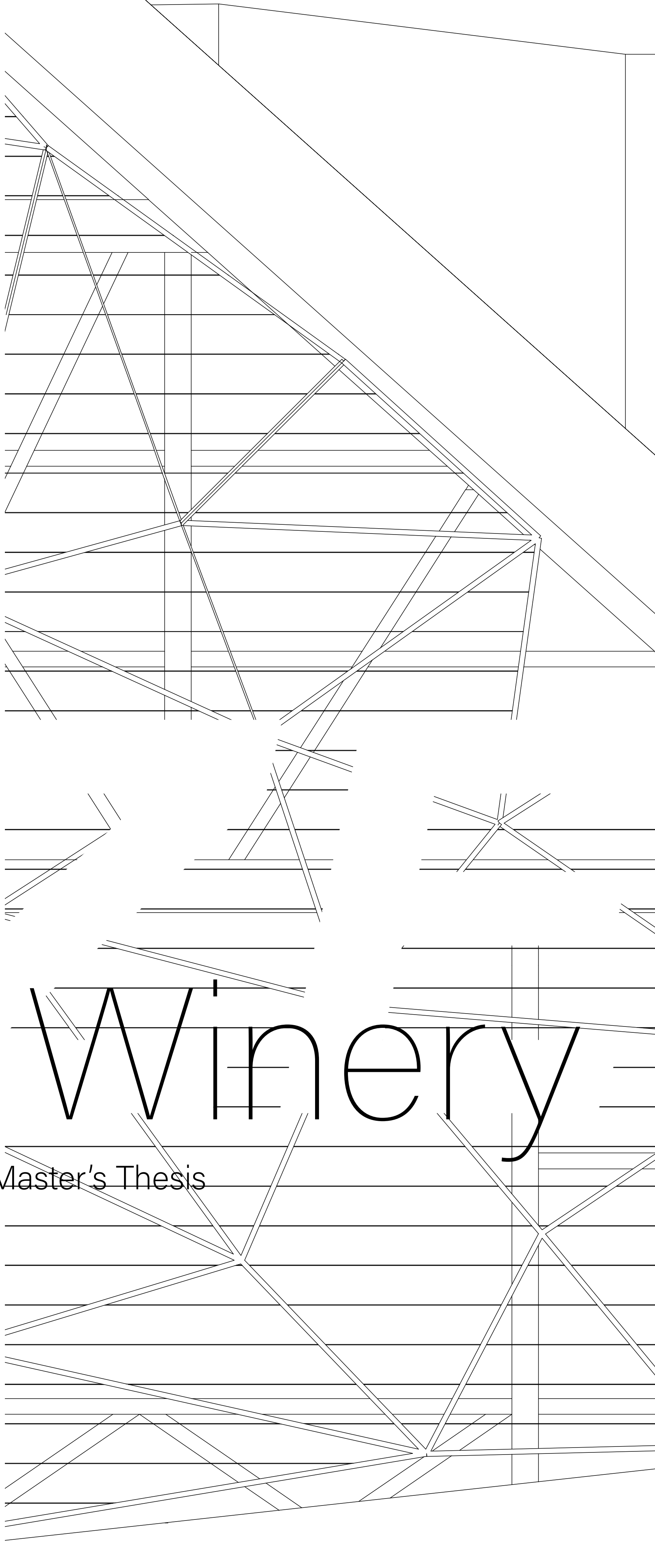

nZE Winery

Lory-Anne Lehmann, Master's Thesis

Univ.-Prof. B.Sc.(Hons)., Brian Cody
Institute of Buildings and Energy

Lory-Anne Lehmann, DEEA Bachelor’s Degree

nZE Winery

MASTER’S THESIS

to achieve the university degree of
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Univ.-Prof. B.Sc.(Hons)., Brian Cody
Institute of Buildings and Energy

Graz, July 2021

Affidavit

I declare that I have authored this thesis independently, that I have not used other than the declared sources/resources, and that I have explicitly indicated all material which has been quoted either literally or by content from the sources used. The text document uploaded to TUGRAZonline is identical to the present master‘s thesis dissertation.

Date

Signature

Preface

Growing up in the Alsatian vineyard, my interest in Architecture has been intertwined with my curiosity for history and traditions. I focused my first years of studies on restoration, design and museography, but as I arrived in Austria for an Erasmus during my Master, the opportunity to join a student competition centred on Energy Design became a personal challenge as well. After a rich and meaningful semester, with only the thesis left in my curriculum, I choose the not-so-easy path of transferring Masters. I was able to develop my own idea for the last project of my studies unlike in France, and stay under the supervision of Prof. Brian Cody.

My brother Anthony is a young winemaker taking over the family business. His intentions are to expand and innovate, to magnify our traditions, showing their prestige and quality. Small wineries in Alsace are usually housed in traditional buildings with underground cellars, sometimes still with earthen floors. However to achieve an ideal balance in a new construction, between energy, attractiveness, economy, environment and culture, new objectives must be set. Designing a nearly zero energy (nZE) winery was for me a way of combining a practical familial reason with the global urgent need of energy efficient architecture.

I would like to thank all who in one way or another helped me through the completion of this thesis. I would first like to thank my supervisor, Univ. Prof. Brian Cody, who steered me to push my ideas further and kept me from settling for less than I was capable of. Having witnessed his expertise throughout my Erasmus is what led me to choose this field for my thesis.

I would as well like to thank my parents, Brigitte and Gilles, and my brother, Anthony not only for their unfailing support during my studies but also for their insights as skilled wine-growers. Their detailed explanations and specifications were the key to the precise understanding of my aims and they also gave me precious and accurate criticism on the efficiency of my design from a winemaker point of view.

I would also like to thank lecturers and members of the Institute of Building and Energy for their advices throughout my Master and answers to confused emails during the pandemic times.

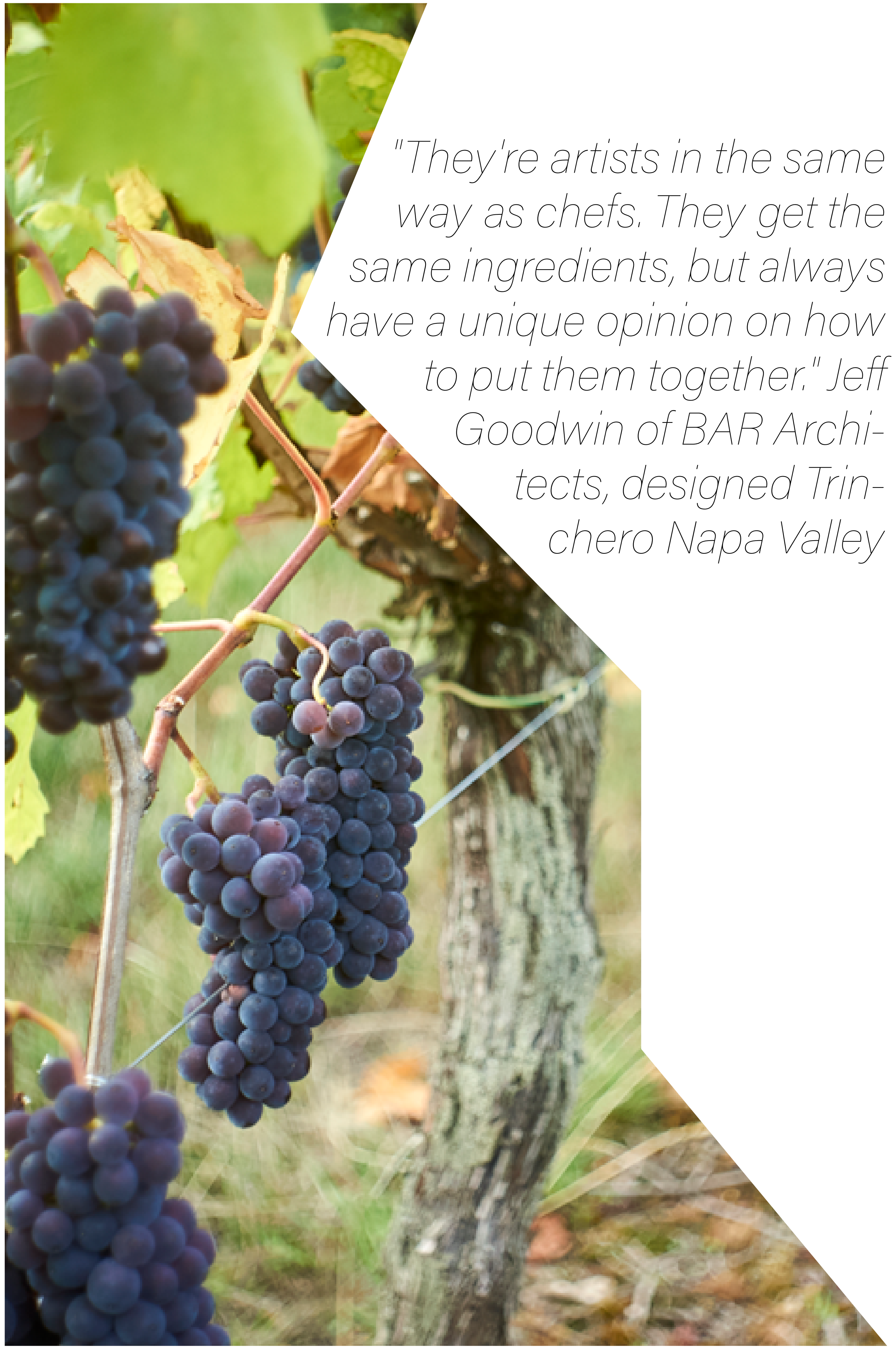
I am grateful as well to Franck Bléger and Franz Regele for the insightful visits of their respective wineries in Alsace and South Styria.

Finally, I must express my immense gratitude to Mederic, Gabriela and Sara for their unyielding support, their many words of encouragement and valuable feedback, as well as to Francesca, for proofreading my writing. Thank you.

Lory-Anne Lehmann

Riquewihr, ©Jean-Paul Krebs 2020

Contents



"They're artists in the same way as chefs. They get the same ingredients, but always have a unique opinion on how to put them together." Jeff Goodwin of BAR Architects, designed Trinchero Napa Valley

Introduction

01

As one of the preferred drinks worldwide, the total volume of wine produced yearly is estimated to be around 260 million hectolitres. However, reaching 1.750 million kWh per year only in the EU[1], the winegrowing sector is extremely energy demanding, which in the current environmental situation can not be maintained at such an extent, whether it be water or electricity consumptions. Lessening the impact has obvious ecological benefits at both a global and regional scale but also influences economical growth and security by entering a sustainable market.

A previous study states that a small winery[2] producing less than 25.000hl/year would consume an average of 16kWh/hl, this consumption being lower for bigger facilities, down to 4kWh/hl for the largest. What are the key factors that would influence the global sustainability of a winery ?

A decoction of the wine-making process will extract all of its specifications and requirements, based on scientific research, publications on existing wineries, visits and details provided directly from winemakers. Then before developing the concept, a thorough analysis of the environment will lead to a comprehension of the high stakes in this particular territory, a region with ever flourishing tourism, international attraction but also a strong cultural identity with the traditional architecture and gastronomy as its backbones.

The resulting project will attempt to combine all specifications of a functional winery for a small vineyard of 10ha. The emphasis in the design is put on the energy concept to achieve a nearly zero net energy consumption, with side goals such as reinterpretation of the traditions and embodiment of the inspiration brought by a young winemaker.

[1] *TESLA project, Intelligent Energy in Europe Program, Current process description Wineries*, Technical University of Madrid, 2013, p.9
[2] *Analysis of energy consumption: a case study of an Italian winery,* Maria Malvoni, Paolo Maria Congedo, Domenico Laforgia, 2017
* On the right, *Harvest Time*, © Lory-Anne Lehmann 2020
* On the left, *Pinot Noir grapes*, © Lory-Anne Lehmann 2020
* On the left, citation from https://vinepair.com/wine-blog/how-a-winery-gets-designed/

02 State of the Art

In order to develop the most efficient design, a precise understanding of the wine process, the winemakers needs and the overall state of the art concerning winery architecture is necessary.

The principle of gravity in the winery

An important notion in the conception of a winery is gravity. Numerous transfers are occurring during the winemaking process, from the press to the vats, vats to barrels, or even between some vats during fermentation. Although these transfers must be realised carefully and scarcely to avoid too much oxygenation which would result in oxidisation, detrimental to the organoleptic quality of the wine. Therefore the use of gravity between some steps decreases the need for pumps along with their risks. Furthermore, in the conception of a sustainable winery, gravity brings another advantage : it does not consume energy. To apply the concept, a construction caved into the side of a hill is the more suitable.

