RESEARCH FOR A MORE SUSTAINABLE ALPINE HUT

CASE STUDY OF RIFUGIO CARDUCCI, 2297 MT., ALTA VAL GIRALBA, DOLOMITI.

1 RIFUGIO CARDUCCI | OWN ILLUSTRATION

RESEARCH PLAN

INTRODUCTION AND PROBLEM CONTEXT

Living the outdoors has always been top of my interests, being this in the countryside, in the hills where I grew up, sailing, and mostly in the mountains.

One might argue that studying the built environment can be seen as clashing with the love for the great outdoors. However, it is right there, at the border between wilderness and construction that lies the challenge for me. How can something be built where it should not, and how does the margin between wild and built looks? How can we live with and within our natural environments?

This passion and these questions sparked the idea for this research, together with a recurring event that I have been fortunate enough to participate with a group of dear friends.

Every year, during the *season's* final days around the beginning of October, a group of locals from both sides of Forcella Giralba, and mountain aficionados, meet at 2297 meters above sea level at the well-known Rifugio Carducci. Located right the Zwolferkofel, or Croda dei toni in Italian, and Monte Giralba, the group meets to celebrate another year of mountaineering and friendship; another year of living the high-altitude areas of the Dolomites.

Musical instruments are airlifted, and those who would not be capable of reaching the refuge by foot can as well take advantage of a short helicopter flight. The event briefly introduced here is an example of what mountains, and refuges mean today: a meeting point where to share a common passion.

This meaning given to the alpine huts and the mountains has not always been the same as today. As beautifully explained by Walther Kirchner in his text Mind, Mountain, and History, "in the course of history, man's attitude toward mountains has not been static; it has changed" (Kirchner W., 1950). Firstly, with indifference, then with fascination, to scientific interest, and finally with sportive attitude, international, nationalistic, or commercial. This evolution towards the mountainous landscape has accompanied the western civilisation along with its evolution and widely changed from epoch to epoch.

The drive towards the Alps' high-altitudes has pushed for the construction of an infrastructure of buildings known as refuges: Rifugio, Refuge, Hütte. The word Rifugio can be translated from Italian as refuge, hut, or at times mountain lodge. This thesis will interchangeably use the words refuge and huts, to indicate the typology of constructions subject of this research project.
These buildings, located within a system of trails and roads have served as shelters and fundamental support for the civilisations that crossed the Alps, from the Roman armies crossing the Theodul Pass, to today's multitudes of people living, working, and spending their precious free time within the peaks of the Alps.
It is at these unique buildings that this research is looking. In the specific, the research will focus on the earlier mentioned Rifugio Carducci as case study.

Rifugio Carducci is one of the many high-altitude refuges built in the Alps. Like all of them, it is faced with the changes occurring to the use of the high-altitudes and the challenges that our civilisation is facing with climate change.
In today's scenes, the high-altitudes can be considered a *playground* for tourists, sports enthusiast and professionals, as well as outdoors lovers. With a range of activities from trail running to paragliding, and from trekking to free-climbing, an ever-increasing number of people inhabits the high-altitudes during the year's seasons.
The infrastructure, and within it the refuges, is therefore called to cater for a differentiated clientele, in need of shelter, information, education, restore, and at times rescue. Together with providing all the mentioned functions and others, the refuge has become a destination in itself. In many circumstances, the refuge evolved into an observation platform to enjoy the surrounding landscape while tasting local delicacies and drinking refreshing beverages. What lies underneath the surface of this vast and fundamental infrastructure, that makes accessible the beauty of nature, are the challenges connected with the supply and staffing of the huts themselves.

In many cases, the refuges is found in difficulty-accessible locations, without a road connection and always disconnected from a municipal grid for electricity, water supply and sewage system. These aspects are often given for granted, but they become challenges in the context of high-altitude refuges.
What follows is a short introduction and overview of the challenges as mentioned above.

These are based on personal knowledge, conversations with the caretakers of Rifugio Carducci, and backed by several publications of the local chapters of the Italian Alpine Club, as well as from "Guida alle buone pratiche nei rifugi in Quota", a good practice guide for refuge's caretakers and owners made available by the initiative for transnational cooperation Espace Mont Blanc.

High-altitude alpine huts, when possible, are supplied via off-road vehicles, cable cars; often with backpacks; usually with helicopters transporting all the necessaries for the operation of the buildings.
Water is almost always a valuable commodity, when possible collected from local springs or streams, at times collected from the melting ice of a nearby glacier or snow reservoir, and at times collected from rainwater. The available water, in a regular urban environment, would not be considered as potable.

Energy supply is once again a challenging topic but simply solved using diesel-power-generators and on some occasions with solar panels and batteries in combination with the diesel generators. A solution that is gaining traction, but that remains challenging for the risks of several days of overcast skies and/or shadow cast on the refuge from the nearby peaks.
The use of on-site diesel generators is still the number one source of electrical power for these buildings, with the consideration that with higher altitudes the engines are reduced on power output, therefore requiring over-dimensioned engines and higher consumptions. Simultaneously, the demands remain considerable, with needs for light, heat, and electricity for cooking and operating refrigerators.

Once all the supplies are inputted into the refuge, what emerges is the challenge of dealing with waste and sewage. Waste is transported down to the valley, or at times, especially in the French Alps, it is incinerated on site. Gray and black waters can be disposed of in septic tanks or other locally-specific systems, depending on the possibilities of the refuge itself.

PROBLEM STATEMENT AND MAIN RESEARCH QUESTION

The challenges here introduced, can give an idea of the complexity of inhabiting the high-altitudes; places that at the same time are fragile and harsh; source of pleasure for those visiting them, and source of living for those working thanks to them.
Given the need for climate action, it is ever more necessary to tackle the challenges that the built environment of high altitudes puts in front of us. As a society, we shall continue to evolve our relationship with our natural environments and develop solutions to live more in concert with it.
In the specific case of high-altitude alpine refuges, the call is to develop solutions capable of fostering the buildings' vocation of fundamental footholds, architectural contact points between built and natural environment. The call is to develop alpine refuges that are part of their natural environment, without harming it. That is instead capable of improving the (eco)systems within which they are built-in.
The consequence of this call is the main research question for this work: **How can the positive impact of a high-altitude alpine refuge towards its (eco)system be maximised?**

The first period of the thesis is dedicated to the understanding of the alpine refuge as an architectural typology, as well as studying the (eco)system within which the case study of

Rifugio Carducci is situated, collecting information and mapping the refuge within its systems, infrastructures, ecology and economy.
The second phase is dedicated to developing the renovation project for Rifugio Carducci; project that will exemplify the answer to the main research question. More on the structure of the research will be provided in the following sections of this research plan.

