The redevelopment of the northern part of the historic Venice Arsenal

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ABSTRACT

The redevelopment of the northern part of the historic Venice Arsenal (covering an area of 20 hectares) required respect for the value of this extraordinarily important architectural complex as a historic monument, while ensuring high levels of efficiency and flexibility for the strategic activities that the area will host.
This paper discusses re-use of buildings dating from the sixteenth to nineteenth century, including the restoration of the original edifices and the installation of new interior infrastructure for offices, laboratories and control rooms; particular attention is given to energy efficiency and environmental sustainability.
Furthermore, technical solutions for the central plant that serves the entire area, which makes use of energy from renewable sources such as lagoon water, will be presented.

Key words: cultural heritage buildings.

THE VENICE ARSENAL

For centuries, the Arsenal was vital to Venice's economy and civil history, as it was home to many of the city’s strategic manufacturing activities and a centre for technological research and experimentation.
Located on the eastern edge of Venice's historic centre, the arsenal currently covers an area of approximately 47 hectares (Figure 1). Open (unbuilt) area accounts for 218,000 m^2, while buildings cover a total surface area of 150,000 m^2.
The Arsenal’s current configuration has resulted from a series of expansions and a continual evolution of building types, which changed over time to adapt to advances in shipbuilding techniques.

Figure 1. Aerial view of the Arsenal today

The Arsenal's origins date back to the twelfth century, a time when sea trade with the Orient was flourishing. Those in power decided to create a state shipyard for building ships involved in trade and defence – known as *galleys*.
The first expansion occurred between 1300 and 1400, when the *Arsenale Nuovo* (New Arsenal) was constructed. Another major expansion took place between 1473 and 1573, when the *Arsenale Novissimo* (Very New Arsenal) was built.
Following the devastation wrought by the French in 1797, the Arsenal's industrial areas were modernized and improved under the Habsburgs (1814-30).
In the early decades of the nineteenth century, after Venice became part of Italy, an important development in ship design arose – wooden ships were replaced by ships with metal hulls. This necessitated a radical change in the Arsenal's buildings and resulted in the construction of workshops, quays, slipways, shipways and graving docks [1].
The final major expansion of the Arsenal took place in the early decades of the twentieth century, when a 9-hectare section of the lagoon was reclaimed to create a third large graving dock, completed in 1917.
As production activities steadily decreased after World War II, many areas of the Arsenal were progressively abandoned, resulting in their inevitable and rapid decline (Figure 3).

