THE ARCHITECTURE OF TERROIR: SUSTAINABLE WINERIES FOR NATURAL WINES

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Summary
Today, the winery design moves between projects dictated by marketing strategies, that take monumental and great symbolical shapes, and the choice of symbiotic architecture where the link with environment typicality and the oenological production is very close. Latter-day international projects for wineries start form this point of view and biological, or even biodynamic, processes and methods blend with formal, technological and material choices proper to an environmental friendly work spaces design. Natural materials, passive strategies, high efficiency plants, use of renewable energy sources, energy and water saving, technology and building innovation, are elements that take part in the winery's style and look. But, above all, these ones redeploy, to the architectural level, the production options that mainly effect the wine typicality and its bond to the terroir, through a biunique connection between building envelope and environmental energy demands for the wine-making process. The paper outlines results of a PhD research on bioclimatic winery design, moving form the analysis of case studies and inquiries in Europe, USA and Australia, to the set of a specific spreadsheet for a preventive winery energy and consumptions computation, able to be used in the first phases of design supporting decisions comparing location, modelling, technology and material alternatives.

1. Introduction
Today, wine and architecture have the same imagery, attesting the care for details, quality of processes and instruments they are both carried out, the will to establish and strengthen the bond with the land, looking for a particular personal identity that, more and more often, expresses as a, out and out wine marketing strategy. If we add that recently the biggest winegrowers have increased productivity and conformed to technology evolution, that explain why, in the last few years, wine architecture has radically changed his face, loosing his traditional historical and rural features to more industrial and, sometimes, stagy ones. Explorers and internationally representatives of this new formal-technological research are the Swiss Herzog & De Meuron that, in the Dominus Winery (Yountville, CA), created a monument to the transformation from grape to wine. Behind them, others wrestled as Graves (Clos Pegase, CA), Calatrava (Bodega Ysios, Basque Country, E), Gehry (Marques de Riscal, E), Zaha Hadid (Bodega Lopez de Heredia, E) and last Mario Botta (Petra, Suvereto, I) and Renzo Piano (Rocca di Frassinello, Zavorrano, I), who have tried in Italy the new language for new wine Maecenas. But while in the United States, orphans both of a viticultural and architectural tradition, the use of design as media has been a bound step, oft expressed with eclectic forms, in Europe, generally most prestigious wineries still have a strong affiliation with the tipicity of their land. The wine rural landscape, because of its own nature, needs and pursues an even building develop that could be termed “deep rooted” in the place through the ward of natural hermitage, the development of local cultivar and of biological complexity, but, above all, through the prime pursuit of environmental quality and the safeguard of place identity. Over and above this, the social dimension of sustainability is placing in territories once clearly distinct form the city, as rural area and, especially, viticultural ones. The use of natural materials, the attention to ecosystem protection, the recovery of local historical heritage and a desire of harmony with natural scenography are qualities that make a winery worthy to be visited. ore or less the same qualities that make a wine worthy to be drunk. Great wines collect the savour of the soil, the spirit of the vine and the care whose cultivated; in a word, they express the terroir, that is the ensemble of environmental elements, climate, soil and landscape and, extending, of human ones, traditions and places as specify and unique features that affect a vine and effect original and inimitable taste of a wine. From this point of view, the sustainable winery design is the sole key to close the cycle wine-terroir.
1.1 Why a sustainable winery design

In the middle of ’90ies, one of the nations not member of Kyoto Protocol, has been oddly pioneer of studies to define analysis framework and complex relationships between geology, climatology, landscape morphology and the selection of grapevines and wines and, then, winemaking processes, to design the product and the brand and, as last step, to design energy efficient buildings peculiar to production requirements. In fact, it’s in USA, and mainly in California, that new lines of winery design have been and still are outlined, finding in principles, materials and strategies of bioclimatic architecture, a management tool of this complexity.

The incentive to research derives not from an ideological agreement to an ethical code of practice, but from the need to face up a real energy crisis indeed. Wine industry is the largest energy user of the California economy’s pillars but, at the same time, it offers, for several reasons, a strong energy efficiency improvement potential. In 2001, the national energy crisis, forced to think back to the wine making process management and provided incentives for a local action aimed to recompute and reduce energy consumption. That’s also because a global sustainable approach, to viticulture and architecture, offers not only production opportunities, as well as marketing and brand communication. In fact, the manifold inputs that generate the layout, when poorly managed, juxtaposed but not integrated in an organic design, render high energy and resources consumption. Besides, a sustainable point of view of environmental issue relate d to the wine-making and marketing, allows form one hand, to reduce environmental impact of activity, replying to even more pressing European standards, to reduce management costs and total energy billing and, finally, to take advantage of the widespread sensitiveness by that time to environmental topics to promote wines on the international market.

2. State of Art

On-going researches in California, offers several cues for their potential repeat in Europe, accordantly with a key revise of values and borders (as economic and technological situation, wine making techniques, historical and cultural heritage). In fact, Europe, even though it’s the largest wine producer, with more than half of total world production, and Italy that’s the second European producer (52,6 mil hl) after France (53,3 mil hl), haven’t started yet any survey or monitoring project on consumes of a sector that weighs on community environment because of consumes and emissions but also is a clear reference for the image of quality of European production around the world. Difficulties to scan statistic data and refer them to the wine production, comes from a first doubt between an industrial or agricultural placing of the wine sector.