THEORETICAL FRAMEWORK

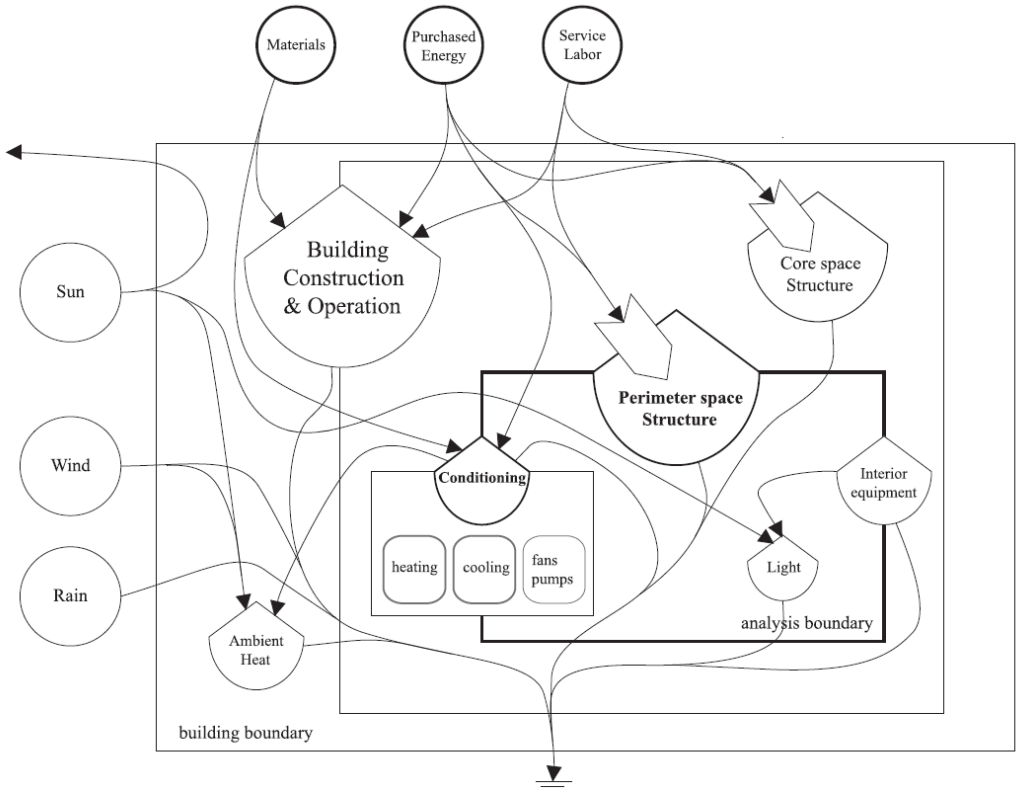
This research takes inspiration from Kiel Moe's work and his push towards understanding the built environment as a connected system of systems.
Starting from the laws of thermodynamics, the research aims at understanding Rifugio Carducci as a *node within an (eco)system*. This definition, developed during this research, identifies the refuge as an element within an infrastructure of refuges, trails, routes. It sees it as a combination of systems for the supply and functioning of the refuge. To cite Kiel Moe's work, in this research the alpine refuge "is an open thermodynamic and ecological system" (Moe, Empire, State & Building, 2017).
As part of the physical environment (Stremke, van den Dobbelsteen, & Koh, 2011), the built elements are governed by the two laws of thermodynamics:
1) Energy is always conserved;
2) during any process, the quality of energy is decreased (exergy) and disorder (entropy) is increased.

What these two fundamental concepts entail for architecture is a call for the designers to consider buildings at a broader scale, considering the effects and the necessary steps and ingredients necessary to the lifecycle of a built element.
In Odum's words this process of understanding the systems connected to, in this case, a refuge is intended to achieve three ends: "maximise the *intake* of available matter-energy, maximise the *transformation* of the matter-energy, and reinforce the system through *feedback*" (Moe, Empire, State & Building, 2017).
What results evident is that "the ability to do work is dependent not only on the form of energy, but also the system being considered" (Brown & Ulgiati, 2004).

The consequences of these considerations are twofold: the substantial refusal of a building as an autarchic system, and the research's positioning on *maximising* the *positive impact* of the *built-with(in) the environment*, a thermodynamic equilibrium of the building's (eco)system.

Autarky, a theory described as "an economic system of self-sufficiency and limited trade" (Bondarenko, 2018), suggests that a system can work autonomously, without external influence. If this concept is considered with the laws of thermodynamics in mind, it appears evident that autarky simply can not exist.
A similar conclusion has been noted by Ákos Moravánszky while discussing the Monte Rosa hut in the Swiss Alps. In his article "My blue heaven: the architecture of atmospheres", he notes that the high altitude refuge "while almost entirely cut off from the physical energy networks, it is very much part of the socio-economic networks of attention-making" (Moravánszky, 2010).
In conclusion, if even a high-altitude alpine hut is not autarchic, but instead part of systems, and even more part of its ecosystem, the natural consequence is that a built element can not

be anything else than a thermodynamic process of intake, transformation, and feedback. It is, therefore, the role of the designer to tune the thermodynamic processes of building to work in balance with the (eco)systems feeding the building, maximising the positive feedback, reducing as much as possible the increase of entropy.



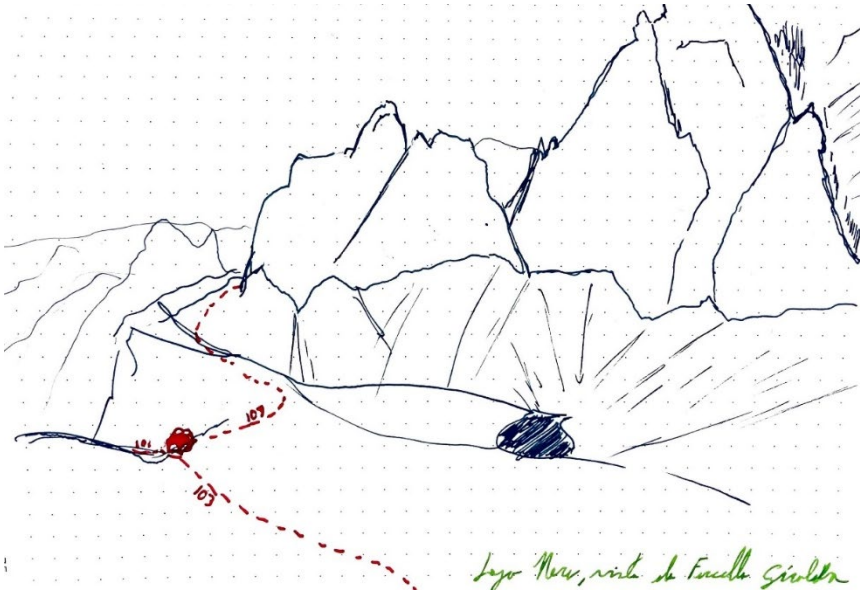
2 YI, SRINIVASAN, BRAHAM (2015) SYSTEM BOUNDARY DIAGRAM | THIS IMAGE EXEMPLIFY THE CONCEPT OF DIFFERENT SYSTEMS CONNECTED TO THE BUILDING

REFLECTION ON METHODOLOGY

The research for a more sustainable alpine hut is divided into two main areas that will then be combined to develop the renovation project for Rifugio Carducci.
Individual methods are combined in different documents and phases to form a complete and diverse methodology necessary to answer the main research question and to develop the project.

