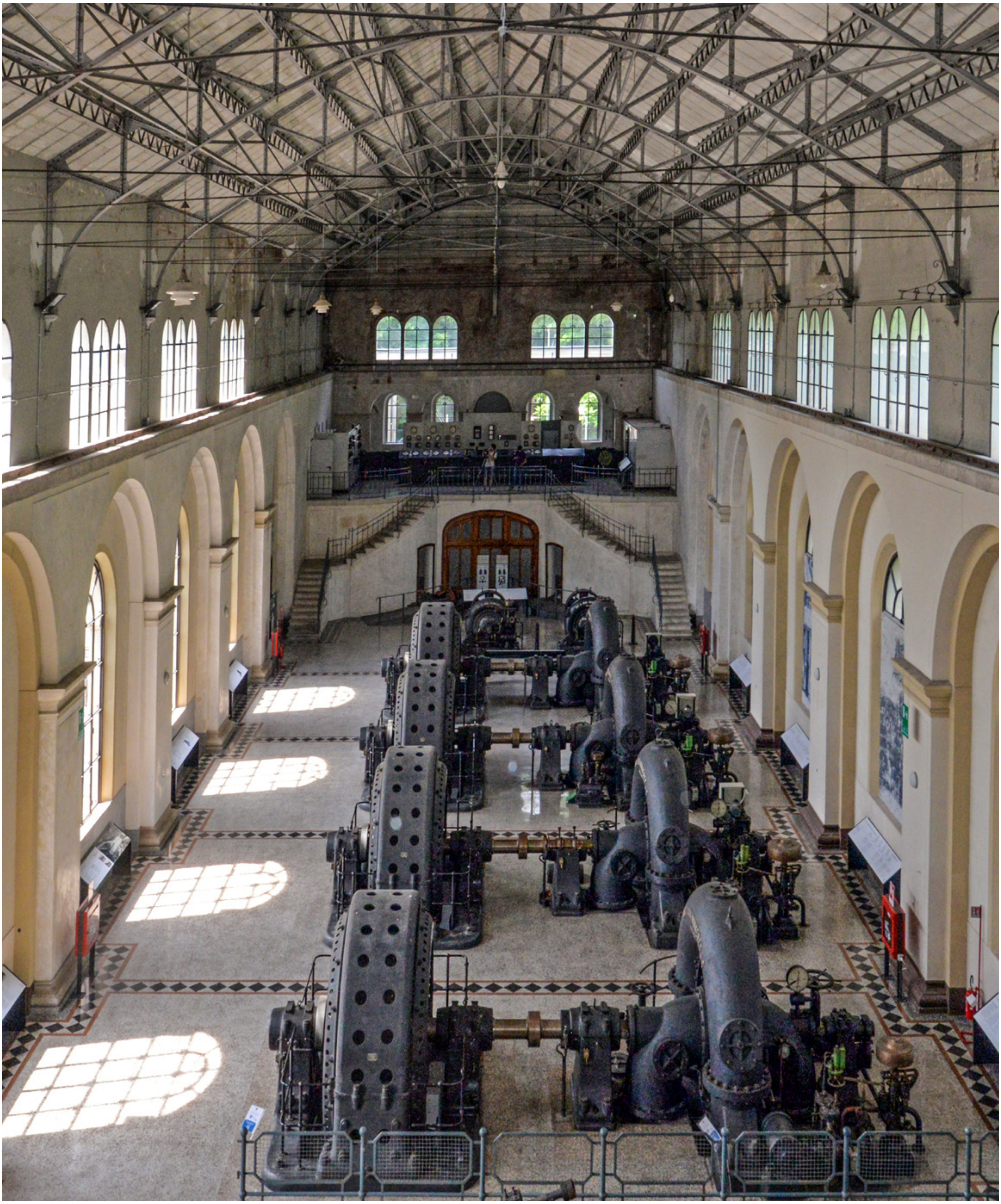

TEMA
Technologies
Engineering
Materials
Architecture

Journal Director: R. Gulli

e-ISSN 2421-4574

Vol. 7, No. 2 (2021)

Issue edited by Editor in Chief: R. Gulli

Cover illustration: Antonio Pitter power plant, interior view (Malnisio). © Francesco Chinellato, Livio Petriccione, 2019

Editorial Assistants: C. Mazzoli, D. Prati

TEMA
Technologies
Engineering
Materials
Architecture

e-ISSN 2421-4574
Vol. 7, No. 2 (2021)
Year 2021 (Issues per year: 2)

Scientific Society Partner:
Ar.Tec. Associazione Scientifica per la Promozione dei Rapporti tra Architettura e Tecniche per l'Edilizia
c/o DA - Dipartimento di Architettura, Università degli Studi di Bologna
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Media Partner:
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Phone: +39 0481 484488

TEMA: Technologies Engineering Materials Architecture
Vol. 7, No. 2 (2021)
e-ISSN 2421-4574

EDITORIAL
NEW HORIZONS FOR SUSTAINABLE ARCHITECTURE

TEMA
Technologies Engineering Materials Architecture
e-ISSN 2421-4574
Vol. 7, No. 2 - (2021)

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DOI: 10.30682/tema0702a

This contribution has been peer-reviewed.

The word sustainability was introduced for the first time in the Brundtland Report of the World Commission on Environment and Development. Sustainability has "sustainable development" as its main principle, which concerns the environment, economy, and society, in an interconnected way; while culture, policy, and technology are considered sub-sectors. Sustainable development can be defined as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs*. In 2015, with the "2030 Agenda", the United Nations codified a strategy for a better and more sustainable future for everyone. The strategy is articulated in seventeen goals. These goals refer to various and broad themes related to several aspects, with significant impacts on daily life (from health to education, from dignity of work to gender equality, from responsible consumption to climate change…). This forward-looking vision is also related to overcoming the initial perspective, in which sustainability was mainly oriented to energy saving.