Temperatures in the wine cellar

The thermoregulation in a wine cellar is a key feature for every step of the winemaking process. Each of them have an ideal range to assure well-preservation, bonification or stabilisation. The stainless steel vats have their own cooling/heating system, thus allowing precise control of the fermentation for each batch. The room accordingly should be kept around 18°C to be comfortable enough working in without having to overcompensate the heat. Also, any significant sudden variation must be avoided.
Much colder, where pallets of bottles await either commercialisation or a couple years for wines such as “Vendanges Tardives”, the storage has to stay at a room temperature between 10° and 12°C.
The barrels need a very specific environment for an optimised quality of wine. The oenologist can decide to store the wine in barrels made of oak, where it will age for a few weeks to several months. The wine develops its structure and aromas, but further fermentation should be controlled. The low temperature in the room is consequently primordial and should stay between 10° and 12°C as well.[3]

Humidity

As much as temperatures, humidity in the different rooms of the cellar have to be monitored and regulated. Most importantly, the barrels room needs to be maintained at 80% humidity. By having a high humidity and regularly misting fresh water in the air, evaporation losses through the wood are reduced substantially as the barrels stay watertight. The humidity in the storage room has to be controlled too. Between 50 and 60% of relative humidity, losses through the corks of filled bottles will be minimised.

[3] *Wine cellar modeling for the assessment of energy efficiency*, Benni, De Maria, Barbaresi, Torreggiani, Tassinari, University of Bologna - Department of Agricultural Sciences, 2014, p.2

Riquewihr, ©Jean-Paul Krebs 2021

Water consumption

Water management is one of the most important challenges in a winery. Indeed, the necessity of thorough sanitation at every step of the winemaking process produces an average of 3 litres of greywater for 1 litre of wine, in an already relatively efficient system.
All around the winery, numerous water inlets provide efficiency to the workers along with slightly slopped floors and drains to ensure evacuation.

Some techniques can be installed to minimise the waste. For instance the use of steam as part of the sanitation process equals less water and a better cleaning agent for tanks and barrels.
Rainwater should also be collected as it can provide more efficiency while used for the dilution of phytosanitary products beside domestic use. Wastewater from the viticulture, which includes chemicals after washing the equipment, have to be collected and treated specifically. Solutions exist such as a pit to empty and wash the sprayer where a soil in a close-circuit is recreated with micro-organisms to degrade the substances.

Wine process & Specifications

White wines

01 Harvest
Sizes defined for a vineyard surface area max of 10 ha of which 1ha of Pinot Noir

Yield white wine 70hl/ha
Yield red wine 55hl/ha
Production : 685hl/year

02 Press
Whole bunch are loaded directly into the press;
An inflated bladder presses the grapes, the juice is flowed to a tank and the dried pomace composed of skins, seeds and stems are removed.

Groundfloor
Size : 3300 x 1750 x 2070mm
Movable mechanically
In use : few hours/batch during approx. 4 weeks
Needs : hot/cold water with drain
hot/cold water high pressure
vapor
air compressor
Access : Top, bottom & sides
Power : 7.7kW
Waste : dried pomace & water

03 Settling of the must
The heaviest particles of the cloudy juice deposit at the bottom of the vat. The juice is transferred to another vat allowing deposits from the first vat to be removed

Underground
Size : capacity max 630hl/year 8-9 tanks + 2 extra, movable mechanically
In use : > 1 week
Needs : hot/cold water with drain
hot/cold water high pressure
vapor
stable temperature / AC
CO2 control pannel
Access : Top & bottom side
Power : -
Waste : lees, CO2 & water

04 Alcoholic fermentation
The grape juice is transforming into wine, sugars are turned into alcohol

05 Fermentation malolactic
Malic acid transformed into lactic acid by lactic bacteria, it stabilizes the wine naturally but also decrease its acidity which is sometimes wanted. To avoid the malolactic fermentation, Sulphur dioxide is used, it stops the bacteria development.

alternative

06 Racking
Transferring the wine to a new tank allows the largest lees deposed at the bottom to be removed, it is called racking and it clarifies the wine. The lees are composed of dead yeast and any remaining solids.

07 Ageing
White wine in Alsace is usually aged in stainless steel vessels. It also can be aged on remaining lees for several months : it participates in the aromatic development of the wine

Underground
Size : capacity max 630hl/year 8-9 tanks + 2 extra, movable mechanically
In use : 3-18 months
Needs : hot/cold water with drain
hot/cold water high pressure
vapor
stable temperature / AC
CO2 control pannel
Access : Top & bottom side
Power : -
Waste : lees, CO2 & water

outsourced on-site

08 Bottling-Corking
Service provider coming to the winery with bottling and corking trucks. Bottles also labelled and packed in pallets.

Groundfloor open air
Service provider
Size : two trucks ~16m long
In use : 1 day
Needs : water

AC 12°C / RH 50-60%

09 Storage
Pallets of 700 bottles stored in a fresh environment with stable temperatures to protect the wine from alteration.

Underground
Size : capacity max 260 pallets overall
100x120cm stackable
Movable, pallet truck
In use :
Needs : hot/cold water with drain
hot/cold water high pressure
stable temperature / AC 12°C
low luminosity
Power :

Crémant d'Alsace

outsourced off-site

Tirage liqueur
Once the base wine is bottled, a mix of yeast and sugar called Tirage liqueur is added and the bottle is then closed with a crown cap. This addition lead to a second fermentation in the bottle.

Bottle-fermented
The yeast in presence of sugars produces CO2 and therefore bubbles. During this fermentation, the bottles are stored horizontally for several months.

Riddling
The dead yeast cells produce more lees in the bottle. The bottles are for that reason then held with the neck downwards, periodically turned and slightly shaken to accumulate all lees in the neck.

Disgorging
The bottle is plunged upside down in an ice cold bath to freeze the lees into a block. The bottle is then turned upright and the crown cap removed. The pressure in the bottle expulse the block of lees.

Dosage
A small volume of wine is lost during the disgorging. So another liqueur is added to refill the bottle, usually the content of the first disgorged bottle and sometimes sugar which can modify the results in the differentiation "Brut", "Dry" or "Semi-Dry" of the initial wine.

Corking
A specific cork is used covered by a wired-cap

Pinot Noir

01 Harvest
Sizes defined for a vineyard surface area max of 10 ha of which 1ha of Pinot Noir

Yield white wine 70hl/ha
Yield red wine 55hl/ha
Production : 685hl/year

02 Destemmer-Crusher
Separating berries from the stems and crushing them to release the juice

Groundfloor
Size : 230x90x165mm
Mobile/Easily movable
In use : Harvest time Pinot Noir
Needs : hot/cold water with drain
Power : 2kW
Waste : stems & water

Primary Fermentation

03 Maceration tank
Juice in a vat with skins and seeds together called the must, colour and tannins from the solids transfered to the juice.

04 Pigeage
The CO² created by fermentation push the solids to the top of the vat, form a cap which has then to be regularly punched down and mixed with the liquid.

05 Alcoholic fermentation
At the same time during the maceration occurs the alcoholic fermentation which transform sugars in alcohol.

Groundfloor
Size : 3-4 tanks of 30hl Ø1600mm
Movable mechanically
In use : Harvest time Pinot Noir, 1-2 weeks
Needs : hot/cold water with drain
hot/cold water high pressure
vapor
CO2 control
Access : Top and bottom side
Power : -
Waste : CO2 & water

06 Free run juice & pomace
The wine is devatted and transferred to another tank. The solids remaining are called pomace and transferred to the press.

Groundfloor
Power : pump 2.2kW or gravity

07 Press
An inflated bladder presses the pomace. The pomace is dried out and the remaining juice liberated is called the "press wine" and flowed in a tank.

Groundfloor
Size : 3300 x 1750 x 2070mm
Movable mechanically
In use : few hours/batch during approx. 4 weeks
Needs : hot/cold water with drain
hot/cold water high pressure
vapor
air compressor
Access : Top, bottom & sides
Power : 7.7kW
Waste : dried pomace & water

08 Blend of the free run juice and the press wine
Heaviest particles deposit at the bottom of the tank, are taken out and wines are then blended into one vat. The wine finishes its alcoholic fermentation

Secondary Fermentation

09 Malolactic fermentation
With time and sometimes with temperature rising in Spring, malic acid is transformed into lactic acid by a lac-bacteria, it stabilizes naturally the wine decrease its acidity.
Oxidation is avoided by having the wine der airlock

Underground
Size : capacity max 70hl/year 3-4 tanks + 2 extra, movable mechanically
In use : few days to weeks
Needs : hot/cold water with drain
hot/cold water high pressure
vapor
stable temperature / AC
CO2 control pannel
Access : Top & bottom side
Power : -
Waste : lees, CO2 & water

10 Transfers and sulphite
Transferring the wine to a new tank clarifies it. The lees, deposit at the bottom of the tank are removed. Sulphur dioxide (SO_2) can be added to protect the wine from bacterial spoilage which can otherwise happen no matter how hygienic the winery is.

AC 12°C / RH 80%

11 Ageing
The wine is transferred to oak barrels to mature for several weeks or months. This allows the wine to develop its structure and aromas as exchanges with and through the wood happens. Sometimes lees are left in the barrel, stirred with the wine to add aromas.

Underground
Size : capacity max 70hl/year, 30 oak barrels of 225l
Ø700mm length 950mm
Movable, 50kg empty
In use : 3-18 months
Needs : hot/cold water with drain
hot/cold water high pressure
vapor
stable temperature / AC 12°C
CO2 control pannel
low luminosity
Power : -
Waste : lees & CO2

outsourced on-site

12 Bottling - Corking
Service provider coming to the winery with bottling and corking trucks. Bottles also labelled and packed in pallets.

Groundfloor open air
Service provider
Size : two trucks ~16m long
In use : 1 day
Needs : water

AC 12°C / RH 50-60%

13 Storage
Pallets of 700 bottles stored in a fresh environment with stable temperatures to protect the wine from alteration.

Underground
Size : capacity max 260 pallets overall
100x120cm stackable
Movable, pallet truck
In use :
Needs : hot/cold water with drain
hot/cold water high pressure
stable temperature / AC 12°C
low luminosity
Power : to be defined

Ribeauvillé, ©Jean-Paul Krebs 2020

Visit of the Winery Hubert & Bléger, Alsace
A vineyard of around 30ha

The original winery was first built in 1970 and was then expanded in 1973 and 1976 with a timber structure and laminated beams. It finally got a last expansion in 2011 after setting new sustainable goals for the winery; a metallic structure with OSB (Oriented Strand Board) panels and wood fibre as insulation.

Above-ground buildings are divided into three areas. The first one, right at the entrance, is the oldest part of the building. Easily noticeable from the street, it includes the shop, a small degustation area with a bar and three offices in the back. It is the only heated part in Winter. The rest of the building is divided between the food handling facilities where only electric engines are allowed and the viticulture area, where tractors and machines like trimmer are stored along with phytosanitary products. These two areas require neither heating nor cooling, but they are insulated.

The cellar itself is spread underneath the whole length of the above-ground buildings. Having it underground lessens the need for climatization, but the winery has a cooling unit nonetheless, put outside, to reach the desired stable temperature.

The goods lift being forbidden to people and no access other than stairs present, there is currently no possibility for them to open in a lawful manner the cellar to the public.
All through the underground visit, the key points raised were wide circulations to facilitate the movements of workers and forklifts for an efficient workplace, a good lighting and more importantly, an oversized aspiration for Carbon Dioxide for safety concerns.

Energy wise, vine stocks and fuel oil are used for heating purposes. The cooling system from the shop and offices is independent from the cellar's. Rainwater is collected and stored in a tank connected to a second pipework, used mainly for the dilution of phytosanitary treatments.

Auxerrois grapes, © Lory-Anne Lehmann 2020

Social Network poll

reddit

Through a social network poll, around fifteen insightful comments were collected on the subject of designing a winery, with efficiency and sustainability as main focuses. The poll, aimed at winemakers who recently built a winery or have noticed flaws in their own, gathered a list of questions concerning the needs of the future business as well as essential features and a set of good examples of successful designs.

Therefrom, the questions to be answered by the winemaker before starting the design are:

How much wine will he make ? The maximum yield currently in Alsace is 80 hectolitres/hectares. With an ultimate goal of expansion to a maximum of ten hectares, the winery would produce at the uttermost eight hundred hectolitres per year.

How many tanks ? Having nine grape varieties in the vineyard and multiples Grand Cru (great vintages), it is best to accommodate a large collection of rather small tanks, allowing a greater diversity. With square tanks from 5 hl to 90 hl, a hundred tanks, the smaller being stackable, would be comfortable.

How many barrels ? The oak barrels being predominantly for the Pinot Noir, the only local red wine, considering the vineyard, an array of thirty barrels is expected.

How much bottled wine will need to be stored on site ? The bottles are stored either waiting for commercialisation or because they are still in the process of ageing. Thus, more than a year's production may have to stay in storage. An upper limit of a hundred thousand bottles per year is to be produced, a pallet storing seven hundred bottles, so around two hundred thirty pallets can be planned, a year and a half worth.

Any part of the cellar to host public and gatherings ? As the trend is showing, wine-tasting and wine-pairing events are becoming more and more popular. The public also expect transparency in how products are made, and have a curiosity for such places. A wine-tasting room, with adjoining kitchen and facilities is a real asset and even more inviting with a view towards the barrel room.

Characteristics have been mentioned as advantageous indeed essentials. The first one is an open floor space to be able to move and work efficiently, it is a must and saves a lot of time. Wide aisles are necessary to move around with forklifts. The second, numerous water access, hot and cold, throughout the winery, with a very effective drainage and slopped floor to facilitate cleaning.