A first area of research is focused on the understanding of the high-altitude alpine refuge as an architectural typology.
Starting from a historiographic study of the relationship between humans and mountains, it aims to understand why we, as a civilisation, as a society, are attracted to the high-altitude areas.
By doing so, it will aim at understanding why, in the heart of Europe's mountains, alpinists have started to construct buildings where until a few centuries ago there was limited widespread interest for any activity. With the study of specialised literature, media articles,

and the conversation with the Rifugio Carducci caretakers, this area of the research is aimed at understanding the characteristics of the alpine huts, based on their role as "sentinels" (Dini,



3 VIEW OF LAGO NERO FROM FORCELLA GIRALBA | TRAILS TO AND FROM RIFUGIO CARDUCCI | OWN ILLUSTRATION

Gibello, & Girodo, Andare per rifugi, 2020) of the border between wilderness and built environment. Their role within the infrastructure of trails and climbing routes that characterise the Alps; their role of destination and meeting place for those living the high-altitudes.

This section of the research will then discuss how the functions and reasons of existence of a refuge are translated into an architecture element within the natural (eco)system, studying some example of alpine huts through written documents, the study of drawings, and the production of sketches.

At the same time, another section of the research project is developed, focused on the more technical and technological aspects of a high-altitude alpine refuge.

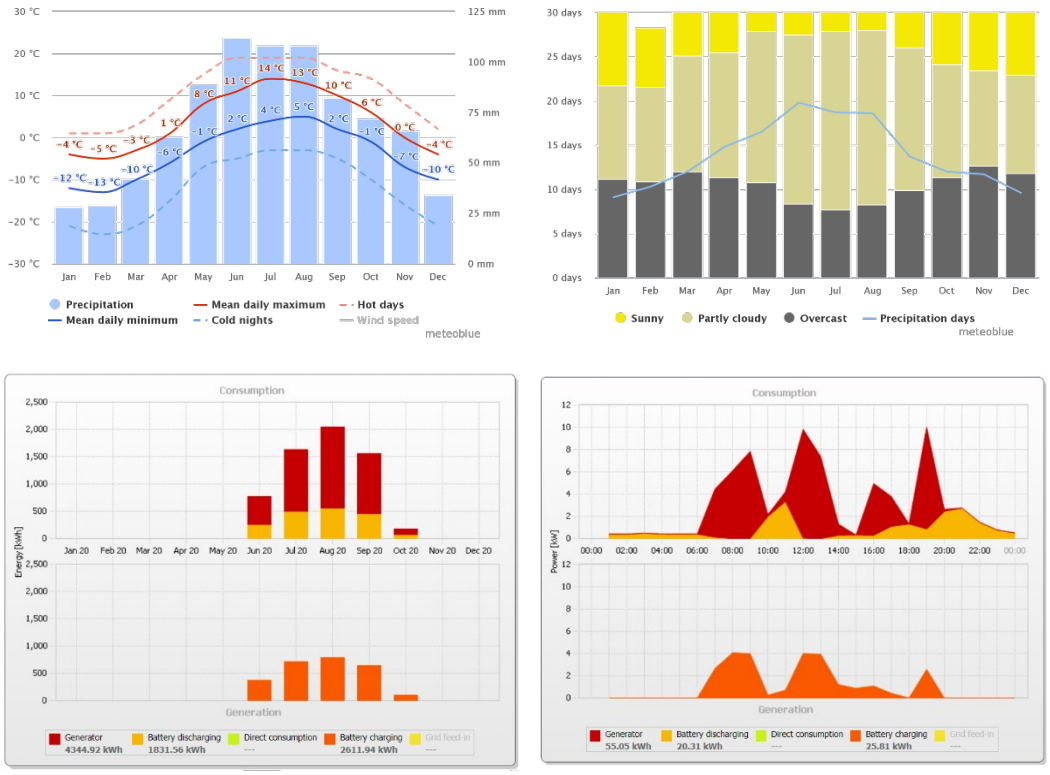
Starting from an understanding of the Alpine and Dolomitic ecosystems, through its geography, climate, economy, and natural resources, this section of the research will shed light on the technical and technological potential of the alpine refuge (Rifugio Carducci). By collecting hard-data of the case-study refuge, the research will study the building as a node within its ecosystems, indicating the supplies necessary to make the refuge work, studying its energy requirements, the water demand and waste production.

By knowing the supply system of the refuge, it will be possible to locate and explore the potential for improving the effects of the node within its environment.

This technical section will continue to be developed throughout the project, assessing and exploring the potential for improved systems, starting from improving the energy storage system, through the research for the appropriate materials for the renovation and expansion of the refuge. As well as continue forwards to improving the hut's waste (and wastewater) management system. Sources for this section are the specific information provided by the refuge's caretakers, the publications of the foundation Dolomites UNESCO, and the several

technical guides/best practices reports for managing huts (i.e. the already mentioned guide by Espace Mont Blanc).

4 Top left clockwise: Average temperatures and precipitations; meteoblue | Cloud, sunny, and precipitations days; Meteoblue | Rif. Carducci 2020 season energy balance; SMA sunnyportal | Rif. Carducci Daily energy balance 7/08/20; SMA sunnyportal