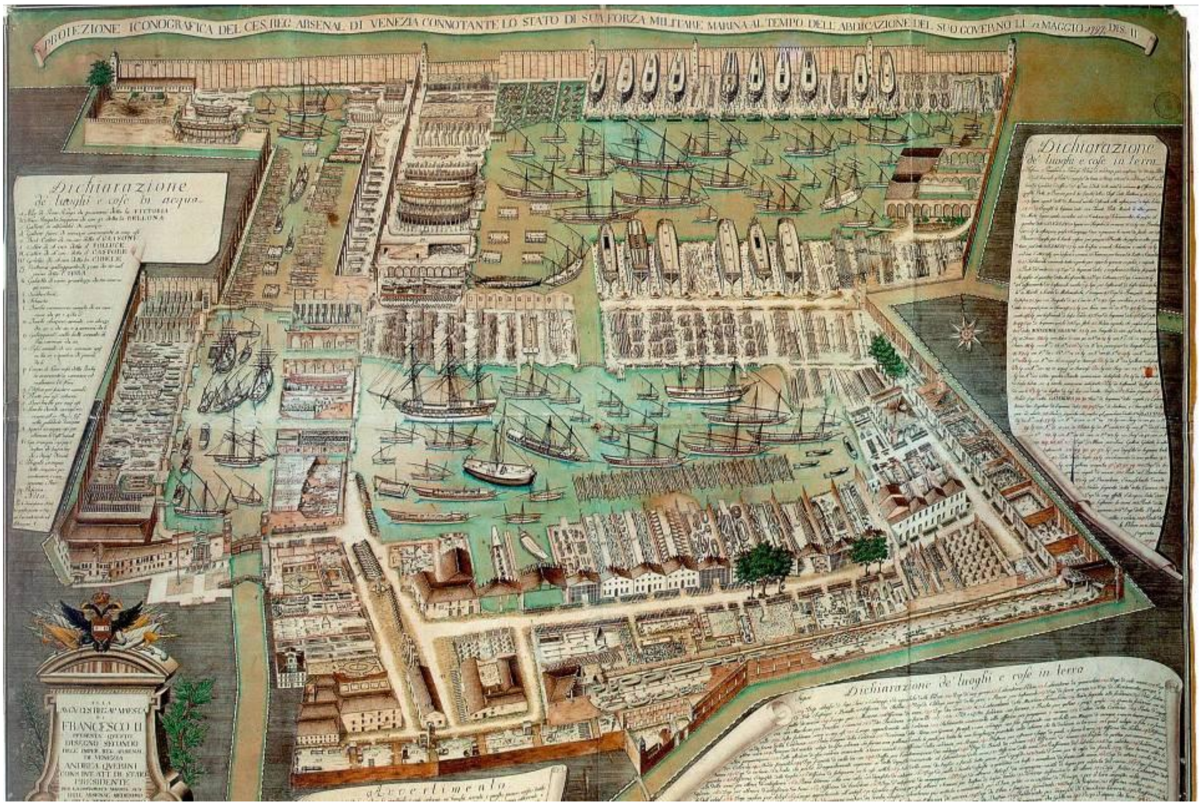

Figure 2. The Arsenal in 1797 (illustration by Abbot Maffioletti)

Figure 3. The state of the buildings before redevelopment

REDEVELOPMENT AND RE-USE OF THE NORTH ARSENAL

The northern part of the Arsenal was constructed during expansion projects that began in the late fifteenth century and ended in the early decades of the 1900s.
The area covers a total of 20 hectares and contains a group of sixteenth-century buildings on the north side of the *Darsena Grande* (Large Dock) and shipbuilding facilities in the north-east section that have access to the three large graving docks.

Confronted with the state of abandonment and decay of this historically-valuable area over the preceding decades, an initiative was begun in the early 1990s to create the Thetis Centre, a leading centre for marine technology.
The project was implemented over a four year period, from 1992 to 1996, with the Centre being officially opened on 3 March 1997. The total cost was 10 million euros.
The project resulted in the return to productive use of approximately 5,000 m^2 of built area and 10,000 m^2 of open (unbuilt) area. It was one of the 32 European Urban Pilot Projects and, more specifically, one of the 5 technological projects – the only one of this type in Italy.
By drawing public authorities' and local players' attention to the district, the project has acted as a catalyst to development in the surrounding area.

Just a few years later, in 2000, the Ministry of Infrastructure and Transport and the Venice Water Authority, through its concessionary Consorzio Venezia Nuova, initiated a programme to restore and make safety modifications to the most important buildings in the North Arsenal [2].
The interventions, which focused primarily on the roofs and walls, were preceded by detailed surveys and studies of the edifices and were performed in a manner compatible with traditional construction methods. The total cost of the safety modifications was more than 60 million Euros.

The objectives of the Pilot Project, the completion of the restoration of highly-valuable structures and the simultaneous implementation of urban-planning tools (the Detailed Plan that went into effect in 2003) all contributed to the area's recent industrial development focusing on innovation and technology.

It is now clear that the turning point in the definitive recovery of this area was the realization of projects relating to the *Centre for the Management of the Lagoon Ecosystem and the Maintenance of the Mose System* (system to protect Venice from high tides).
The project, initiated by the Venice Water Authority through its concessionary in 2006, plans for the complete renovation of 12.5 hectares, the re-use of 6 sixteenth-century buildings to house offices and control rooms, the creation of new spaces for industrial activities (maintenance facilities for gates and other parts of the Mose system, as well as boats and service vehicles), the improvement of open areas and the realization of new centralized plants and utility networks for the entire area.

This initiative and projects promoted simultaneously by other parties that include

- The *National Research Council*, which installed its prestigious *Marine Science Institute* in this area, reutilizing four additional sixteenth century buildings,

- The Company *Arsenale di Venezia*, established in 2003 by the City of Venice and the Agenzia del Demanio (State Property Office) to develop the Arsenal, which is completing the renovation of other important buildings, including the nineteenth century “Torre di Porta Nuova” and one sixteenth-century building,

have definitively established the area’s path to recovery and redevelopment – in a few years, it will once again be a vital and living part of the city, as it had been for centuries.