Research Analysis

Layout and energy efficiency for wineries has been researched through experimentations and comparisons during the past years. As a wine producing country, Italy is equally concerned by the impact of the industry and multiple studies have been carried out there.

Energy consumption in the winery is almost entirely due to cooling, air conditioning of storage and ageing rooms. The consumption can be divided over two periods influenced by the seasonality of the winemaking process : harvest months generally extend from August until October, this period reaching a big 43% of the total, while the rest of the year is 57%. Accordingly, the energy demand for air conditioning in the winery over the whole year hit around 70% of the total consumption.[4]

The winery analysed in Barbaresi's *et al* study[5] has a vineyard of 23 hectares with a production of around 2,000hl/year while the case of this thesis has a small production of less than 700hl/year on a 10 hectares vineyard. Models with variables (harvesting modality, materials and vertical distribution of the building envelope) are compared. The results show an important difference in the energy demand between the two most opposed models. The first one, mechanical harvest, thermal characteristics of the buildings envelope set to a minimum and above ground buildings only, considering all conditioned volumes reach 23.87 kWh/m3 calculated with the software EnergyPlus 8.1, while the second model, manual harvest, thermal characteristics set to all of the volumes and partially underground buildings requires 12.84 kWh/m3. In all combinations, insulation always plays a significant part, "with a 43% reduction of energy required per cubic meter". The insulation of internal partitions and unconditioned rooms is a plus.[6] The power peak during the year is related to the fermentation cooling, in this study 12935 Kwh (29.99 kWh/h), but it depends greatly on the weather conditions.[7]

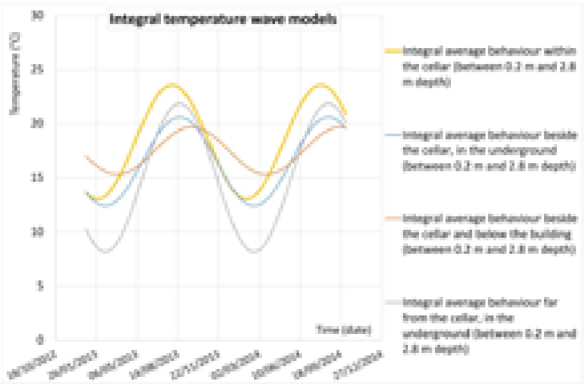
"A system sized based on fermentation cooling power peaks can provide thermal energy for the whole building and take advantage of any overlap between positive (heating) and negative loads (cooling)."
Barbaresi *et al.* 2017

Barbaresi outlines as well on his paper the CO2 emitted during the whole process of winemaking per bottle, "2.17 kg/bottle, of which 0.73 kg/bottle related to wine processing inside the winery", without considering "about 100g/bottle [related to must fermentation]".[8] In the example of this thesis, the CO2 absorbed, considering Ventura *et al.*[9] calculation of 22 tonnes per hectare and a yield in Alsace of 80hl/hectare, can be estimated at 2 kg/bottle.

[4] *Experimental analysis of thermal interaction between wine cellar and underground*, Benni, Tinti, Barbaresi, Torreggiani, 2015, p.4
[5] *Analysis of the thermal loads required by a small- medium sized winery in the Mediterranean area.* Barbaresi, Torreggiani, Tinti, Tassinari 2017

[6,7,8] *Idem*, p.20
[9] *Indagine sui flussi di materia ed energia da vigneto e daterreno nudo nell'interfilare in un sistema viticolo dell'italia centrale,* Ventura, F et al., 2007, Quaderni Viticoli Enologico

In 2015 Benni *et al.* carried out a study on thermal interactions between wine cellars and underground. An underground wine cellar has substantial advantages regarding thermal control in multiple ways. An insulated building above



Integral temperature wave models, Benni *et al.* 2015

the underground construction have a direct impact on the internal temperatures, thickness of the cellar's walls and their insulation influence the thermal wave phase shifting. By exploiting the ground's insulation properties, the cellar is protected from temperatures peaks and sudden variations.
However, analysis of results[10] also shows that the temperatures inside an underground room during summer exceed the limit for wine storage, leading the conclusion of this research to points a necessity of high insulation of the basement from the aboveground building and consider heat exchange systems with the ground at the cellar depth.
According to the authors, there are three factors in addition to the underground temperatures that have an impact on belowground wine cellars: first, the thermal attributes of the building above, insulated or not, heated or not; then the ventilation inside the cellar and finally the heat storage capacity of the walls and slab, affecting the thermal wave.[11] Having control of these three parameters conjugated with an underground cellar reduces greatly energy consumption regarding thermal needs.

Regarding the ventilation, it is not only impacting temperatures but also primordial for wine ageing and storage conditions. Due to the high humidity, the air velocity is crucial to avoid mould formation, although it has to be maintained low to prevent wine losses from the barrels.[12] Natural ventilation achieving a steady enough flow and even distribution without stagnation zones is hard to obtain or at least not sufficient. It is therefore necessary to implement a weighted mechanical ventilation, with an air velocity inferior to 1 m/s.

[10] *Experimental analysis of thermal interaction between wine cellar and underground*, Benni, Tinti, Barbaresi, Torreggiani, 2015, p.31

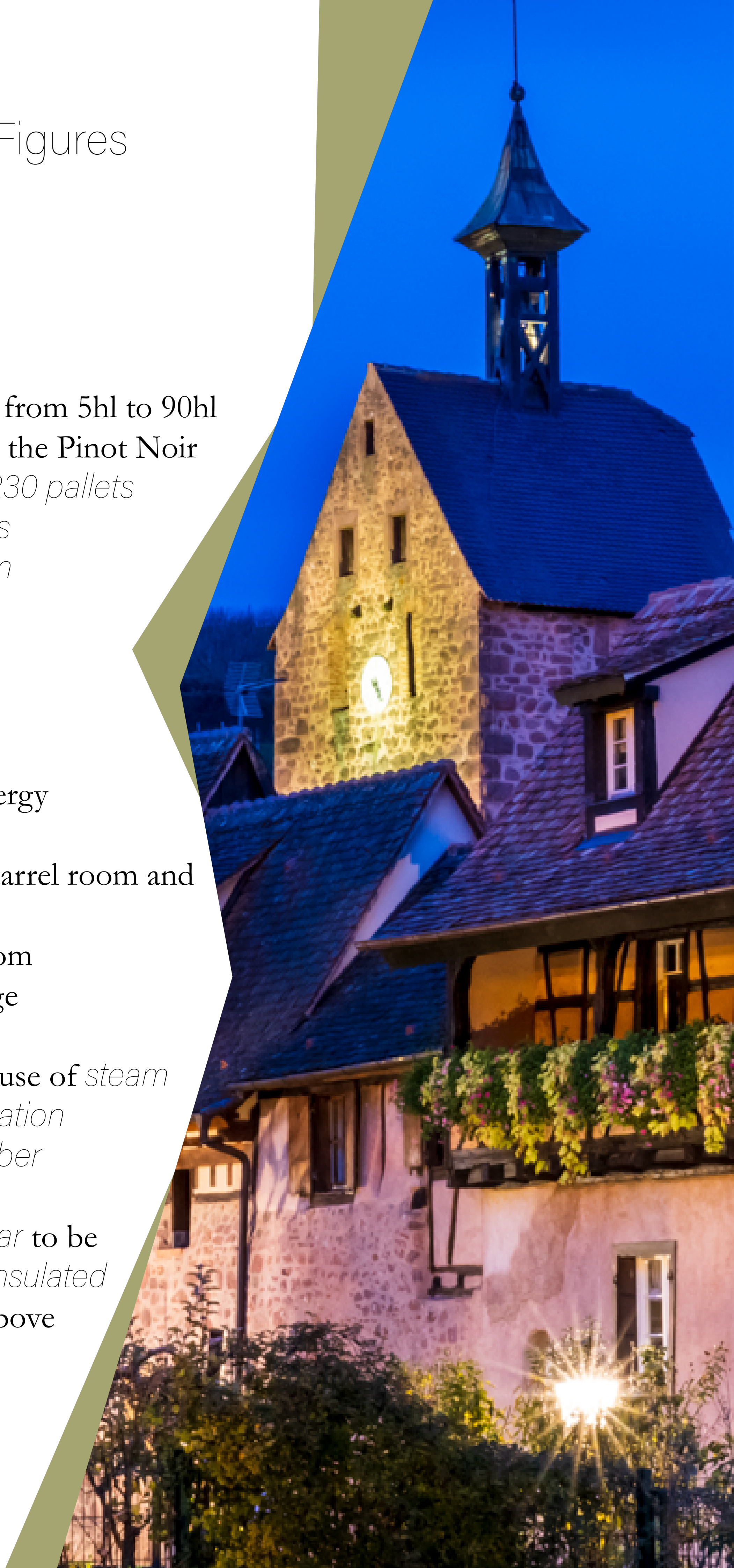
[11] *Experimental analysis of thermal interaction between wine cellar and underground*, Benni, Tinti, Barbaresi, Torreggiani, 2015, p.15
[12] *Numerical simulations for the optimisation of ventilation system designed for wine cellars*, Santolini et al 2019, p.180
* On the right, Riquewihr, ©Jean-Paul Krebs,

Key Facts & Figures

10ha Vineyard
685hl Production

need of *100 tanks* from 5hl to 90hl
30 oak barrels for the Pinot Noir
storage room for *230 pallets*
each of *700 bottles*
Wine-tasting room
Open-floor space
with wide aisles

Gravity to save energy
18°C vats room
b/w 10 and 12°C barrel room and storage
80% RH barrel room
50-60% RH storage
slopped floors,
use of *rainwaters*, use of *steam*
Mechanical ventilation
August to November
Power peaks
Underground cellar to be favoured with an *insulated building* directly above



Site & Project

"The new winery should be seen as a statement, showing the prestige of Alsatian terroir and wines. A noble value to be shared with visitors who come to discover an innovative approach to wine while maintaining tradition."
Anthony Lehmann

03

Environment & Location

Riquewihr is a village of around a thousand inhabitants in Alsace, a famous wine country in the North-East of France close to the German border. Although it is small, the historical medieval walled city is extremely touristic all throughout the year except for a small off-season in January and February, counting around two millions tourists[13] per year. Listed in the Plus Beaux Villages de France, having undergone very little damage during the two world wars, the traditional timber-framed houses are for the most part really well preserved. Numerous winemakers houses, with traditional underground wine cellars are still in use. In fact, the tradition of winemaking in Riquewihr dates back to the Middle Ages and it has been – and still is, with its forty-eight wine-growing holdings[14] – an essential constituent of the local economy. The average size of each farm today is 4.4 hectares. The village is nestled in the heart of the vineyard, hosting famous slopes of great vintages and is a key step along the Alsatian Wine Route.

The site for the project in this thesis is at the entry of the village, a dual-aspect plot situated between the main access to the village – the Wine Route – and a small street leading to a residential neighbourhood.

The terrain has a clay soil with aquifers and has no building nearby overshadowing.

As a plus, unlike other wine countries, greywater produced by wineries are treated at the municipal level.

[13] L'Alsace (newspaper), Pierre Gusz, 19.01.2016
[14] Local Urbanisation Plan, report from 2017

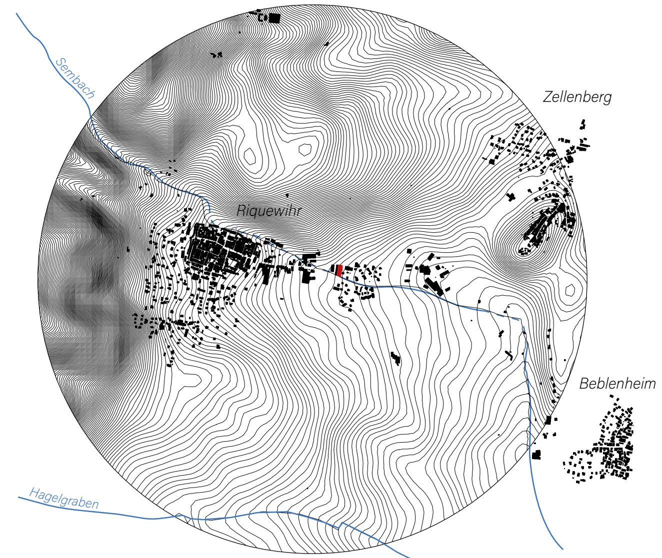
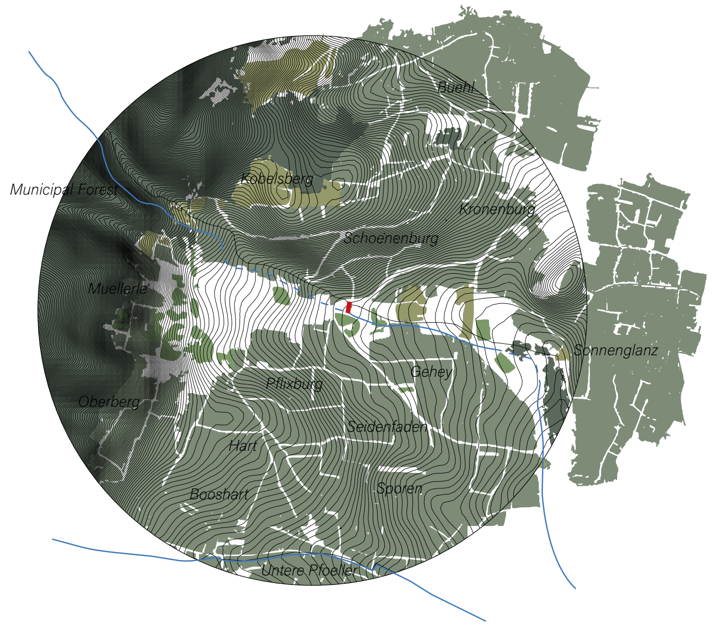


Figure Ground

Riquewihr is nestled between hills and mountains. Nearby villages are no more than 2km away. The studied area is in a residential area with a low population density.