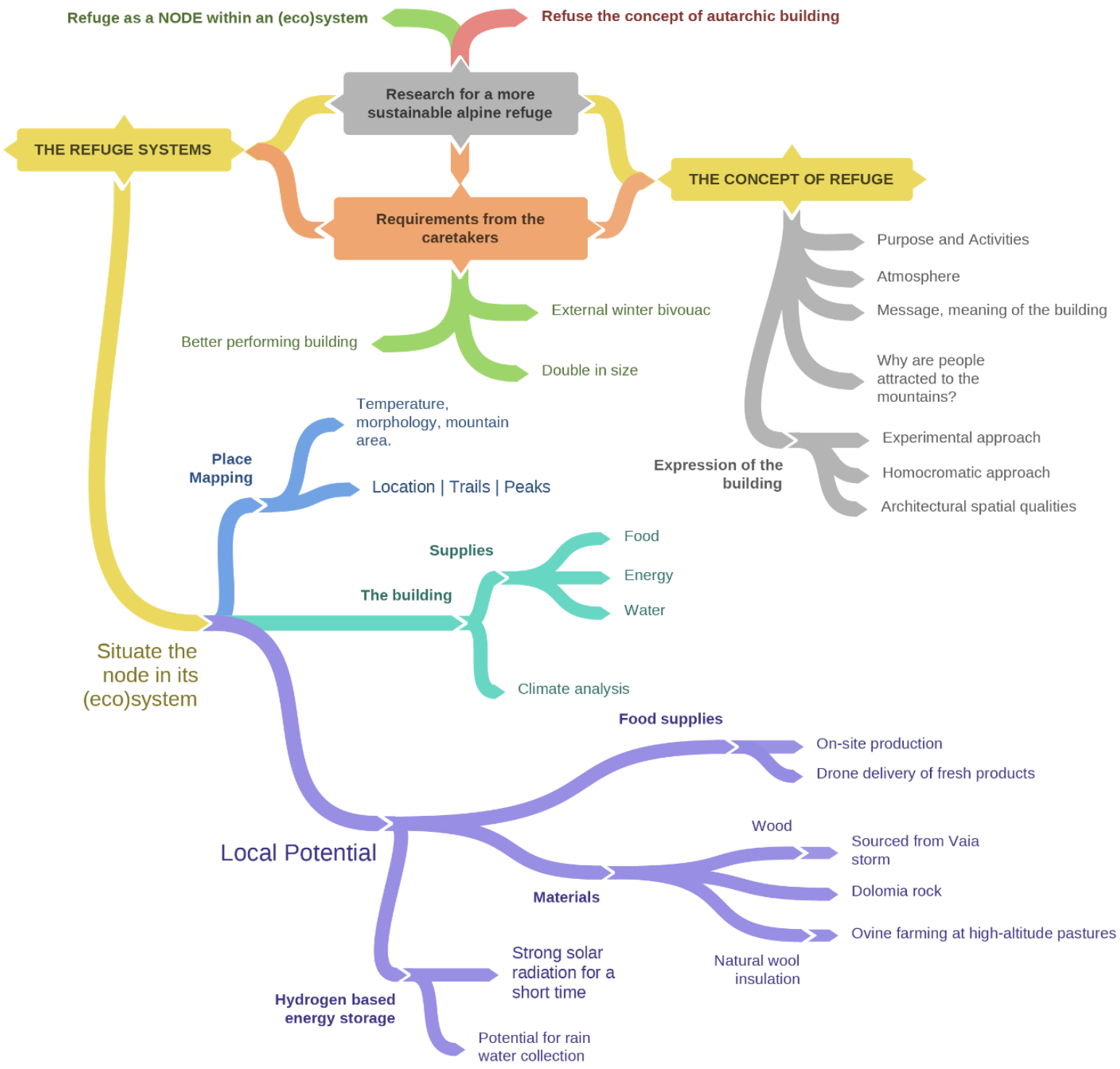


The combination of the two mentioned sections of this research will be the dialogue between the characteristics of the hut as a sentinel, refuge, shelter and destination, and the technical functioning of the hut itself, seen as a node within an (eco)system of people and resources (as introduced in the theoretical framework section). This discussion and combination between the meaning of refuge and technical functioning of the refuge will shed light on the potential for an architecture of high-altitudes that maximises the positive impact for its (eco)system. Initially as a sort of *position paper,* this section will be reflected upon and continued during the design phase of this research project.

In conclusion, the methodology developed for this research combines different methods:

- Specialised and scientific literature study
- Study and analytical sketches of precedents
- Collection and interpretation of hard data
- Feasibility and potential calculations
- Conversations with the caretakers of Rifugio Carducci
- Study of interviews, magazines, videos
- Mapping of resources, supplies, local potential

DIAGRAM OF THE RESEARCH



5 RESEARCH DIAGRAM; OWN ILLUSTRATION WITH COOGLE.IT

STRUCTURE OF THE RESEARCH

What follows is the structure of the three sections to be developed for this research.

SECTION A: ARCHITECTURE OF HIGH ALTITUDES

An essay discussing "why people are attracted to go up there?", focused brief history of alpinism and an overview of the human aspects of high-altitude areas. Then a look at the architecture of high altitude, what is built, why, what are the qualities of those spaces.

ALPINISM: WHY AND SHORT HISTORY

Why and first history, the relationship between humans and high altitudes | Why are people attracted to go up there? | what is so special about this place? / Mountains?

WHO USES THE MOUNTAINS TODAY?

Cantieri d'alta quota 8 "Gente di montagna" | tourism report from Dolomites UNESCO

THE CARETAKERS

Cantieri d'alta quota 6 "vocazione rifugista" | Newspapers / video interviews

ALPINE REFUGES

The concepts and reasons for them.

THE ARCHITECTURE OF A REFUGE

Case examples two kinds: Experimental and Homochromatic.

RIFUGIO CARDUCCI

Introduction and history of the refuge with its evolution until today, pictures plus plans.

SECTION B: "TECHNICAL" REPORT

A data-centred report on the area of the project that sets the scene for the design and aims at presenting and understanding di system / environment of the project, looking at its potential from a more technical aspect.

ALPS: GEOGRAPHY, CLIMATE, BIOLOGY, ECONOMY

Short overview

DOLOMITES

Short overview

RIFUGIO CARDUCCI WITHIN ITS SYSTEM

Introduction to the location and the following chapters.

.1 MAPPING ITS NATURAL ENVIRONMENT

The "crode" typology of nature, rocks, water availability. Climate with temperatures and winds.

.2 Mapping the infrastructure
The trails, climbing routes, dolomites without borders, alte vie.

.3 the node within the system
Energy supply and consumption of the current refuge, water supply and consumption, food supply, fuel, number of visitors, menu. The refuge's caretakers supply hard data.

Potential for a more sustainable refuge

.1 The materials potential
With reference to VAIA 2018 and the diversification of farming activities, argue the use of wood from the storm for the structure, and the wool from the sheep for the insulation.

.2 The energy potential
Argue the production of energy on-site using hydrogen. It connects to the experimental and exploratory vocation of the refuges. (solar potential, average ground temperature

.2.1 hydrogen in the built environment
A short review of the state of the art of hydrogen use in buildings (Japan example from Andy)

.2.2 Hydrogen as an energy carrier for this refuge
Argue the potential of producing this "fuel" on-site, combining the results of the previous section, presence of water, solar radiation, shadow.

.3 Supply potential
What the previous potentials open up for the supply side to the refuge? Drones to reduce the use of the helicopter?

SECTION C: CONCLUSIONS/POSITION/MANIFESTO/REMARKS/REFLECTIONS
How do the two previous sections interact with each other and what do they mean for the potential of architecture at high altitudes, what do they mean for an architecture, what is the architectural position for this project?

As a built element within the natural environment (Dolomites UNESCO call for reinventing the high-altitudes, and the refuge as a destination. How does the architecture answer to these drivers?

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AN ALPINE HUT PART OF THE (ECO)SYSTEM

RIFUGIO CARDUCCI, 2297 MT., ALTA VAL GIRALBA, DOLOMITI.