EXAMPLES OF SOLUTIONS ADOPTED FOR THE RE-USE OF HISTORICAL BUILDINGS

The redevelopment of the northern section of the Arsenal required the development of project models that respected the areas’ value as a historical monument, while ensuring that the buildings would be able to accommodate new uses.
Developed under the guidance of public bodies that protect cultural heritage, the plan allowed these important buildings to be reutilized as energy efficient and comfortable workplaces, while retaining their historical appearance.

A brief summary of the renovation interventions that Thetis designed in collaboration with well-known architecture studios follows.

All of the interventions feature:

- Reversibility and recognisability of the new interior structures that were added to the existing buildings. The new interior structures are primarily bolted metal constructions that are structurally independent from the historic buildings.
- Use of heating and cooling solutions that make the most of the features of the historic buildings (which function as both a shield from the elements and a heat reserve) as well as the modern structures (realized with lightweight materials) used to create the interior infrastructure, whose primary function is thermal and acoustic insulation.
- Incorporation of architectural solutions, shapes, materials and colours that maximize the use of natural light for interior lighting. This was an especially important issue when renovating spaces whose original use (warehouses or workshops, for example) did not require as much interior lighting as the new use (primarily offices and technology laboratories).

A prime example is provided by the Thetis Centre. The architectural design, by Iginio Cappai and Pietro Mainardis, involved the creation of new reversible interior infrastructure within existing buildings, which were constructed between the late nineteenth century and the first decade of the twentieth century.
The strength and effectiveness of this particular architectural solution lies in the logical relationship between the “container” (existing structure) and the new interior infrastructure designed to house offices and technology laboratories (Figure 4). The space between the two parts of the building can be viewed as a modern reinterpretation of the space that existed between the sides of galleys and the walls of the Arsenal's historic buildings when they were used for shipbuilding [3].

In this example, the structure's modularity and simplicity of construction allowed for quick installation and the creation of a flexible workspace – a feature that is essential for ease of use.

Figure 4. The Thetis Centre

This same approach, albeit with very different materials and architectural solutions, was employed by architect Cecchetto when he designed the plans for Thetis' new offices a few years later, in 2000.
The new structure, also housed in an early-twentieth-century industrial building, was a metal frame covered with steel, polycarbonate and glass (Figure 5). The transparent volume allows the historic building's interior to be seen and reflects the interior architecture – brick pillars and arches, metal roof trusses, large windows, and skylights supported by trusses that, together with the principal structural elements, lend rhythm to the space [4].
In this example, air circulation for the new interior structure was achieved through a system of movable windows with openings arranged to produce effective ventilation.