- Existing buildings
- Project lot
- Stream (open-air & below ground)



Vegetation

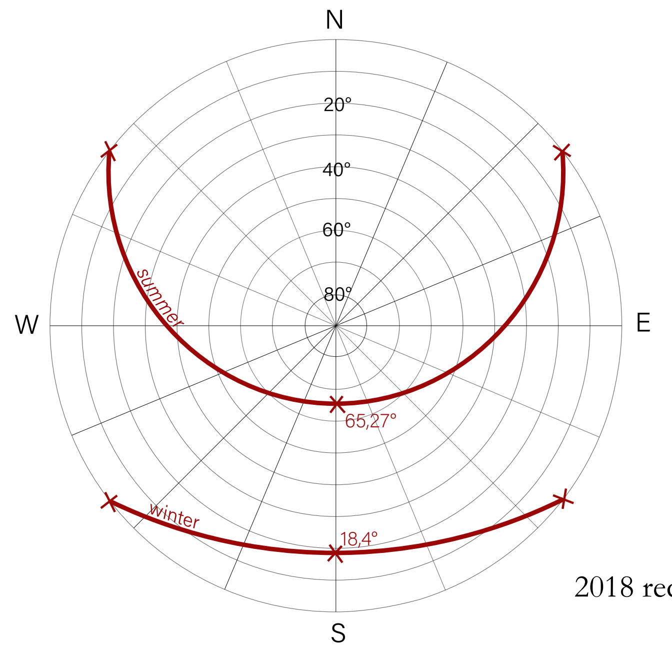
Riquewihr is called the Pearl of the Vineyard. The small city is literally surrounded by vines, but also a step away from the Vosges mountains where the municipal forest is located. Other plantations are rare ont the hills apart from a few orchads and the village doesn't lack private gardens. Names of hillsides are used in the designation of the wine. The Schoenenburg for instance is a classified Grand Cru terroir.

- Vineyard
- Forest
- Orchads
- Private gardens & Football fields
- *Hart* Name of the hillside

Network

As a highly touristic region, Alsatian villages are linked by an efficient network. The Wine Route follows the hills of the vineyard in its entirety and access to the motorway from Riquewihr is less than 5km. Numerous paths used by winegrowers also form scenic walks through the vineyard landscape.

- Wine Route & main roads
- Secondary streets
- Historic center (pedestrian streets)
- Vineyard paths
- Stream (open-air & below ground)



Winter

Rise 7:18 azimuth 125,45°
Noon 11:28 azimuth 179,99° elevation 18,4°
Set 15:39 azimuth 234,54°

Summer

Rise 3:30 azimuth 52,22°
Noon 11:32 azimuth 180° elevation 65,27°
Set 19:34 azimuth 307,78°

Temperatures

-5°C < x < 25°C rising
2018 records of temperatures, 1,4°C above the normal

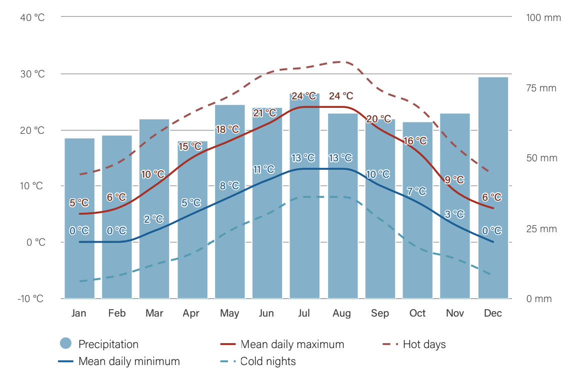
Less and less precipitations
2018 -30% rain

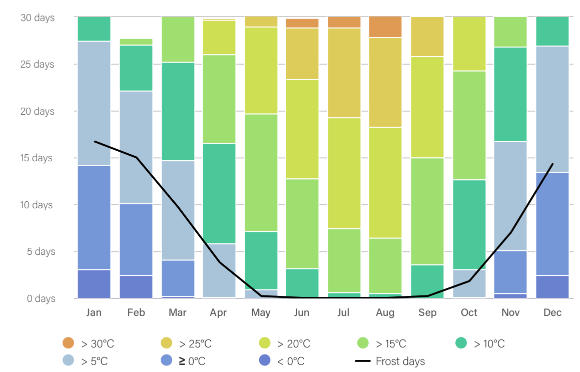
Protected from North Wind from the Schoenenberg

Riquewihr altitude

Min 230m
Max 936m
Project altitude 250m

Average temperatures and precipitations & maximum temperatures diagrams, source meteoblue

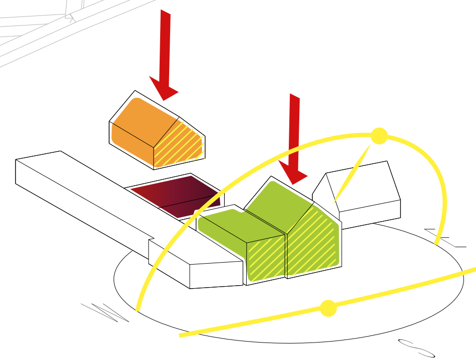


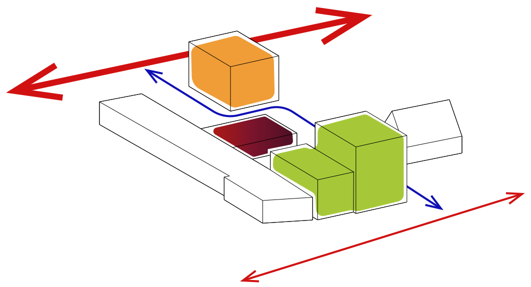


Design Concept

01 PROGRAM

Split of the **3 functions** – Private, public and professional– taking into consideration the difference in traffic between the two streets



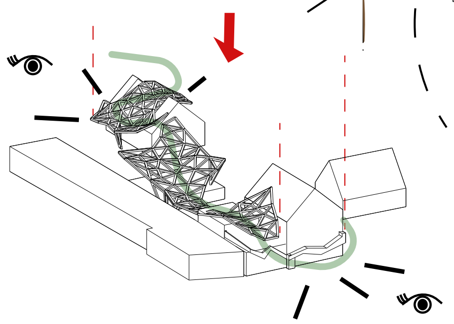


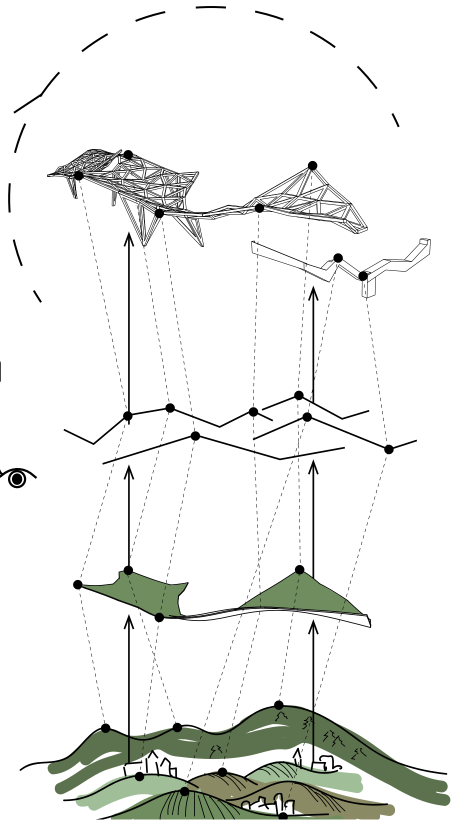
02 SHAPING

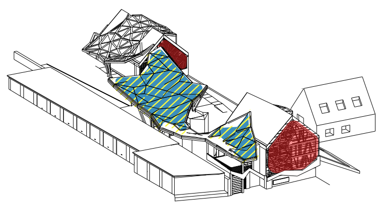
A contemporary version of a traditional style, timber as main structure, **traditional shell**, facing South

03 BLENDING VS STANDING OUT

Integrated into the surrounding hills, emulating the environment, but **catching the eye**, the modern part is literally embracing the traditional volumes. Enhance the views from the interior.

