
Pogačnikov	1,840	445	1.86	N/A
Valentina Staniča	410	200	0.48	N/A
Dent Parrachée	386	Diesel: 71 Propane: 2,786	0.99	N/A
Average per year & hut	**7,714**	**Diesel: 1,749 Natural gas: 346 Propane: 253**	**7.16**	

Reduction of fossil fuels in the different huts is associated with a reduction in the number of helicopter trips needed to transport fossil fuels to the facilities. For the calculations it is considered that only diesel is transported, and that the helicopter can carry a maximum of 820 kg per transport (or 1000 L) of diesel per trip. On the other hand, in Slovenian and French huts, as the diesel reduction is small, it is not considered to imply a reduction of even one trip, as the supply usually coincides with the transport of various equipment to the hut at the beginning of the season.

- The total number of **trips avoided on average per year between all huts is 14**
- The kerosene consumption used is about 100 kg per trip, and therefore the **total reduction of kerosene is 1.4 tonnes** per year among the total number of huts

Exhibit 4. Improvement of energy management in the huts

The following table includes the technologies that have some relation with energy reduction or efficiency improvement, indicating a brief description of the improvement made, as well as a qualitative assessment of whether the impact observed is more or less significant.

Hut	Technology	Technology implemented & Qualitative improvement achieved	
Lizara	AAI	Automation for the optimisation of battery charging and generator start-up management, in order to increase the service life of the battery bank.	↑↑
	Thermo-Chimney	High efficiency chimney installation that allows heat recovery from wood combustion	↑↑↑
Bachimaña	Electrification	Replacement of diesel boilers with electric heaters so that renewable electricity is harnessed in periods of surplus.	↑↑
	Efficiency	Application of thermoprotective paint on the interior walls of rooms to avoid damp and improve thermal insulation.	↑
Estós	AAI	Exploitation of the surplus of the hydraulic turbine for battery charging	↑↑↑
	Insulation	Installation of innovative and ecological insulation in several areas of the hut (ground floor, stairs, rooms) to improve the efficiency of the heating system.	↑↑
Llauset	Insulation	Installation of innovative and environmentally friendly insulation in the battery room to condition the temperature of the batteries and extend their service life.	↑
Montfalcó	AAI	Modification of the water supply installation to the hut, replacing the existing water pump with a more efficient one, and optimising its operation.	↑↑
Torino	Water Plants	Installation of 2 plants, one to collect water from the environment, and another one to reuse water and reduce the need for external water supply to the hut.	↑↑
Dent Parrachée	Wood stove	Installation of two wood stoves with air recirculation	↑↑
	Insulation	Several actions to improve thermal insulation in various rooms of the facility.	↑↑

There are some actions that are considered to have greatly improved the use of energy in the huts, such as the thermo-chimney at Lizara and the full use of energy from the hydraulic turbine at Estós. There are two others whose improvement may not be particularly significant, such as the application of thermo-protective paint in Bachimaña or the insulation of the battery room in Llauset, but which somehow manage to improve the energy management of the installation in some way, either in terms of operation or maintenance of some of the equipment in the energy system. And finally, there are several technologies that moderately but noticeable improve the energy management of the huts.

Exhibit 5. Main outcomes of the project

- A **methodology** has been developed to assess the implementation of different renewable technologies and efficiency improvements in off-grid micro-grids, adapted to various countries and hut characteristics.
- The project has covered a **wide range of installation typologies**:
    - huts open all year round, open only during the summer months, or closed for a few months in winter.
    - 8 of the project's huts are only accessible on foot, 2 of them are accessible by road, and 1 of them by cableway.
    - The altitude ranges from 800 m (Montfalcó, ES) to 3300 m (Rifugio di Torino IT).
    - The number of visitors and guests is very diverse among the different huts.
    - There is a great diversity in baseline emissions, ranging for example from facilities emitting less than 2 tonnes/year of CO_2 (Slovenian huts) to those emitting close to 100 tonnes/year (Italian hut).
- The **environmental impact achieved** in the project through both the renovation or new installation of renewables, as well as through efficiency improvements (automation, insulation, replacement of equipment) is reflected in the following figures:
    - Total cumulative renewable production between all installed technologies: 144 MWh
    - Total amount of diesel not consumed: 29,400 litres (288 MWh)
    - Total amount of natural gas not consumed: 9,207 kg (123 MWh)
    - Total amount of propane gas not consumed: 4,200 litres (27 MWh)
    - Total cumulative CO_2 emissions avoided between all huts: 145 tonnes
    - Average CO_2 avoided emissions: 7.2 tonnes per year per hut
    - Number of helicopter trips avoided between all huts: 14 flights per year.
    - CO_2 emissions avoided by reducing the number of helicopter trips: 0.28 tonnes per year.
- **Slovenian huts are undoubtedly the real success stories of the project as they have managed to completely eliminate diesel consumption in their facilities**, which demonstrates the enormous possibilities of converting small, temporarily open facilities into zero-emission facilities.
- A **prototype seasonal energy storage system based on hydrogen** has been installed in Bachimaña (Spain). It has been able to store excess renewable energy for more than 8 months in the form of compressed H2, which has been re-electrified to power the hut's micro-grid. This system will be used mainly as an extended backup for the hut's battery system when the hydraulic turbine that supplies the hut is inoperative due to breakdown or maintenance.
- An **insulation made from recycled sheep's wool has been identified**, with excellent thermal and acoustic properties, which has been implemented in two applications: improving insulation in the living area, and in the cabin where there are batteries associated with photovoltaic generation (protection against low temperatures).