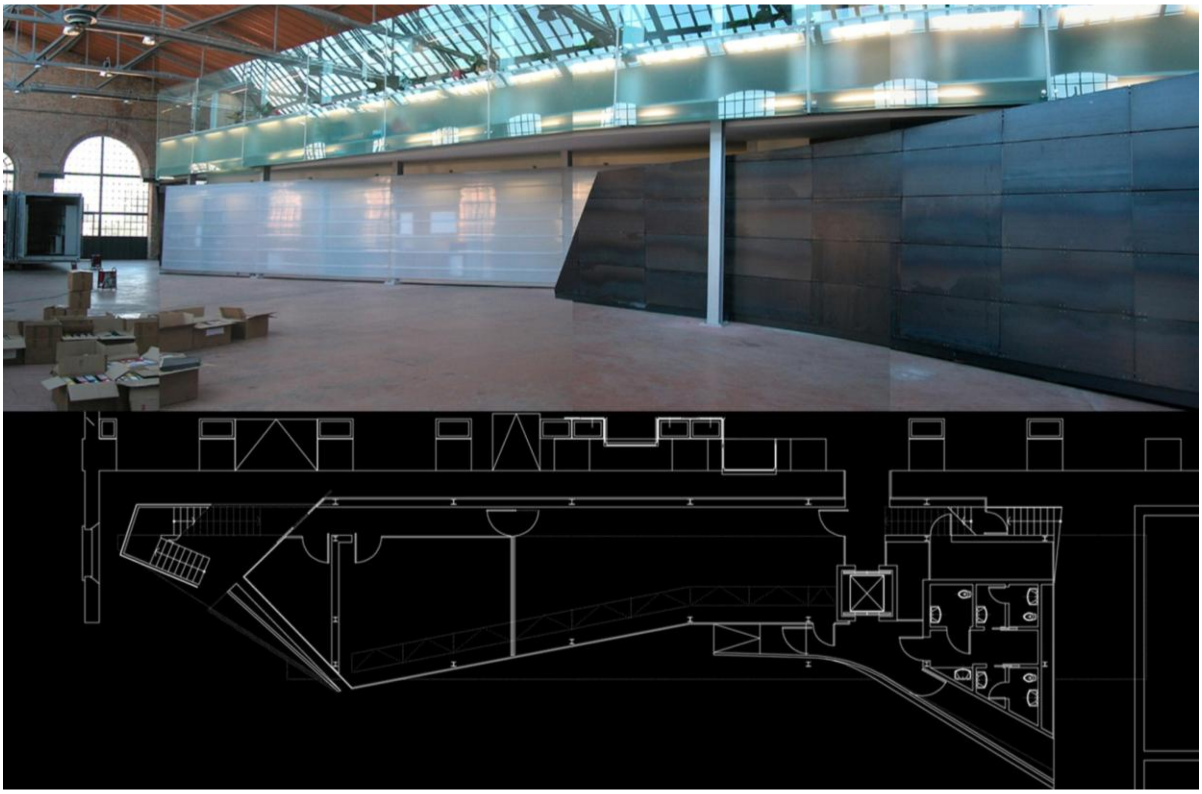

Figure 5. The expansion of the Thetis Centre

The two examples described above, and feedback regarding their energy performance and comfort, served as guides in planning the renovation of the sixteenth-century buildings of the *Novissima Grande* several years later.
For this renovation, natural light proved to be a particularly complex problem; it was resolved by installing new skylights in the roof and carefully configuring the interior structures (Figure 6).

The architectural solution designed by Cecchetto, which had already been successfully employed in the National Research Council's facility, involved a layout in which offices were arranged in parallel structures approximating the size and spacing of the galleys that were once constructed inside these buildings.
The new internal structures, which are thirty to forty metres long and seven metres wide, have sections designed to make the most of the natural light coming from the skylights in the roof. A longitudinal walkway connects the individual office structures with the stairs and elevators, and features openings in several places that provide glimpses of the large sixteenth-century arches.