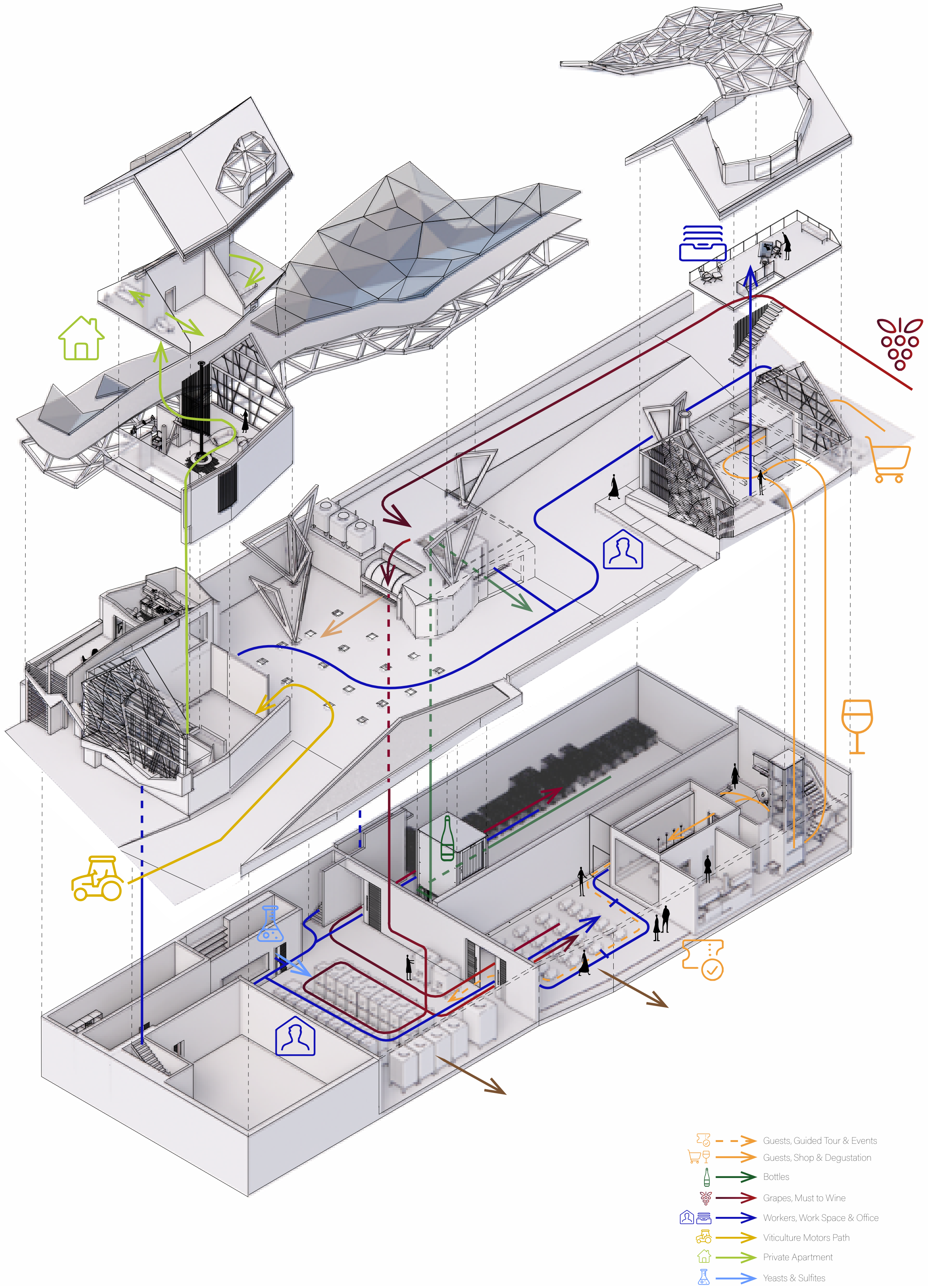






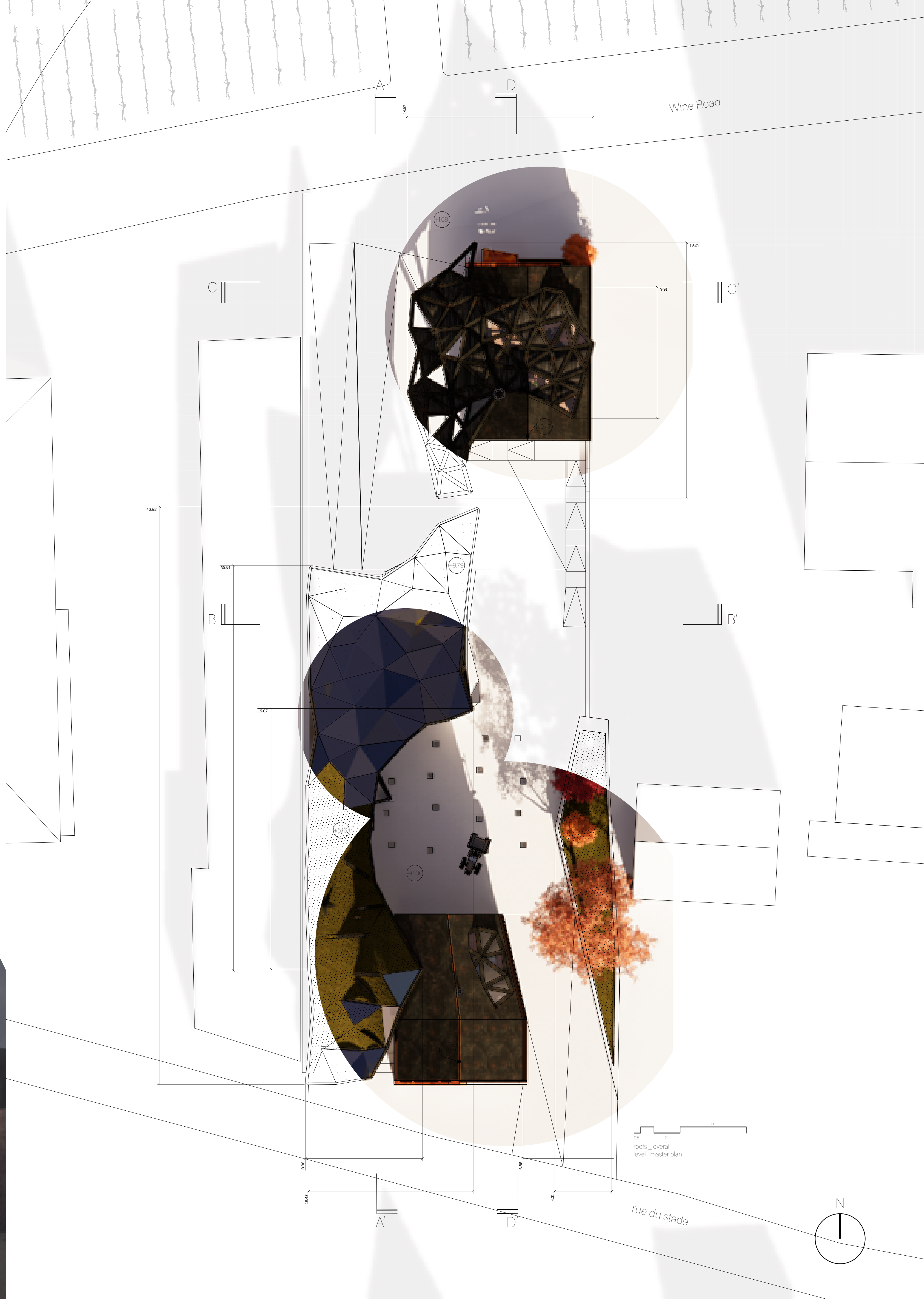
04 ENERGY WISE

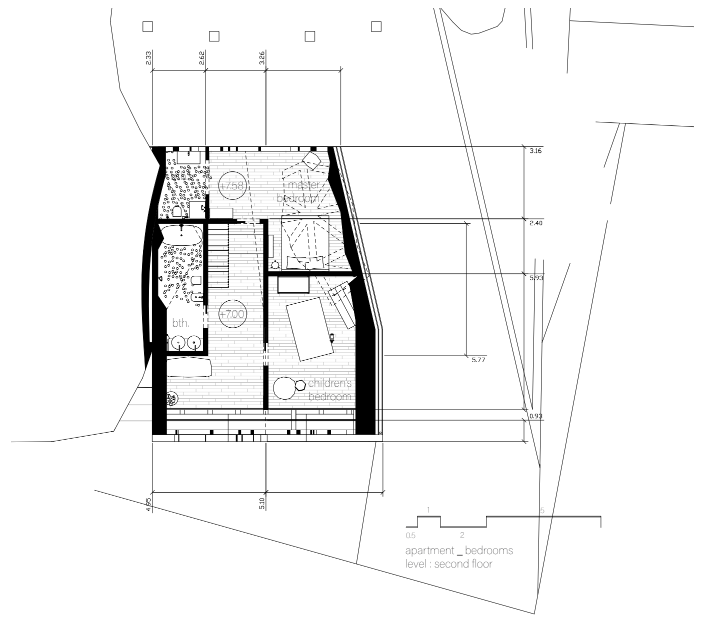
The whole building is designed with **energy optimisation** in mind. Protection of the facades, materials, orientation, water managment. Energy concept detailed p. 38-39



Plans & Sections

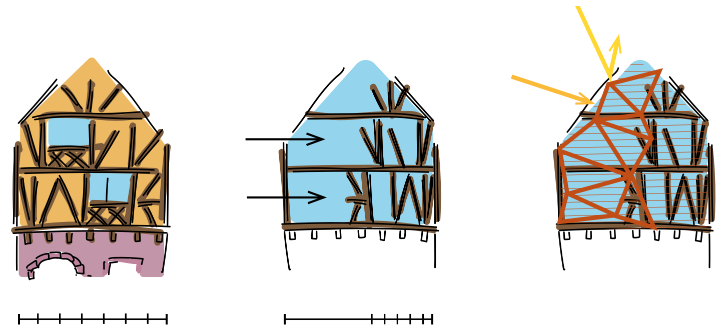
"A courtyard for easy manoeuvring, tractors, deliveries, emptying and washing tanks. The press in a protected and covered area, easy to clean."

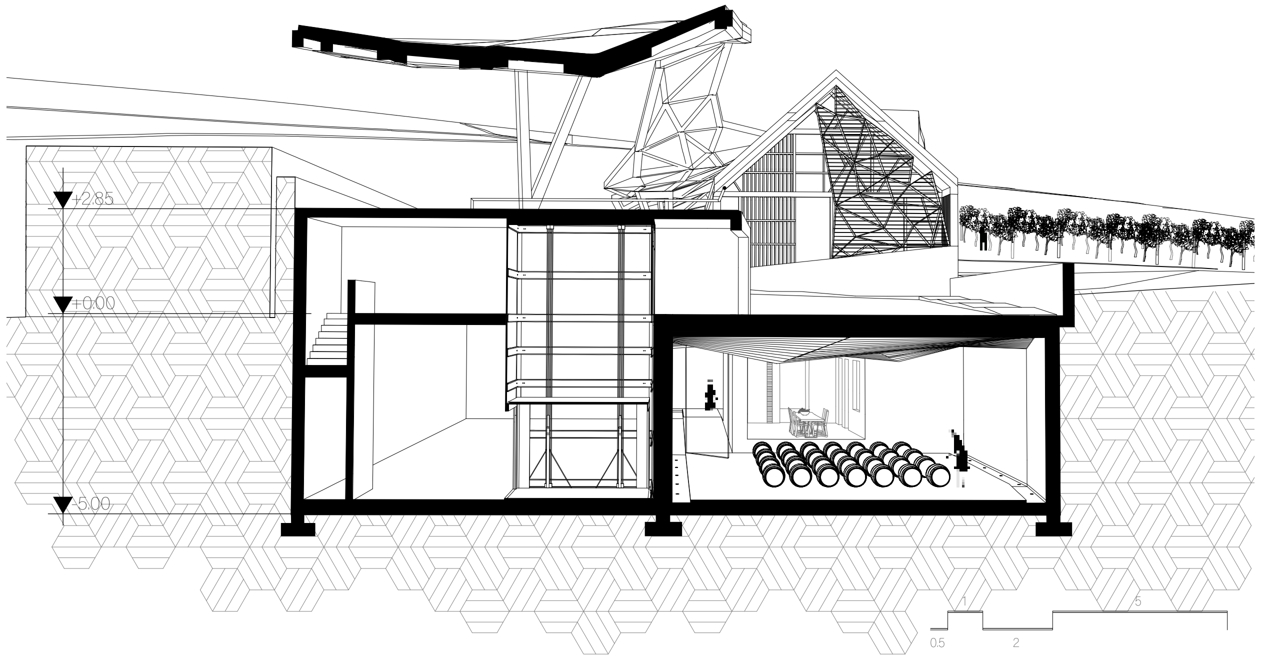




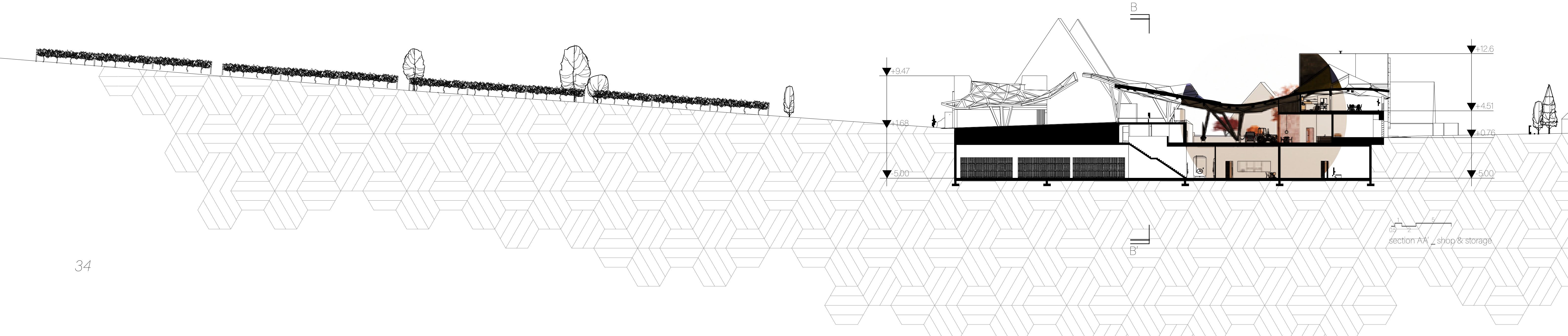
Ingenuity,
efficiency,
quality of the
workplace,
attractiveness
profitability,
cultural inheritance