1 RIFUGIO CARDUCCI | OWN ILLUSTRATION

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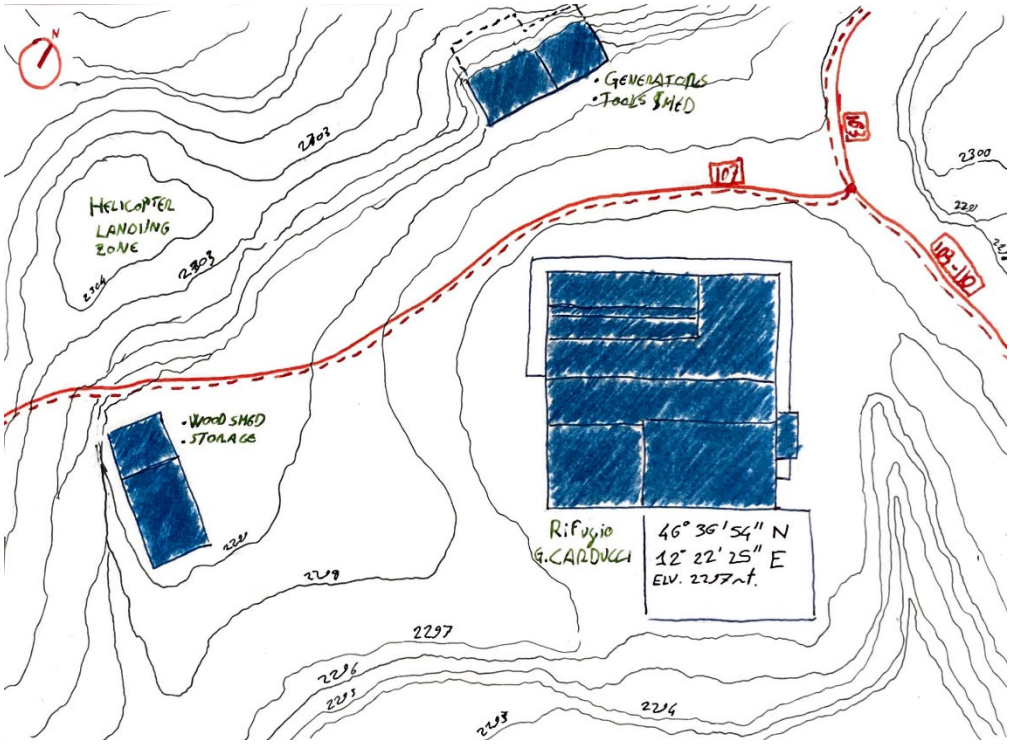
DESIGN BRIEF



2 RIFUGIO CARDUCCI SITE PLAN

This document introduces the design phase for the renewed Rifugio Carducci. The site is formed by three buildings, the refuge itself, a woodshed used as storage space on the South West of the main building, and a generators and tools shed on the North West. Furthermore, the refuge site can be reached from trails 103, 107, and 107. Finally, the helicopter landing zone is located West of the hut.
For a short overview, read the *KEY ASPECTS* boxes at the end of every section.

1_NARRATIVE INFRASTRUCTURE

The first characteristics that strike the visitors of this refuge are the welcoming sense of **hospitality** and **conviviality** that the caretakers convey to all the guests.
It is to these characteristics that the spatial qualities of the hut should cater for.
Simultaneously, the project should focus on the hut's primary function of **shelter**. Still, as it emerged from the research, it should embrace its role of **contact point between natural and built environment**.
As so common in the history of alpinism, the expanded refuge project should speak the languages of **exploration** and **experimentality**, innovating with the use of technological solutions and the material's choice.

3 CABANE DE MOIRY - CAS - A BUILT ELEMENT IMMERSED IN THE NATURAL ENVIRONMENT

With a limited opening period, and a challenging location to reach, the project for the hut's renovation should strive to develop **affordable** solutions.

Owned by the Italian Alpine Club of Auronzo, the refuge would probably be renovated thanks to the club's funding and private donations. It is therefore crucial that the solutions developed in this exercise reflect and economically responsible attitude.

KEY ASPECTS

- Main qualities of the refuge space: Hospitality and Conviviality
- Key functions: Shelter and contact point between nature and wilderness.
- Project language: Exploration, experimentality, affordability.

2_OPERATIONAL BRIEF

The alpine refuge is only open for the summer season, from late May to mid-October, depending on the snow situation.
Given the location, the staff spends the season mostly at the refuge, with the occasional necessary hikes to town.
The working day starts early in the morning, preparing breakfast for the guests, and finishes in the night when all the needs are catered for. It is not a standard job with regular working hours and commuting time, but a demanding work that requires flexibility and abundance of skills.
The tasks to be performed vary from kitchen duties, waiting tables, bartending, along with repair and maintenance jobs to the various aspects and systems of the refuge. Administration and supply are also up to the staff that often hikes to Auronzo or to the near Rifugio Comici for picking up necessary items and perishables for then carrying them back to the refuge. At the refuge, they also perform the roles of ambassadors of the nearby peaks, information point for the many visitors.
At times the staff performs maintenance of the nearby trail infrastructure, and in case of necessity, they perform first-aid duties.

Guests of the refuge generally pass by the hut during day hikes or use the facility as a stopover for more extended activities. Ranging from all ages and backgrounds, the guests find the refuge as a welcoming destination and temporary shelter.
More extended stays at the refuge are rare and generally due to meteorological circumstances, while the vast majority of guests arrives at the refuge throughout the day or late afternoon. After a night of rest, it is common for the visitors to leave early in the morning for the climbs or trails ahead.

KEY ASPECTS

- The working day for the staff starts early in the morning and finishes late at night.
- Tasks for the staff varies from kitchen duties, to supplying and servicing the refuge.
- Guests spends a short time at the refuge, a few hours to a couple of nights.

3_TECHNOLOGICAL BRIEF

The exploratory and experimental attitude that drove the first alpinists to ascend to the high altitudes should be translated into the technical and technological approach towards the renovation of Rifugio Carducci. If its roles and functions should be preserved, the renovation project gives the possibility to explore innovative solutions.
Given the project's location, strong attention should be paid to the constructability and technical aspects of the project.
As discussed in the "node within an (eco)system" document, the refuge is only accessible by foot or by helicopter. It is therefore fundamental to keep this aspect into consideration when developing the technical and technological aspects of the building.
The following sections will address the aspects of energy, water, materials, and constructability. Taking advantage of the key themes of experimentality and exploration, the refuge should develop an expressivity that integrates technology in its forms (see Cabane de Tracuit as example).

ENERGY

As already introduced in this research, the current energy production system is a combination of diesel generators and solar panels.
The goal of this project is to remove the need of the refuge to rely on fossil fuels, making the refuge energetically self-sufficient. Therefore, potentials for energy savings, heat recovery and energy-producing technology (such as PV, solar collectors and small wind turbines), will be investigated. And as a challenging assignment, to that end of energy neutrality, the experimental use of hydrogen as primary energy storage will be explored, hence eliminating the need for generators and batteries.

4 REFUGE DU COL DU PALET - HYDROGEN STATION - FIRST ALPINE REFUGE USING LOCALLY PRODUCED HYDROGEN AS ENERGY STORAGE

The use of hydrogen requires an electrolyser, fuel cells, and storage capacity, along with a PV surface of approximately 160 square meters. The first elements are to be placed instead of the current system. PV panels should be integrated with the design of the refuge.