Although the word "sustainability" was first used in the 1980s, its concept is older. With the 1973 oil crisis following the Kippur war, an energy-saving process was launched, which soon involved even the building sector. From these first actions, it is possible to understand that the Italian policy for sustainability was mainly oriented to energy consumption reduction through the reduction of transmittance of the building envelope[1]. Later, an additional goal was defined, which was the improvement of the efficiency of heating systems[2].

These first regulations did not have a tangible impact on the architectural image. In fact, the regulatory prescriptions could be observed by including insulation materials in the external layers of walls or roofs, and adopting double glazing glass, instead of a single glass. So, the required performances were obtained by improving the thermal resistance of the existing building components, with no substantial difference in the formal appearance.

From the first years of the new century, the prescriptions of technical regulations, which spring from European Community, characterized the buildings more clearly. In fact, the adoption of a massive building envelope (with a superficial weight higher than 230 kg/m^2) was imposed in almost the entire Italian territory[3]. The consequence was increased thickness of the external walls from thirty centimeters to forty-five centimeters. On the one hand, this extra thickness improved the thermal inertia of the building envelope; on the other hand, it allowed reducing the thermal bridges because a masonry layer covered the load-bearing structural components. However, this solution had a series of technological difficulties. Therefore, it was soon decided to use thirty-centimeter-thick masonry with heavier bricks and external insulation, i.e., single-body masonry with insulation coat. The same regulation had another pivotal point, which was to keep the attention of the designers to the energy cost of summer cooling that has significantly increased in the last years. In this framework, adopting shading systems and natural crossed ventilation became almost mandatory, bringing other influences on the building image.

The concept of sustainability has become popular among people thanks to the introduction of energy classification. In fact, this type of evaluation clearly shows the quality of an artifact, even to people who are not experts. It was adopted in the building sector with the same regulation.

The framework was completed in the early first decade of this century when legislators imposed that fifty percent of the primary energy used by every building must come from renewable energy sources[4]. It is a remarkable requirement, even if it is addressed only to domestic hot water production. The development of studies and experimentations addressing the BIPV (Building Integrated PhotoVoltaic) springs from the need to integrate photovoltaic systems, the most common type of removable energy plants, into the building envelope. These solutions are alternative to the BAPV (Building Applied PhotoVoltaic) systems, in which the panels are located on terraces or roofs without caring for the quality of the appearance.

The influences of the sustainable methodology on the architectural and constructive appearance of buildings have gradually led to codify a new building type, with zero energy consumption, called ZEB (Zero Energy Building), or with very low energy consumption, called NetZeb; they have been recently introduced and codified in the technical regulations[5]. The autonomy of this architectural language is evident, thinking to the buildings which belong to this set.

As already said, the current practice to relate sustainability only to energy consumption is already outdated, thanks primarily to scientific research. In the current view, this concept considers several other aspects; in the building sector, its main target is the innovation of components.

As a result, it is possible to note an increasing interest in using responsive building components, i.e., able to adapt to user needs. This practice is now more accessible due to the availability of user-friendly and low-cost control and management systems, the so-called BMS (Building Management Systems) on the market. These components are able to read the boundary conditions and set the building subsystems through a network of sensors and switches. Therefore, considering the presence of people, indoor and outdoor atmospheric conditions, time of the day, and other similar data, the BMSs can optimize the indoor comfort by turning on or off lights, cooling or heating systems, opening or closing ventilation valves, shadings, and curtains, and other devices. This field is quite broad and diversified, from simple systems for private residences to complex ones for the headquarters of large companies, even with self-learning ability (so-called intelligent systems). The real sustainability level of these kinds of plants is based on a balance between cost-saving, due to the automatic actions of BMSs, and the installation and maintenance costs, with particular regard for kinetic actuators.

The increased complexity of the building components, depending on the improvement of the performance and from the kinematics, can be mitigated by the new control tools of the design process, among them the rapid prototyping technology. The last one increases the process sustainability as it allows more thorough monitoring of design errors before starting the actual construction, thus saving time and money.

The prototyping process allows obtaining a smaller scale physical model directly from the virtual model. The availability of computerized numeric control tools has increased the speed of this process; for this reason, it is called rapid prototyping. These machines automatically control and handle their work tools in the assigned spaces, with three or more degrees of freedom.

There are two main types of prototype methodology: additive and subtractive methodology. In the first case, the machine makes the model by adding the materials, layer by layer. The most common machine is the 3D printer, in which the tool is an extrusion head able to melt a polymer filament that settles in several layers and makes the item. Instead, subtractive prototyping works by removing the shavings from the initial block or sheet to create the item. The most common machines are lathes and laser-cutters.

The next step of this technology is the production of building components on-demand through large-scale computerized prototyping machines; this vision is in line with the 4.0 and 5.0 industry development plans. Bringing these tools directly to the building site would allow the use of local raw materials to create closer relationships with the local building practice. This approach is a remarkable implementation of the sustainability of buildings, at least from a theoretical point of view, due to reducing transportation costs and waste.

Notes

1 Italian Law n. 373/1973

2 Italian Law n. 10/1991

3 Directive 2002/91/CE; Italian Legislative Decree n. 192/2005, n. 311/2006

4 Directive 2001/77/CE; Italian Legislative Decree n. 28/2011

5 Directive 2010/31/UE; Italian Legislative Decree 26/6/2015