section CC' _ shop & storage



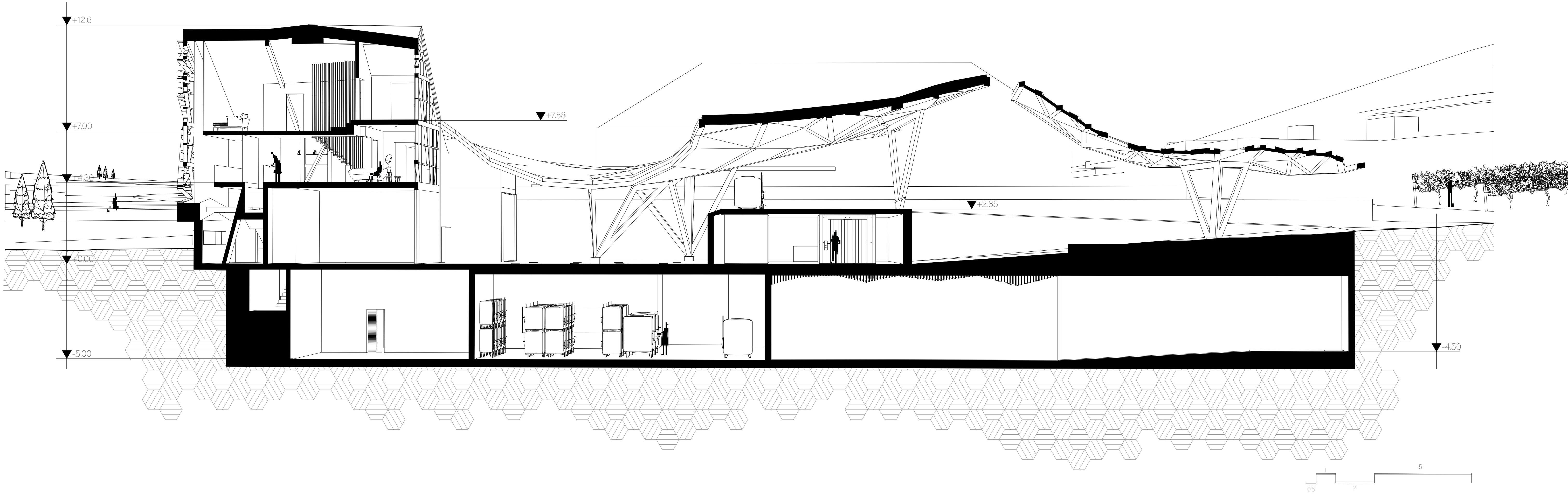


section BB' _ barrels & storage

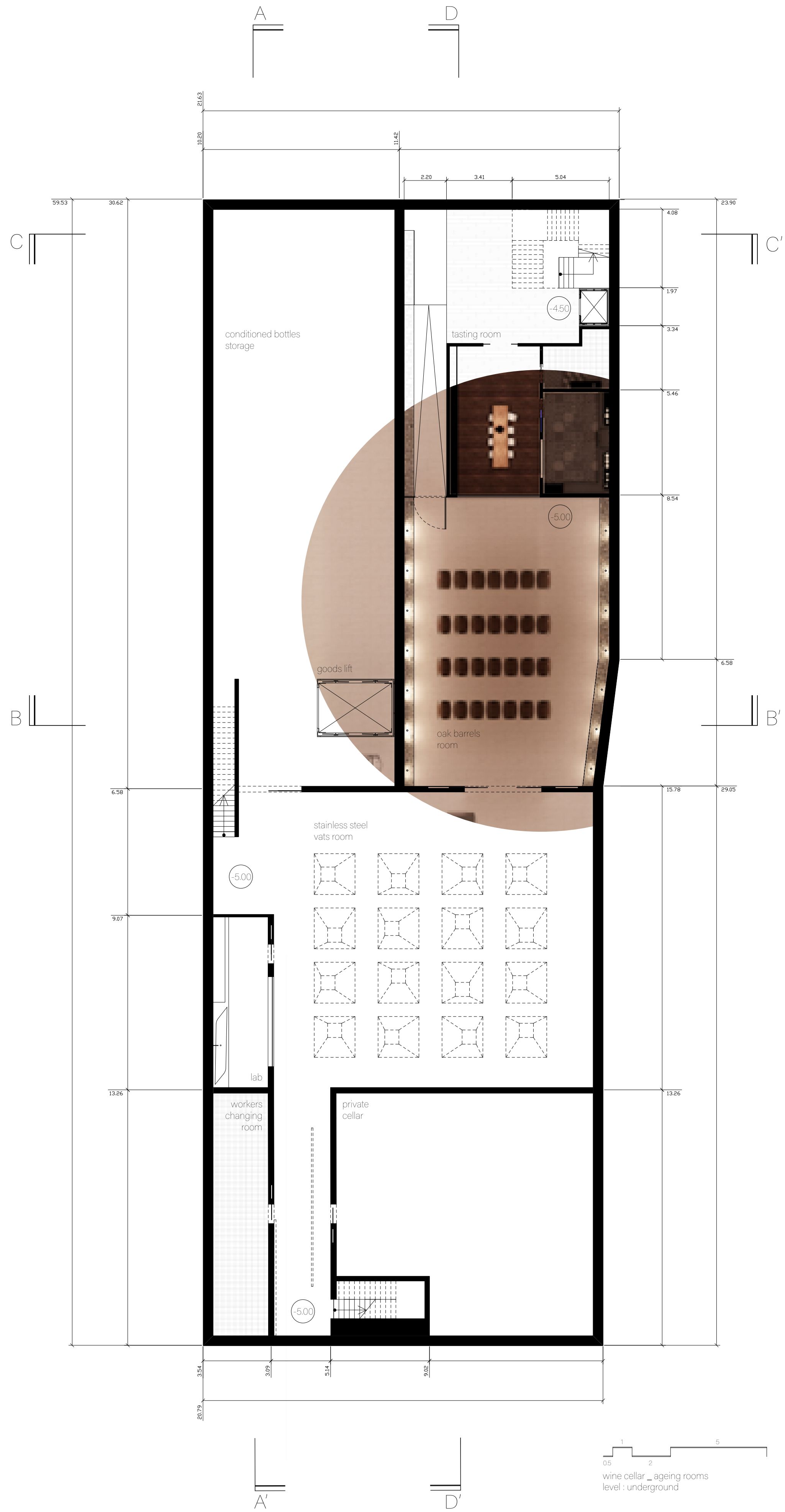


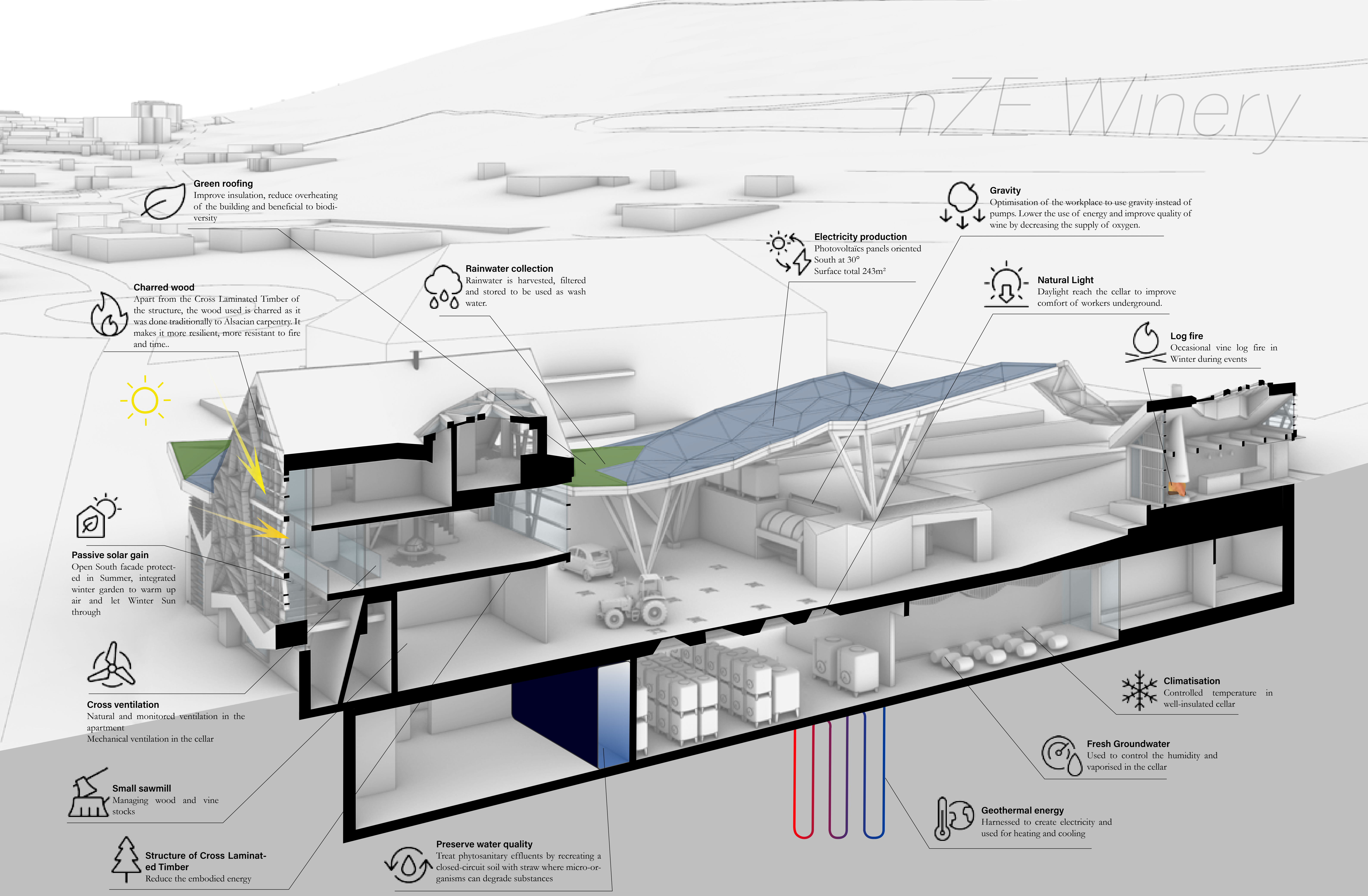
section AA' _ shop & storage

"If we can't move well through a space to get our jobs done, then efficiency and effectiveness go out the window."
Mollie Haycock, assistant winemaker at Scott Harvey Wines



section DD' _ shop & storage


A
D
C
C'
B
B'
conditioned bottles storage
tasting room
-4.50
-5.00
goods lift
oak barrels room
stainless steel vats room
-5.00
lab
workers changing room
private cellar
-5.00
A'
D'
wine cellar _ ageing rooms
level : underground



nZE Winery
Green roofing
Improve insulation, reduce overheating of the building and beneficial to biodiversity
Charred wood
Apart from the Cross Laminated Timber of the structure, the wood used is charred as it was done traditionally to Alsacian carpentry. It makes it more resilient, more resistant to fire and time..
Rainwater collection
Rainwater is harvested, filtered and stored to be used as wash water.
Electricity production
Photovoltaïcs panels oriented South at 30°
Surface total 243m²
Gravity
Optimisation of the workplace to use gravity instead of pumps. Lower the use of energy and improve quality of wine by decreasing the supply of oxygen.
Natural Light
Daylight reach the cellar to improve comfort of workers underground.
Log fire
Occasional vine log fire in Winter during events
Passive solar gain
Open South facade protected in Summer, integrated winter garden to warm up air and let Winter Sun through
Cross ventilation
Natural and monitored ventilation in the apartment
Mechanical ventilation in the cellar
Small sawmill
Managing wood and vine stocks
Structure of Cross Laminated Timber
Reduce the embodied energy
Preserve water quality
Treat phytosanitary effluents by recreating a closed-circuit soil with straw where micro-organisms can degrade substances
Climatisation
Controlled temperature in well-insulated cellar
Fresh Groundwater
Used to control the humidity and vaporised in the cellar
Geothermal energy
Harnessed to create electricity and used for heating and cooling

Total Surface Area: 1613m²
- Of which heated: 377m²
- Of which cooled: 430m²
- No Heating/Cooling surface: 806m² (includes garages, exterior storage, private cellar)

PV Panels area: 242m²
PV Panels efficiency: 15%
Yearly Solar Radiation: 1100 kWh/m²

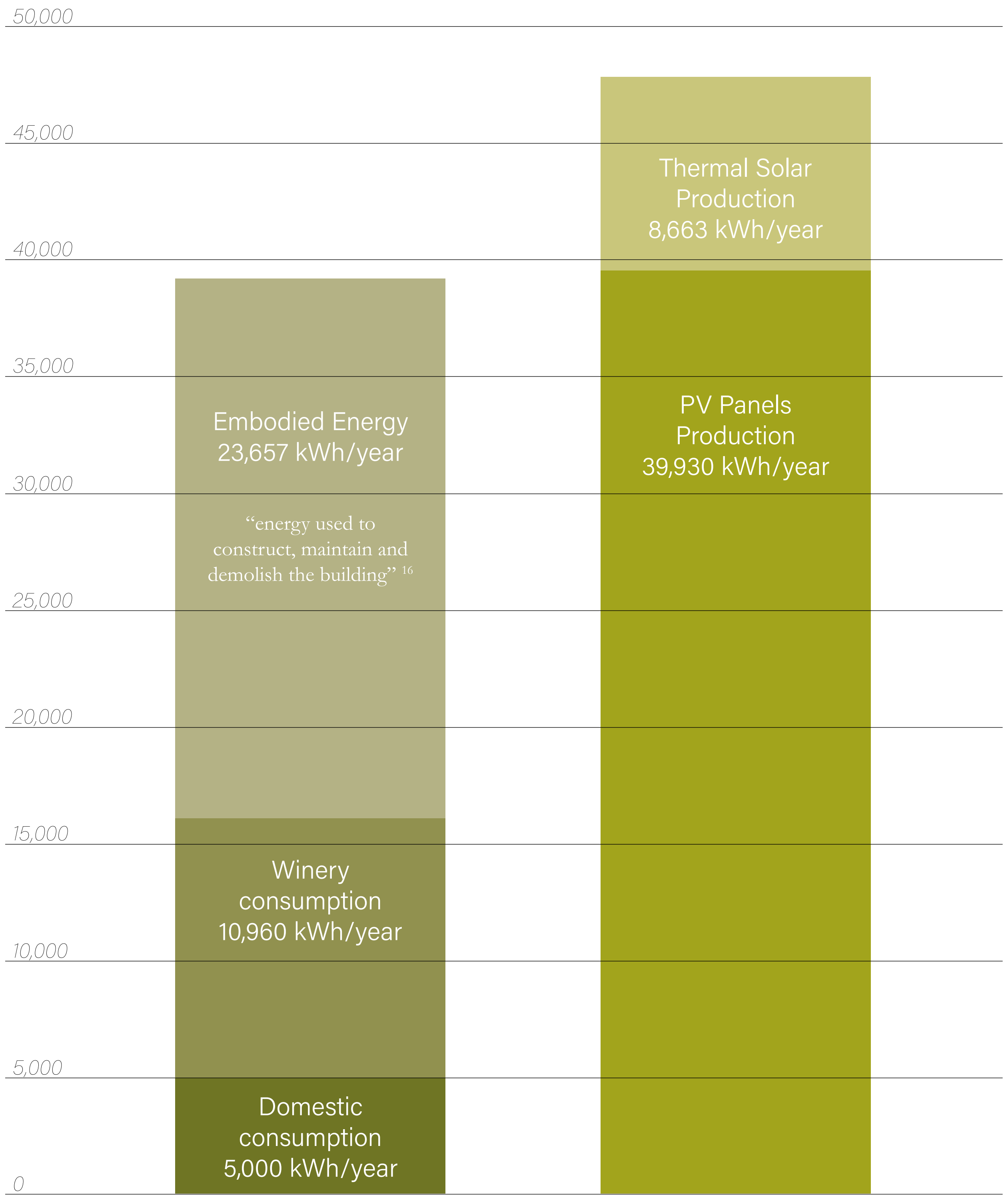
Life Span considered: 100 years
Life cycle Embodied energy[15]: 5,28 GJ/m²

Additional Thermal Solar panels on the West facing roof: 25m²
Thermal Solar panels efficiency: 55%
West facing roof Yearly Radiation: 630 kWh/m²

Heat Pump
Geothermal energy: Cooling need reduced with ground waters use and heat exchange
Heating need: reduced by occasional wood fire

[15,16] Azari, R., & Abbasabadi, N., *Embodied energy of buildings: A review of data, methods, challenges, and research trends, Energy & Buildings 168*, p.227, 2018

Energy Balance
nearly Zero Energy or net Zero ?