WATER & WASTEWATER TREATMENT

Always a precious element at high altitudes, water is available for the refuge thanks to a nearby spring. The use of spring water should not be increased. This means that the options for water savings will be explored in the existing building and that further extensions to the refuge will be very water efficient.
The local climate instead suggests the collection of rainwater, abundant during the summer months. This water can be used for sanitary purposes and for the production of hydrogen, as discussed with 'Energy', and as discussed earlier in the research.
With the use of water comes the need for wastewater treatment. A principle of no harm to the environment should be applied to the solution of this aspect.

MATERIALS

Currently built with locally sourced rocks, with the newer addition made of wood and steel, the refuge is a combination of different epochs and material cultures.

The ampliation of the hut should consider the peculiarities of the high altitudes, without mimicking the valley, but rather embrace it as a place for exploration. Intending to produce the maximum positive impact on the local environment and economy, it is important to select a palette of materials, locally available as much as possible. Where this is not possible, an evaluation should be made according to the matrix proposed in this document, nevertheless considering the material from its broader perspective, environmental and economical, as well as its technical qualities. The following materials should be considered in the design phase:

- *Timber*: Being a fundamental part of the local economy, wood should be the primary material of choice for this project. Although not available at the hut's location, the alps' valleys rely on the economy surrounding this material. Specifically, damages created by recent storms have left an oversupply of wood that needs to be cleared for the forests to grow once again.
- *Wool*: The natural properties of wool make it a suitable insulation material. Used mainly for clothing, buildings can also benefit from wool as a primary insulation material. Its natural properties make it fire resistant, while its elasticity does not allow it to settle over time. Furthermore, in the hut's condensation problem, wool would not be damaged nor develop mould.

  From a local economy perspective, the request for this material would allow for differentiation in the local farming economy, diversifying from dairy, and expanding the efficiency of use of higher altitudes grazing lands.

5 NATURAL WOOL USED AS INSULATING MATERIAL

6 GABION WALLS CAN BE FORMED USING LOCALLY AVAILABLE ROCKS

- *Rock*: Widely available at the hut's location, dolomite rock can be used to form gabion walls. The use of this technique can reduce the need for transportation on site of concrete aggregates.

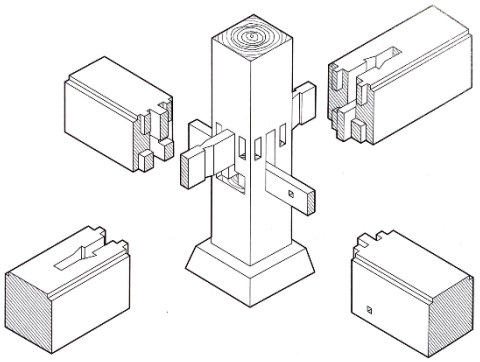
CONSTRUCTABILITY

Because of the environmental conditions, construction works have to be performed during the short opening season of the refuge, and they should contain the following characteristics:

- *Fast assembly*: construction processes have to be performed before or during the opening season, this gives the construction site a maximum life of four

months from beginning to end. Under harsh conditions of winter it is not possible to spend extended periods of time at the refuge. The goal is to develop fast assembly solutions and at the same time, not shut down the refuge.

- *Ease of assembly*: reduced complexity in the assembly processes reduce construction times and potentially materials. Simultaneously, ease of assembly means that the hut's staff can perform part of the tasks. As it is often the case, high-altitude buildings are assembled with the help of volunteers from the Italian Alpine Club; therefore, simpler construction methods open the possibility of involving the community with the project up to the construction phase.



7 A Press Fit Timber Building System can be used for the refuge, meeting the requirements of ease and fast assembly

- *Lightweight elements*: Transportation on site is a limiting factor, with loads up to 800 kg per flight and expensive rotation costs, the number of flights should be reduced to the minimum, maximising the payload per flight. At the same time on site, the use of machinery is extremely limited therefore it needs to be considered that the construction elements may need to be lifted and placed by hand.
- *Resistant solutions*: occasional strong winds and the winter conditions of the location require for careful consideration of the shape and strength of the building. It is not uncommon that during winter, the occasional avalanche hits the refuge from the north side of the building. While lower structures are usually covered by snow, protruding elements and parts of the building can be damaged.
- *Near zero-waste construction site*: reduction of construction waste is fundamental in every project, in this waste disposal become a considerable expense.

KEY ASPECTS

While **enhancing the sense of shelter** the renovation project will embrace the early alpinists' attitudes of **exploration and experimentation**.

- Energy: **Self sufficiency** is the primary goal, achieved through the study of potential energy supply, heat recovery, energy producing technology. Hydrogen will be explored as primary energy storage source.
- Water supply & water treatment: a **principle of no harm** is applied to the project, so no discharge of untreated water is allowed on site. Water supply is to be expanded with collection of rainwater.
- Materials: sourced in proximity, aimed at **maximizing the positive impact** on the environment and the economy. Renewable materials should have priority, along with local availability.
- Constructability: **affordable solutions** based on ease of assembly, lightweight elements, resistant solutions, and a near zero waste construction site.

4_PRACTICAL BRIEF

THE REFUGE

As seen in the previous sections of the research, the refuge underwent a series of ampliation throughout its life, starting from the four small rooms in two floors of the 1908 building, to the latest addition of 2018.

Given the complexities of the construction at high altitudes and its history of stratifications, it is important for this project to add another layer of history to the refuge.

8 CABANE DE TRACUIT - FACADE WITH INTEGRATED PV PANELS AND ENERGY EFFICIENT SHAPE

The characteristics of space need to cater to the conviviality and hospitality so much appreciated in the refuge while combining the sense of shelter with the contact with nature.

From a technical and technological perspective, the project will address the optimisation and maximisation of integrated PV surface, while combining a compact and well-insulated shape.

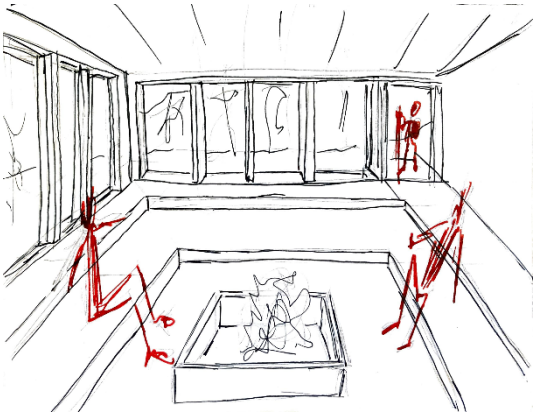
Insulation and ventilation aspects need to be addressed for the existing building as well as the new ampliation.

The capacity of refuge needs to be at least doubled. Currently, the hut has three dorms of approximately 16 square meters each, for a fixed capacity of 25 beds. The dining areas can be equipped for hosting 15 to 20 more people if strictly necessary.