However, due to a general homogeneity of agronomic and oenological techniques, energy consumption could be presented as similar to the ones come out from American studies, that, if compared to some Italian inquiries could be useful as base for reflections on an operation potentiality. Starting from this point of view, feasible answers could be investigated, architectural ones too, to the requirement of a symbiotic link between the wine and its land that, moving from agronomic reflections and strict marketing strategies, expresses itself and gains value through an environmental friendly architecture. Climate diversity is the first cause of large vines variety.

Then, bioclimatic winery design could be a tool to propose in architecture the same variety founded in climatic context, as source of originality and coherence with the style of the wine produced. Now, the design plan becomes more complex, not for the potential to define models and shapes or codify a new building type, rather for the recognition of peculiar surroundings elements that could direct project input and, consequently, typify architectural design without ignoring the operation of space related to wine making process. Process that, in centuries and especially in last years, has developed scientifically and technologically, modifying its operating sequence, technical and manpower requirement, management and turning from procedure to supply chain and supplementing elements borrowed from parallel and connected fields.

2.1 Design of process

In times, winery acquired a process complexity that affect the production cycle, machines, equipments and plants to manage it and, consequently, it requires to modern industrial buildings a flexibility and an adaptability, that historical underground cellars are lacking for. At the same time, they found poor margins of applicability also in low design industrial buildings, that are flexible but not representative and hardly controllable from a cost and consumes point of view, because of their indifference to the process and its needs. In fact, the design of a new winery cannot leave aside from definition of wine process, step by step articulated and scanned as a variable operative sequence both temporal and spatial (related to type of wine, working strategies, etc.), as from the arrangement of oenology plant, needed to manage single vinification, aging, bottling steps.
At the same time, design of such complex buildings, cannot prescind, rather it gets feature from this, internally, from the analysis of physicochemical transformations during winemaking and, externally, the environment that both certainly condition indoor quality and building energy performance. Wineries are energy-intensive industries: energy is used mainly for spaces and plants cooling, but also to produce compressed air and gases, and to run pumps and bottling lines, also considering that often vinification of reds needs a must or yeasts growing heating. Besides this, commercial and administrative spaces, storage rooms as working spaces required lighting and a conditioned climate that could be set by electric appliances.

On the other hand, wineries are also water-intensive: phases that required the largest use of water are pressing, fermentation, barrel wetting and cleaning and bottling. Therefore, ability to save energy and resources, renders a prompt economy and, in a longer term, also a trading gain: in such moment of great sensiveness of public opinion for environmental topics, the public image of winery gets character when provided of a sustainable management program and, eventually, an ecological footprint label.

Therefore, the main aim of this research, carried out in the XIX cycle of Technology of Architecture PhD at the University of Florence, Faculty of Architecture, is to propose a methodological approach to a bioclimatic wineries design, articulated in four main steps:

- study and definition of planivolumetric wineries related to production system, type of wine and climate context through a graphic audit of wine comfort related to thermal-hygrometric data of the three main wine areas of Italy (Piedmont, Tuscany, Sicily);
- analysis and setting of feasible organizing and functional distribution of work spaces models, related to work sequence survey on case studies;
- rate of medium performances of technological element of building envelope according to wine comfort data;
- set of a calculation models to test energy performances of wine buildings to provide designer instruments for a preventive check of energy consumptions according to several feasible technological solutions.

3. Energy design and energy label

The PhD research aims to underscore the demand of merging between production and building that moves to a point of view about wine-building (as part of a system and not just as a unconcerned envelope), most coherent to Italian building and architectural tradition and to a bioclimatic lay out of “lacus” and “cella vinaria” design that sinks its roots into European vine tradition.

In a R&D scenario, mainly oriented to residential trade, an integrated design of building and winemaking, would to point up assessment requirements of energy saving (40% of energy from primary resources) given by applying combined strategies (materials, high efficiency technologies and plants, resources management, recovering and recycling of sweeps and refuses..) in industrial building design, as promoted in ‘80ies in California and Japan by the Zero Emission Factory program.

Facing a wide availability of guide lines, investigation methods, evaluation protocols of sustainability, energy consumption or environmental friendship of residential buildings, international research surveys not so much of industrial buildings indeed.

Offices, schools, museums, hospitals, these are the last new survey fields, while industry still remains on the borderline, due to a general difficulty, rather an impossibility, to standardize requirements and performance for buildings so hard limited by needs and bonds of each different industrial process they can accommodate. Each production process has distinct requirements in terms of location, space, volume, climate, plants and equipments, energy, services, timetable and so on, that are improbably know by designer and hardly performed in terms of energy demand because of a general lack of inquiries and available information.