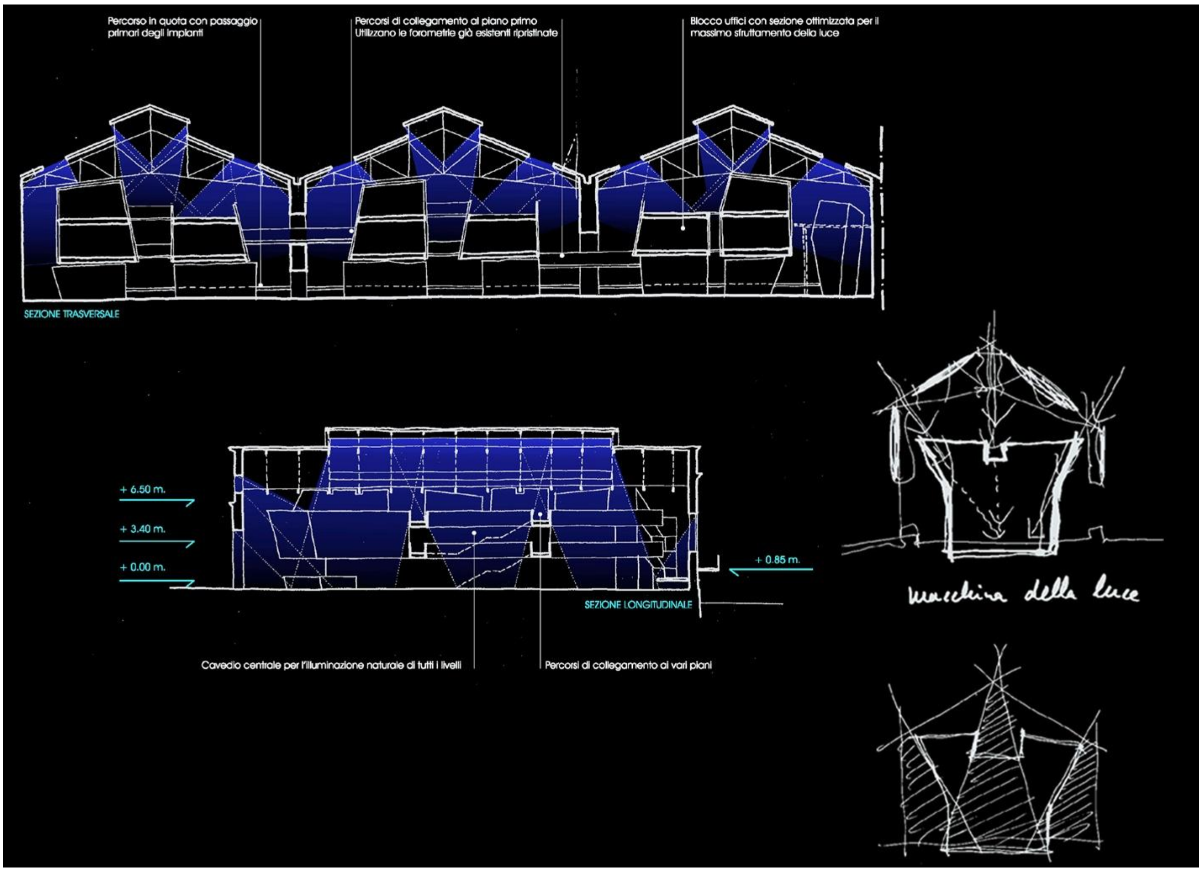

Figure 6. Plans for the interior of the Novissima Grande construction halls (architect: A. Cecchetto)

In the examples described above, the resulting structures were particularly effective with respect to energy efficiency, even when severe restrictions on interventions were imposed because of the historic nature of the building.

Historical building fabric coupled with modern internal structure and devices have, in fact, energy saving physical features that contribute to thermal performance.
Heavy masonry walls have large mass and weight; the inertia modifies the thermal resistance of the wall by lengthening the time scale of heat transmissions. This effect is amplificated by the inner space between new and ancient structure that reacts like a sort of dumper to the weather temperature picks.
These solutions allow the creation of new spaces, well suited with up-to-date facilities, efficient HVAC systems, and good IAQ, achieving the valuable Class B of the Italian national energetic regulation.

In recent interventions, high efficient HVAC systems are based on water heat pumps; geo exchange in lagoon that produces fluids for conditioning; moreover, motors have variable speed drivers, and automated control system optimize the demand and the comfort levels during different periods and occupancy.