Common/dining area: The current number of seats is sufficient, but it is possible to increase it to accommodate more guests.

The evenings are often spent at the dining tables with different group of people talking and sharing stories with each other. At times events are held at the refuge where alpinist

show pictures from their endeavours, while other times music is played in group.
To foster this particular characteristic of this refuge, a common area should be included in the project, providing space for the mentioned events, and forming a privileged border between indoor and outdoor space.



9 FAST SKETCH OF A COMMON AREA SPACE FOR THE REFUGE. A FIREPIT, SITTING SPACE, WINDOWS TO EXPERIENCE THE OUTDOOR VIEWS

Dorms: two 8-beds dorms and one 9-beds dorm are currently present at the refuge, each with a surface of approximately 16 square meters. The new area should provide dorms with a different number of beds to cater for the different groups of people visiting the refuge. Differentiation in the number of beds allows for the heating of only the necessary spaces.
The total number of beds should be brought to at least 50 with dorms of at least 4-beds each and one larger shared dorm.
With the capacity increase, more services (toiles and showers) should be included in the ampliation project, paying attention to the minimum use of water.

10 FAST SKETCH OF A CORRIDOR WITH WINDOWS TO PROMOTE THE CONTACT WITH THE NATURAL ENVIRONMENT WHILE BEING SHELTERED BY THE REFUGE

Staff area: The aim for the staff areas is to have two private rooms and other rooms for male and female staff. Of the two private rooms, one already exists, while the second one can be obtained from the new winter bivouac. When possible the rest of the staff occupies one of the dorms, otherwise share one dorm.
Since the staff spends almost the entire season up at the refuge, it is important to provide adequate space for them. Aspiration of this project is to provide at least two rooms for the staff, with reserved services. A common area for the staff would be an added benefit, although the free time is usually spent in the common areas of the refuge or outside.

KEY ASPECTS

The main characteristics of space shall cater to **hospitality and conviviality**, with **integrated technological aspects**, in a **compact and well insulated shape**.

- Common/dining area: A **common space for the guests** to interact should be included, making it a **buffer zone between wilderness, and built element**. A small ampliation of the dining area is possible.
- Dorms: the hut's capacity should be ampliated from 25 to **at least 50 beds**. Dorms should be of **different sizes** of at least 4 beds each. Services should be ampliated accordingly.
- Staff area: **Expanded** of at least one room, the staff area should offer **private spaces** and renewed services.

OUTDOOR AND DEPENDENT SPACES

The refuge itself is only one part of the infrastructure. The outdoor areas host many activities during the opening months. The terrace just outside the refuge is a privileged observation platform for the breath-taking surroundings.

The surrounding grounds have often hosted events and concerts. This is usually done on the northern side of the refuge. Impact on the surrounding areas must remain to the minimum, with subtle solutions if interventions are necessary. Although there is no "property line" as commonly understood, the guideline for this project is to keep its footprint as small as possible.

Temporary structures can be placed, provided that they can be easily stored inside during the off-season period.

Temporary elements should be stable enough to resist the occasional high winds and the air movement during helicopter operations.

Dependent spaces include storage sheds, waste management location, and the generators shed. North West of the refuge a semi-underground shed stores the generators and the batteries, along with serving as a tool shed.

A waste management area is currently found near a shed on the South East of the refuge. Waste is separated as much as possible and stored outside, where needs to be covered and made as much as possible not accessible to wild animals.

When necessary and possible, the helicopter airlifts the waste and transports it to the valley. For this operation, the waste bags need to be moved and placed into a cargo net.

A storage shed, on the same location as the waste management area, serves as woodshed and storage place for empty barrels and crates of empty glass bottles that will once again be airlifted down to the valley when possible; as well as private room of one of the caretakers.

11 FOOD PRODUCTION CAN BE INVESTIGATED FOR USE AT THE REFUGE, CONSIDERING THE ALTITUDE, CLIMATE, AND DISASSEMBLY REQUIREMENTS

Food production is an interest of the caretakers. Currently a few chickens live outside the refuge, with access to the woodshed, providing fresh eggs for the kitchen. To increase the on-site production, it would be interesting to explore the possibility to use

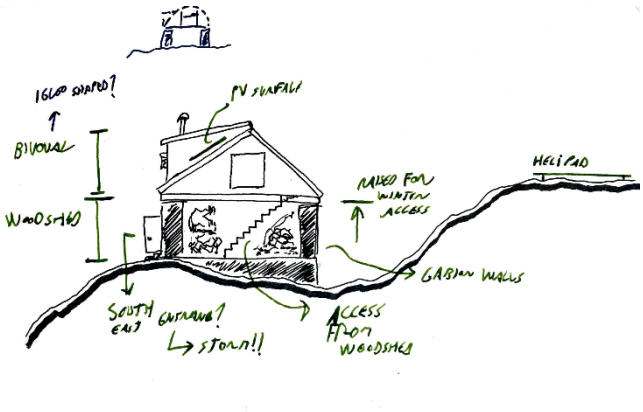
KEY ASPECTS

- **Minimum to no impact** is mandatory.
- Transformation of generators' room into Hydrogen station.
- Food production: removable greenhouses to be placed in the vicinity of the refuge | chickens coop.
- Waste management area: Gabion walls for enclosing the area; raised floor; use of big bags for shredded materials; openable lid/cover for airlifting.

demountable and movable greenhouses, although altitude might play a role in its feasibility.

WINTER BIVOUAC

Huts provide a fundamental infrastructure for inhabiting the high altitudes. Where there is not enough space or not enough presence of people huts are replaced with *bivouacs*, small cabin/shelters always open and accessible to everyone where it is possible to spend the night and warm up.



12 WINTER BIVOUAC SCHEME

This essential service must also be offered by the regular huts, that when closed, have to provide an accessible room where it is possible to take shelter.

Currently Rif. Carducci offers a 7 square meters room that remains open throughout the year.