This general lack of knowledge, is more worrying because, rather spurring research, it affects also the normative resolutions. In fact, last Italian energy regulations, as DLgs. n. 311 29 December 2006, oblige designers, builders and user to provide energy labels (counting and proving their energy consumptions through time) to the buildings they project, build, reside, excepted to industrial, craft, rural not residential buildings when spaces are heated because of production process needs or using energy wastes otherwise not serviceable. 1

Related to the specific wine sector, in opposition to this oversimplifield approach, international and local researches, carried out in California, Australia, and some Italian region (as Pidemont), demonstrated that, wine industry, and Italian one too, has high energy and water consumptions, focused in some months during harvest, that then settle to mid-low levels for spaces and musts cooling (that's still the main cost) and for bottling, up to an annual budget of 20-25 kWh/hl of must produced. That means, in a small-medium winery, an annual consumption of 25.000-30.000 kWh, for vinification, vats and aging- storing rooms cooling. Even if partial and local, these results confirm the problem formulation about two critical points: the reduction of electric energy and water use.
That means a large amount of noble energy (mainly electric energy to run heat pumps) adsorbed from public grid, exactly during peak season, when air conditioners also run in residential.

While some wineries already decided to monitoring and manage their energy consumptions, few instructions exist in sustainable winery design for a preventive energy balance in first steps of planning. That's because, as already above written, few instructions in energy and water wine industry consumptions are available for energy designers, who have to add process uses to standards ones, normally well managed by software used to check the energy balance of buildings.

4. The winery tool

The new trend of wine world, especially in Italy, is to tighten relationship between architecture and context, meant as productive scenario (including the design of winemaking process) and as rural environment (including climate, geography, morphology) through a formal and technological imagery that, when understood process variables, assures the management of product ones. Starting form this, the research aims to define, from on hand, a technological feasibility project for a bioclimatic winery design in Italy, planning efficiency as a positive connection between requirements end performances, from an other hand, it propose an excel tool for the energy balance of winery, related both to architectural design (such as surfaces, volumes, orientation, shape, materials, transmittances, insulation levels an so on, see Fig. 1) and winemaking details (grape varieties, type of wines, hl produced, fermentation and aging period, climate requirements, ecc.). The excel tool, formed by ten spreadsheet, allows to calculate yearly energy demand for winery running, starting from the climate localisation of project, according to UNI 10349. The analysis is carried out focusing on the three main winemaking step: fermentation, fining / aging and storage. Each sheet requires data related to materials, technological envelope solutions, dimensions, number of elements, persons, appliances and their operating time in order to define partial energy/water consumptions and how much they affect total amount. User can details performances of spaces, structures and materials used, and calculate internal gains and loads, U value, seasonal thermal flows through envelope, ventilation flows, cooling/heating demand, related to winery layout and local climate. Formulas used have been derived from current Italian or European energy laws and regulations and in particular form UNI EN ISO 13791 Thermal performance of buildings - Calculation of internal temperatures of a room in summer without mechanical cooling - General criteria and validation procedures and UNI EN ISO 13790 Thermal performance of buildings - Calculation of energy use for space heating.

Figure 1 first spreadsheet: geometrical data and thermal performance of building envelope
The final result (Fig.2), is indicate as kWh/m² year and kWh/m³ year, in order to respond both to national requirements as European standards of energy labelling. In fact, the DLgs 311/2006, ask for an IPE Energy Performance Index of heating in winter season [kWh/m² year], related to surface/volume ratio and to climate zone that has to be lower than table n. 2.2 – Annex C reports; otherwise, European standards as local regulations developed in some Italian regions and commonly recognized as good practices (like Casa Klima) express building performance as kWh/m².

**Figure 2** final spreadsheet: Yearly Energy Demand

The performance sheets (internal temperature, thermal load, free gains, leakages, thermal mass, cooling demand, ventilation) offer the opportunities to simulate the design of passive-active and bioclimatic strategies of the building to satisfy wine making environmental requirements, as outlined and calculate through process sheets (vinification, aging, storage) Opportunities to combine and manage through the excel tool, demands and consumptions of production process and building performances and consumptions, allow the designer to dominate some complex productive features (as kind, number, running of equipments, chemical reaction and thermal load due to vinification process) modelling the building around oenologist, cellerer, winegrower requirements.

**Figure 3** total leakages, free gains, solar gains, heating demand, cooling demand and CO₂ eq. emissions for vinification, aging, storage

For each of three winemaking steps, the tool details total leakages, free gains, solar gains, heating demand, cooling demand and CO₂ eq. emissions (Fig. 3), then summing results in a global perspective that define % contribution of each phase to the total amount of gains, leakage, energy consumption and CO₂ emission.
5. Conclusion

The final target of this research is to provide designers with a tool that could support the general layout supplying them some indications about winemaking processes and equipment, extraneous to architectural field.

The complexity of expertness and factors involved in winery design (fluxes of ideas, feelings, material, energy, technology, people) could be managed part as plan inputs, directly by designer that interact with others who take part in decision making process (grapegrower, agronomist, oenologist, treasurer, marketing manager), part as sensible operative data, directly by the tool that controls the interplay between process and product (both wine and architecture), so to integrate and solve, almost in the first proposal, the dualism of expertises architect-oenologist.

References

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