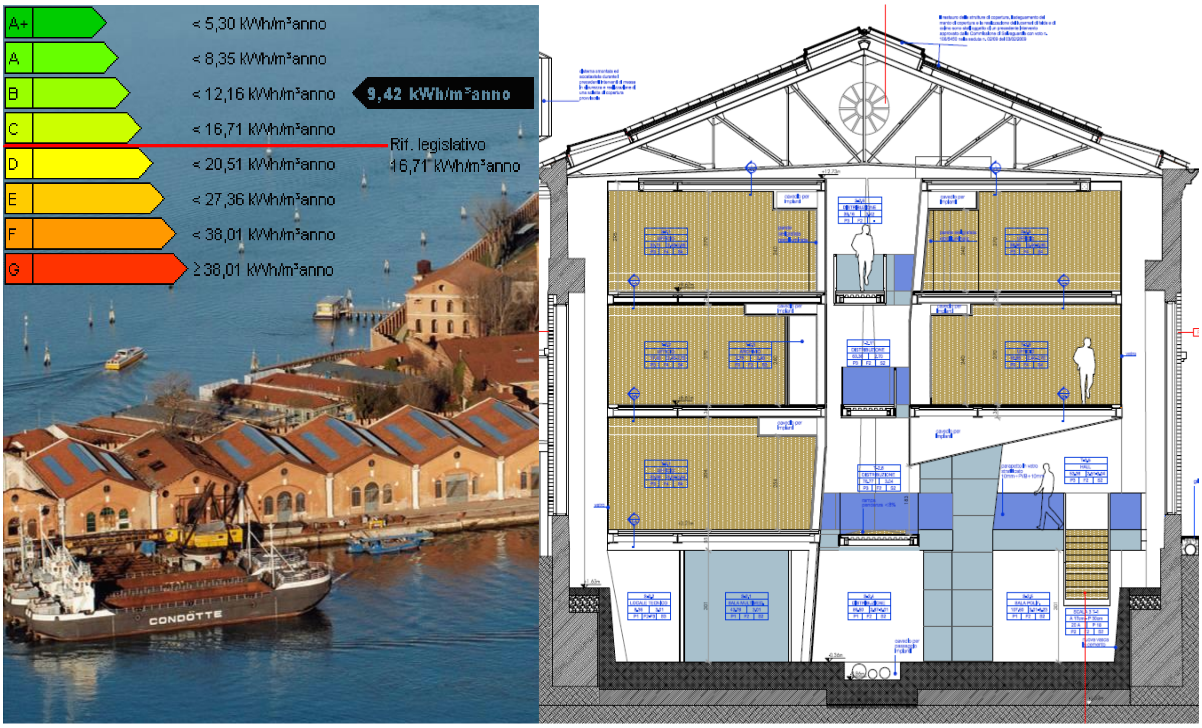

Figure 7. Example of intervention and energy valuable class achieved

BUILDING SERVICES

As with interior infrastructure, the building services solutions needed to respect the area's value as a historic monument.
In the case of the Arsenal, it was essential that the infrastructure ensure: low architectural impact; high energy efficiency; energy savings; low construction, maintenance and running costs; low environmental impact for the surrounding area in terms of emissions and noise and heat pollution; and modularity and system expandability to adapt to further development of the area.
The design choices for the area destined to house the Mose Centre are particularly interesting.
In this case, low enthalpy district heating (closed loop) will connect all the building in the north Arsenale, transferring to the heat pumps the geothermal energy from the Venice Lagoon by means of a centralized heat exchange plant.
The system operates on the principle of thermal exchange: the lagoon water is used to dissipate heat in the summer and provides a source of heat in the winter (in other words, a geothermal plant that uses lagoon water).
The low enthalpy district heating is also combined with cogeneration plant for generating electricity and heat that could be transferred to the closed loop.

The plant offers novel features that are not typical of a standard generation system (boiler and air-cooled chiller) and makes use of materials and solutions that ensure general efficiency. In addition to environmental sustainability, the geothermal plant designed for the Arsenal also offers benefits with respect to:

- energy recovery: the system allows for the installation of 4-pipe plants so that environments with opposite thermal loads can be heated and cooled simultaneously. The closed-loop system enables excess heat produced by equipment to be recovered by using heat pumps to transfer it to other buildings – there is no cost for this heat other than the energy used to run the pumps.
- flexibility: the building services (thermohydraulic and electric) allow for a high degree of flexibility in their use. This may bring considerable economic benefits in the future if there are significant increases in the cost of energy (both electricity and natural gas); if this happens, it may be preferable to produce energy on-site through cogeneration.
- losses on the lines: as the water in the loops has a temperature similar to that of the exterior ambient temperature, costs relating to thermal insulation of the pipes are eliminated and losses of thermal energy on the line are avoided. In addition, ambient temperatures in the winter remain above 2-7°C, so the water will continue to circulate.
- environmental impact: the thermal exchange plant needed to balance thermal fluctuations in the water loop uses water from the lagoon as an energy source, thereby minimizing the plant’s visual impact, as well as noise pollution and emissions. Furthermore, no combustion, flames or fumes and no chance of carbon-monoxide poisoning are produced during HVAC operation;
- modularity: the system has proven to be particularly suitable for performing construction work in stages, as it permits the building services to function in individual buildings even during transition periods when the general building services network has not been completed.

This building services solution, along with the construction choices described in the previous sections, enabled the Arsenal to be redeveloped in a manner consistent with the most progressive energy efficiency and environmental sustainability standards.

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