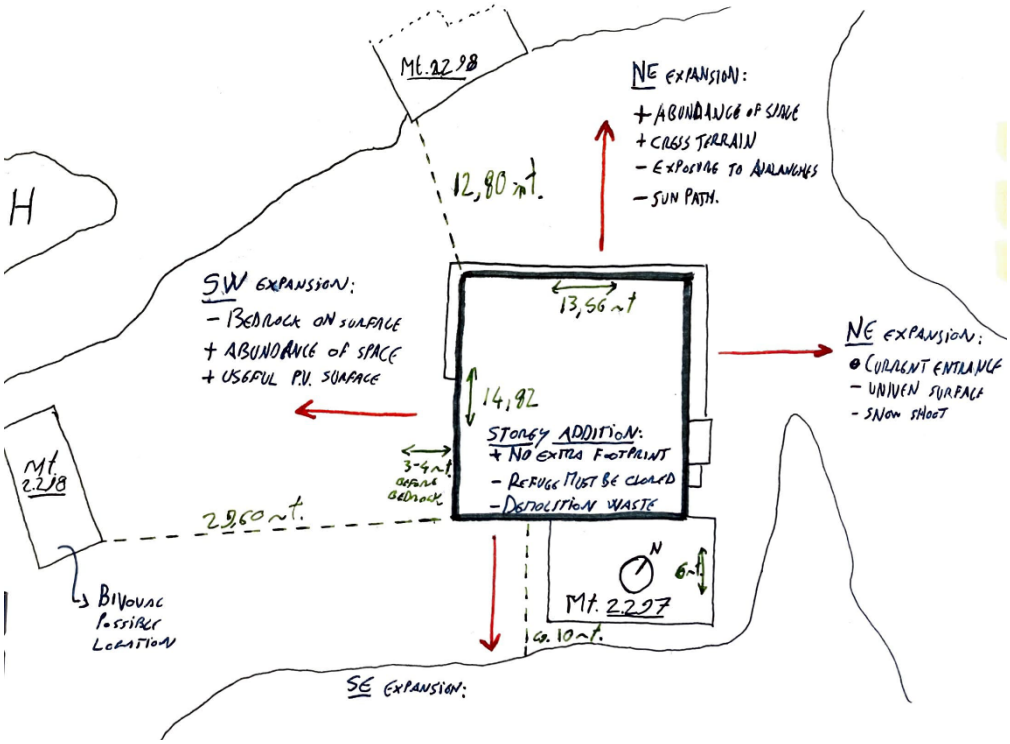
The renovation and expansion of the refuge offer the possibility to provide a better solution for the winter bivouac, while at the same time providing extra space that, during the summer season, can become a private room for the hut's caretakers.

Currently one of the caretakers sleeps in the woodshed, with a new bivouac it would be possible to provide needed personal space, that the public can access during the closing period of the hut.

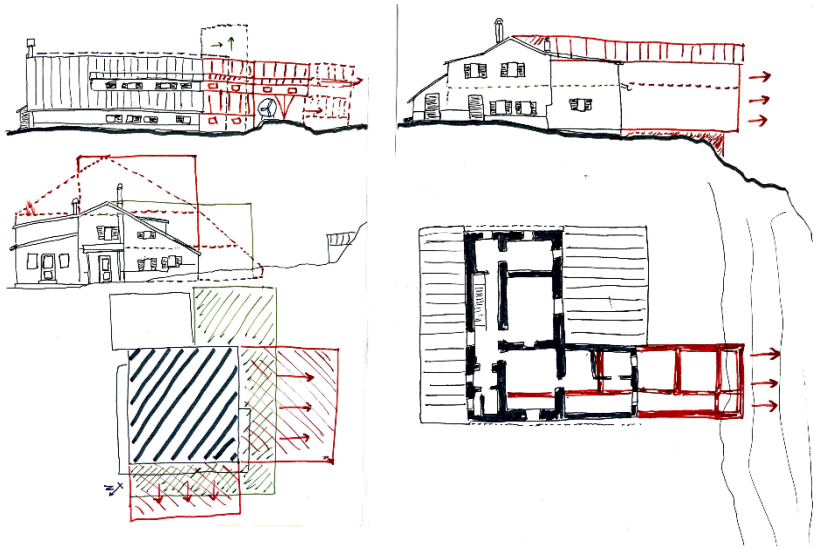
KEY ASPECTS

- Ensure **accessibility throughout the year**.
- The volume should remain minimum for heating economy.
- 4 to 6 berths.
- Heating and cooking area.
- Independent electrical system: a small light for the night, powered by an independent solar panel and using the batteries currently powering the refuge.
- The bivouac should be integrated with the woodshed so that in winter, it is possible to use a stove as a heating source.
- In summer, the bivouac becomes the private room of one of the caretakers.

5_EXPANSION EVALUATION AND MASSING SKETCHES



13 EXPANSION DIRECTIONS EVALUATION SKETCH. FOR EACH DIRECTION PROS AND CONS ARE EVALUATED



14 EXPANSION STRATEGIES AND MASSING STUDIES SKETCHES.

6_SOLUTIONS EVALUTATION

A Multi-criteria evaluation model is to be developed based on the work of William Braham presented in his book "Architecture and System Ecology: thermodynamic principles of environmental Building Design, in Three parts".

In addition a qualitative framework can be developed based on the work of Akadiri et. Al. "Multi-criteria evaluation model for the selection of sustainable materials for building projects". The hierarchical structure of the material's decision-making process can be organized as follows:

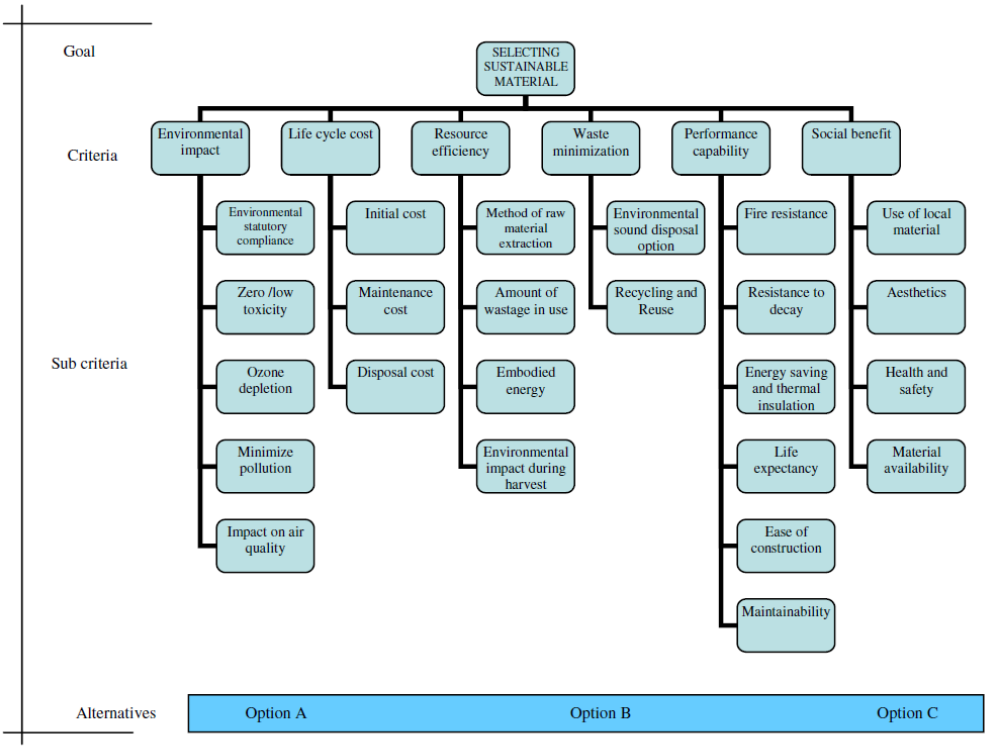


Fig. 4. Hierarchy of the decision problem.