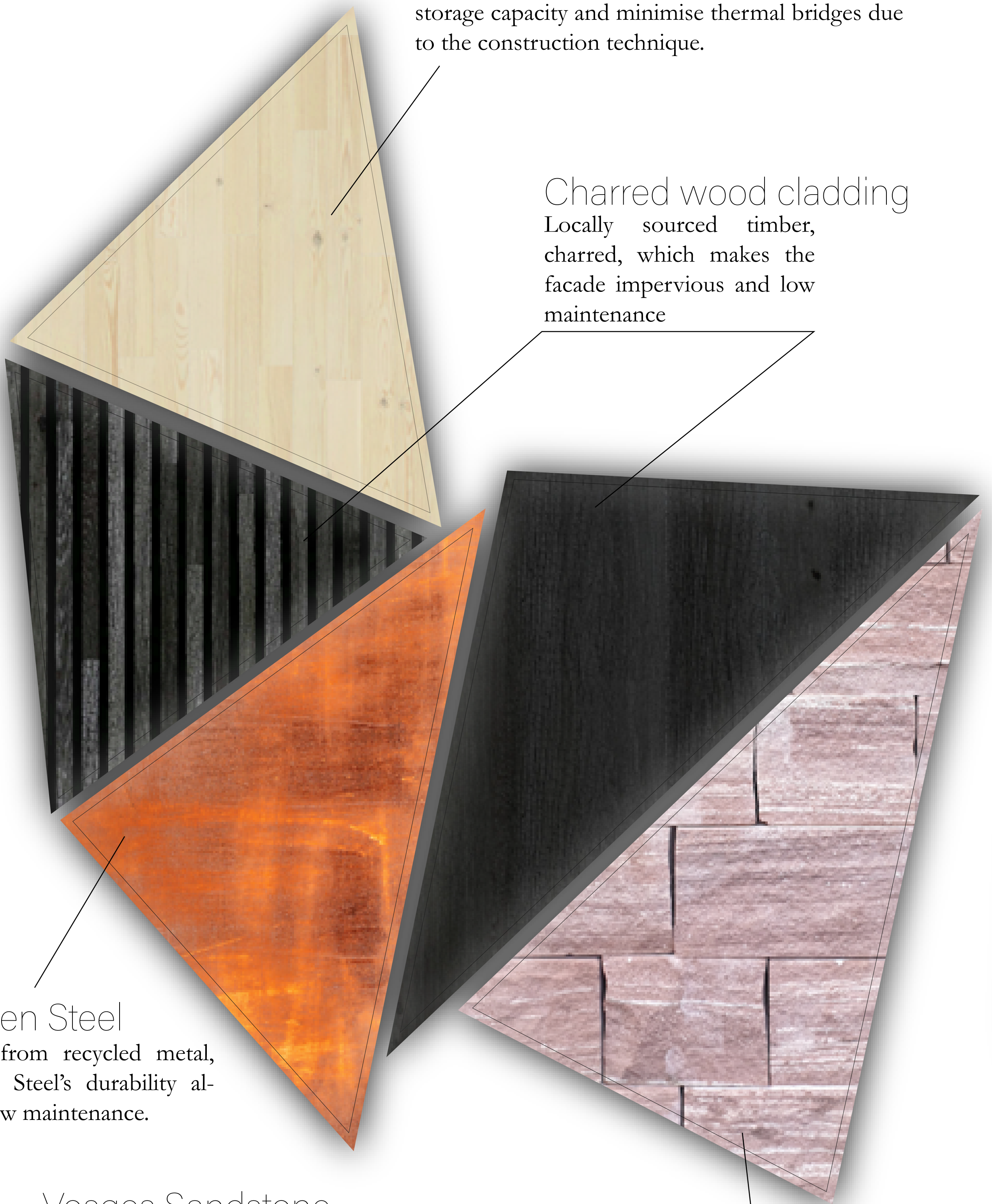


Cross-Laminated Timber

Low primary energy demand, panels provide heat storage capacity and minimise thermal bridges due to the construction technique.

Charred wood cladding

Locally sourced timber, charred, which makes the facade impervious and low maintenance



Corten Steel

Made from recycled metal, Corten Steel's durability allows low maintenance.

Vosges Sandstone

A stone widely used in Alsace, there is several quarries throughout the region. Resilient material, it was used to build the cathedral of Strasbourg (completion 15th century).

Embodied Energy & Materials

The winery is designed entirely with a historically grown materials language of the region. This allows a significant reduction of the embodied energy, as all the suppliers as well as the trades involved in the construction are locals.

Sedum Green Roof

Natural insulation, the green roof also improves eco-diversity and integration in the environment.

Timber Fibre Insulation

Complementary to the timber structure, boards are created from sawmill's waste.

Recycled Wooden Floor

Wooden planks are a common traditional flooring. Recycled timber is not only eco-friendly, it also brings character to the atmosphere.

Polished Concrete

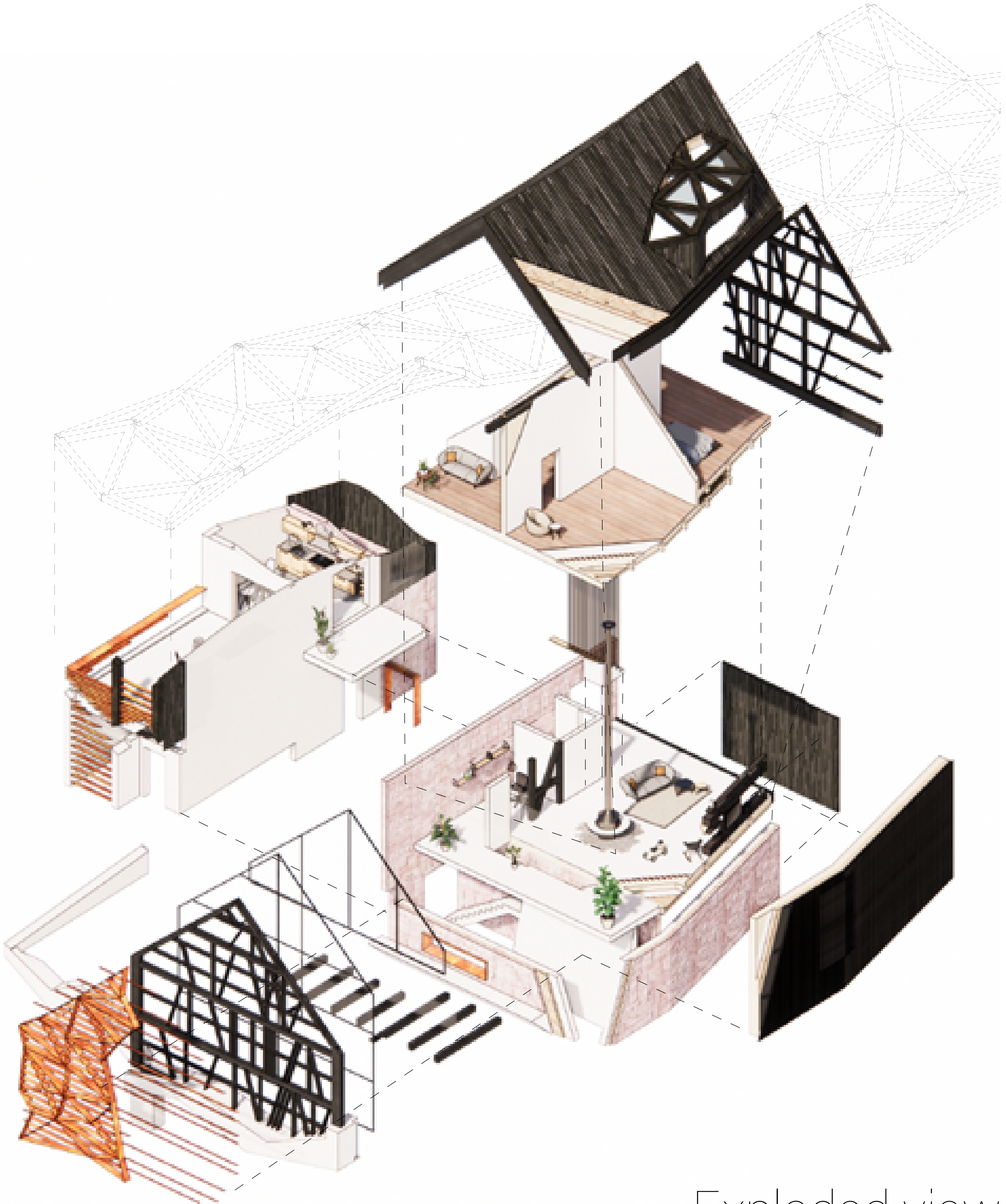
Reduced maintenance, highly resistant, it uses the existing concrete slab as a finition. It also reduces energy cost by enhancing light reflectivity.

Shou Sugi Ban

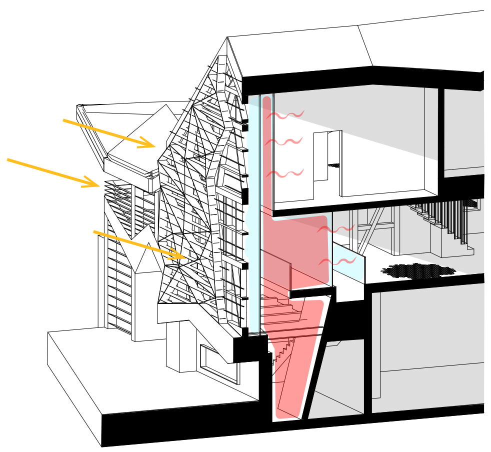
Charred Wood

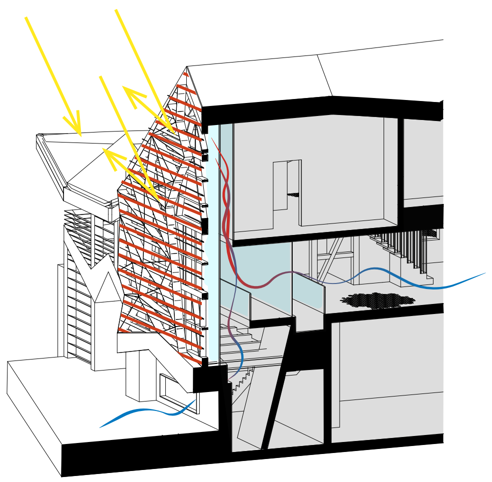
Shou Sugi Ban is a well-known Japanese technique meant to preserve the wood, protect it against insects and putrefaction. As a plus, the obtained colour is definitive.

In Alsace, it was customary to char the framework of traditional timberframed houses. Besides the above-mentioned benefits, charred wood has a better fire resistance which is non negligible in tight old city centers.



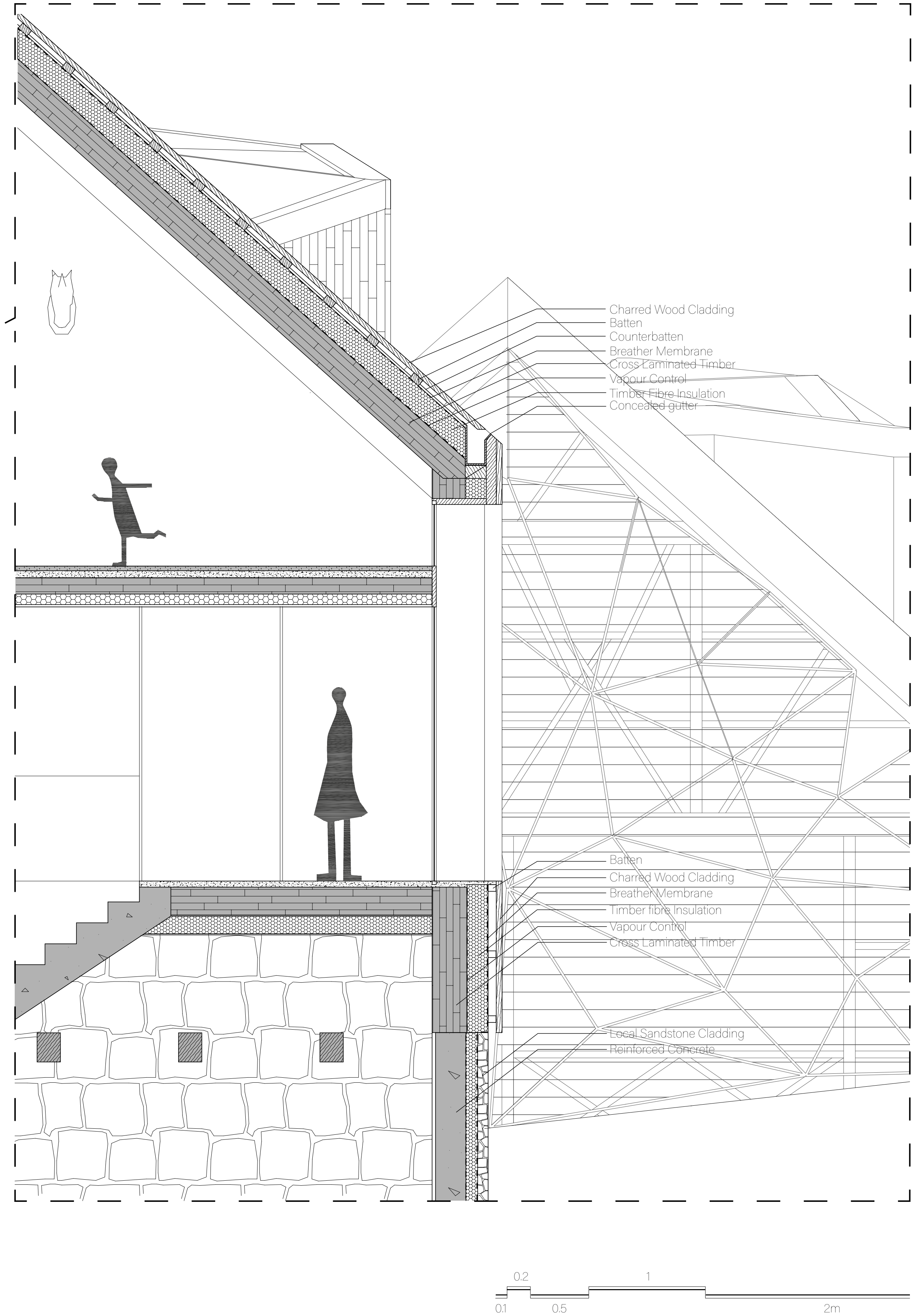
Exploded view

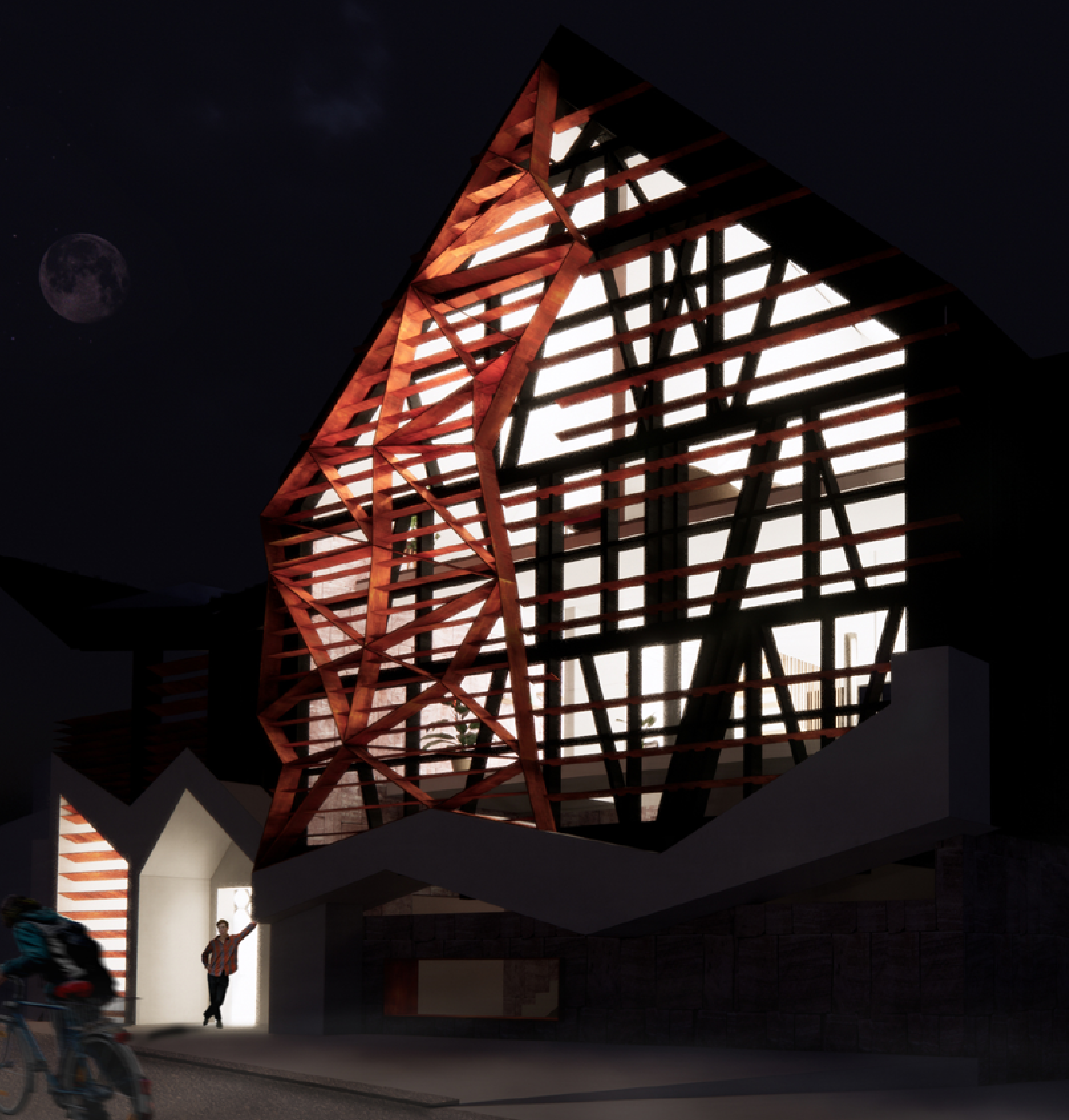




Detail Facade

Detail Cladding





05

Conclusion

As a winery situated in a dynamic wine country, the challenges faced are many and varied. In addition to the economic, social, efficiency questions the design of such a building obviously raises, today the sustainability problems widely spread in the sector must be matched. The analysis of studies already carried out on the subject associated with discerning specifications and recommendations of winemakers, locals or from other nationalities, have led to a detailed panorama of the requirements from a net zero energy winery. Furthermore, the stakes brought by the territory set up a delicate scenery, deserving to be enhanced.

With a production of nearly 700hl per year, the designed winery is classified within the smallest vineyards, which are pointed out as the most energy-intensive per litre of wine in the profession, with a consumption of 16 kWh/hl. However, with a carefully scripted energy concept, thought-out facades, orientation according to the sun and seasons, handpicked and attentively sourced materials as well as adapted floorplans, both the energy consumption and the embodied energy can be positively affected. The energy balance obtained results in a net zero energy building, able to produce more than its needs therefore reaching the aim of this work.

As this project has highlighted, it is essential while designing net zero energy building to establish a state of equilibrium between the need to cover energy demand in self-production and the urgent global need to reduce the actual life cycle consumption in buildings. One without the other would not be truly sustainable.

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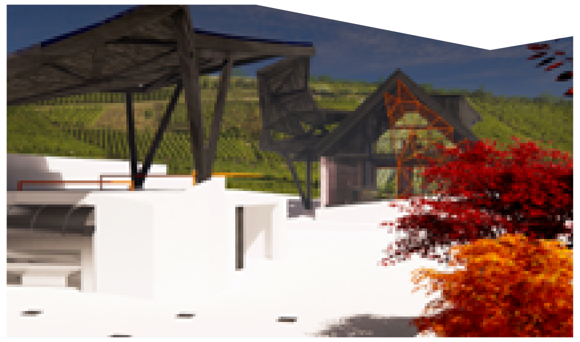
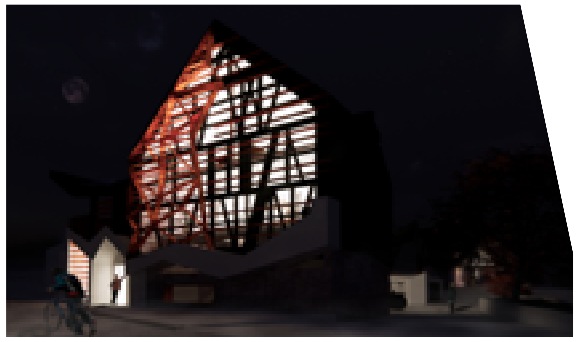
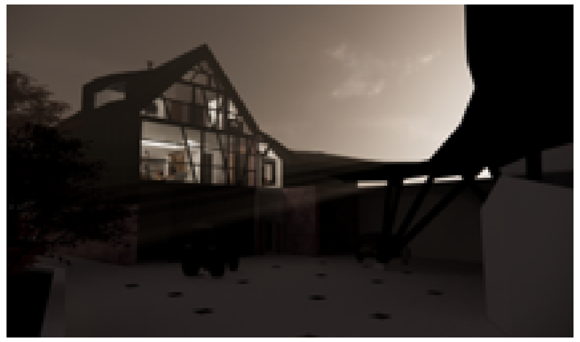
Photography not owned : https://www.facebook.com/jeanpaul.krebs
Software used : Rhinoceros, AutoCAD, Enscape, Adobe Creative Suite

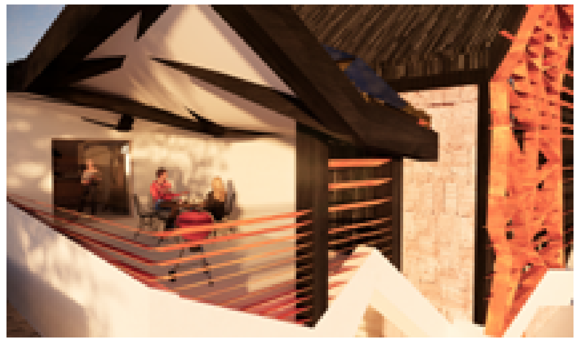
Illustrations

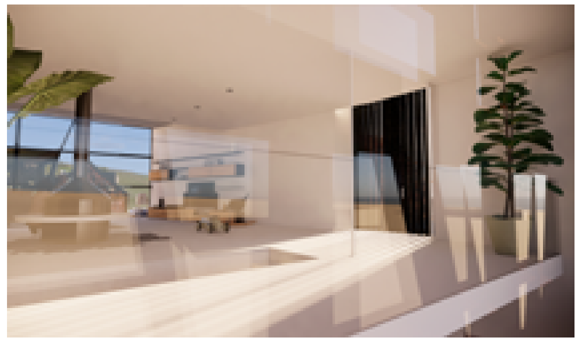
Gallery

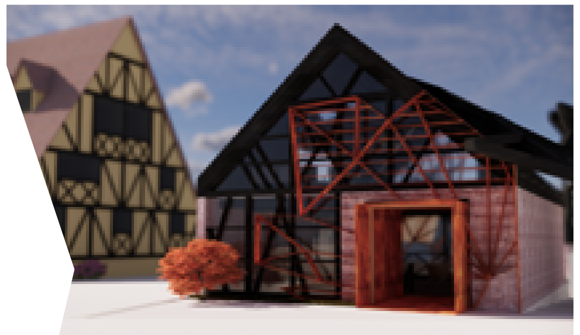


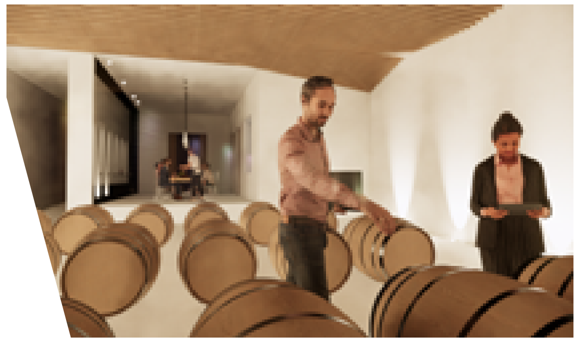












Abstract With environmental issues becoming increasingly important, the energy-intensive wine sector, particularly in Europe, is trying to lessen its impact. Although the process itself is already very energy demanding, higher efficiency can be reached through improved design. In Alsace, France, a wine region with more than 150 millions bottles produced per year, the majority is still produced using traditional underground wine cellars or huge new structures, which lack expertise.

After a thorough analysis of the climate, the situation and the wine process requirements - based on scientific research and publications on existing wineries, plus detailed specifications directly from winemakers - the project developed in this thesis is a functional winery for a small vineyard of 10ha. The emphasis in the design is put on the energy concept to achieve a nearly zero net energy consumption.

ige TU Graz