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Technological Imagination in the Green and Digital Transition

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Chapter 79
New Paradigms for Indoor Healthy Living

Alberto De Capua

Abstract For some time, we have been witnessing a series of alarms that warn us that our wealth is leading to an exaggerated and increasing use of energy and resources, as well as the deep and irreversible transformation of natural systems and social inequality, causing a continuous growth of the overall impact of the human species. "Ecology" and "environment" have become the key words of the third millennium: a media bombardment that has helped to overcome the insurmountable barrier of indifference and insensitivity. Everything that has to do with architectural design, from the choice of materials to the technologies used, has been confronted with the term "sustainability," whose meaning, despite the attempt to place it in a univocal definitional apparatus, always takes on different nuances and meanings. The text defines the complex system of principles that animate architecture today whether those aimed at greater attention to and protection of the health of users and the environment or also concerns social and economic issues when it is proposed as a cultural, social, ecological and economic change necessary to safeguard future generations. Today, we are often witnesses of an inadequacy and poor quality that concerns precisely the aspects of health and safety. The origin of this failure is attributable to attitudes, indifferent to housing needs, easily found in the majority of designers: the environmental scale of the project intended mainly as morpho-typological abstraction, the superficiality in technological choices, and the poor verification of interactions between technical elements and housing needs.

Keywords Health · Indoor air quality · Environmental quality · Sick building syndrome · Housing

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79.1 Introduction

The control of the environmental quality of an architectural project is one of the most recent and essential requirements of the design activity, whose main purpose is to control those physical parameters closely related to the definition of the microclimate of confined spaces and environmental comfort. It is a matter of identifying parameters and related methodologies able to control the state of the environment, according to needs arising from existential conditions and activities of users with reference to the phenomena of "heat," "cold," "noise," "light," "air purity," defining the structured set of environmental "surroundings."

Each of these parameters can be considered as indicative of a measure of environmental quality and, at the same time, can be considered as an initial element of assessment of the so-called "technological quality," that is, indicator of the effectiveness of the technical-constructive solution.

Controlling the environmental quality of the project, in the awareness of these aspects, is obviously difficult. Also because, to this new need, there are several unfavorable elements: the increase in the technological complexity of the building product; the introduction of new technologies; the lack of knowledge of the behavior of building materials with respect to external actions and over time; the difficult measurability of energy costs, and the polluting effects of building production (Stiglitz 2016).

Today, in addition, it is not possible to give up the idea that the new basic indications for the design and implementation of architecture, in a perspective of circularity (Losasso 2021), should concern the impact of buildings both on the environment and on the consumption of resources, but above all, on the health, comfort, and safety of the occupants, as is increasingly emerging from the scientific and technical debate.

The fundamental performance that users require from built spaces is that of having conditions suitable for living well and being able to carry out their activities well, and indoor pollution is an objective indicator of the general inadequacy of buildings and the discomfort of users. We are, however, often witnesses of inadequacy and poor quality that concerns precisely the aspects of health and safety. The origin of this failure, the demon of development (Faloppa 2016), is attributable to attitudes, indifferent to housing needs, easily found in the majority of designers: the environmental scale of the project intended mainly as morpho-typological abstraction, superficiality in technological choices, and poor verification of interactions between technical elements and housing needs.

Situation further worsened by the advent of industrialization and, within this, the contribution of chemistry, due to which hundreds of new materials have been introduced into the construction field that should have perfected the living and building.

These, really, made more difficult the quality control of the built environment and its compliance with the needs of users, more and more distant from the process for the production of housing.

79.2 A Public Health Problem

For some years now, in the most developed countries, a new issue of primary interest for public health has emerged: the air we breathe inside non-industrial buildings is more polluted than the air outside, and most of the population spends up to 90% of the time of their lives in such places (U.S. Environmental Protection Agency 1989; Lepore et al. 2010).

The house, after decades of building policy oriented toward objectives of "quantity" first, and then "quality," has long since lost that aura of sacredness that has historically distinguished it, becoming, by now, a dangerous place exposed to radiation of natural and artificial origin. Houses, hotels, offices, schools have concentrations of pollutants dangerous to health higher than those detectable outsides. The causes of this situation are attributable to several factors, such as the introduction of new products in the building cycle, the lack of attention to the design of technical solutions, and the decrease in ventilation due to the increased sealing of buildings.

The buildings we inhabit are often polluted, dangerous, degraded, poorly ventilated, and unsuitable for the climate. It seems natural to assume that the quality of the project is inadequate with respect to the complexity of the problems, knowledge, and requirements. Designers and builders have rarely corresponded with a real technical-professional adaptation to technological innovation, to the evolution of the social framework or to the mutation of housing needs (Mercalli 2018).

And just for a few years, there has been insistent talk of building-related illness[1] or sick building syndrome[2] (De Capua 2008, 2019). Houses, schools, hospitals that until a few years ago escaped any control of air quality and healthiness of the environment are now the subject of specific studies.

At present, we cannot say that the problem has been solved, nor that the knowledge acquired is able to describe and manage all the mechanisms through which the phenomenon occurs.

In Italy, the same legislation in force is certainly not suitable to deal with the problem: only sporadically, in fact, the attention of the legislature and the public administration has been addressed to the confined living environments, and when this happened, it was only for specific sectors and pollutants to correct situations

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[1] The symptomatology is specific and can be traced back to a precise etiological agent: these are almost always microbial agents. Typical examples are legionnaire's disease, a form of acute pneumonia due to a microorganism present in air-conditioning systems or particular allergic reactions. These types of diseases can then be attributed to a specific source of indoor pollution: the contamination of air-conditioning systems in the first place, but also by the action exerted by air humidifiers in a polluted environment (humidifier fever). B.R.I. occurs in a limited number of people living in a given indoor environment.

[2] It has different characteristics from B.R.I. The symptoms are nonspecific and can be grouped into five basic categories. All of these symptoms, unlike B.R.I., regress or disappear as individuals move away from diseased buildings. Since S.B.S. has been observed and described almost exclusively in offices, the regression of symptoms has been, as a rule, observed when returning from work in the evening and during the weekends. There is a wide range of factors potentially associated with the symptoms that determine sbs: chemical, physical, biological, or psychosocial.

now worrying (Ministero della salute 2015). The search for solutions that would allow the exploitation of valuable areas has caused designers to forget the beneficial influence, both psychologically and physically, of air and natural light. The rush to build and the cost of labor has imposed the use of materials that are easier to use, but often unproven.

The spread of “do it yourself” has put in the hands of the common man highly dangerous products, if used without due caution.

All these actions, but above all the combination of them, have had the effect of worsening indoor air quality. It is not just a matter of discovering that indoor pollution situations can occur equal to or greater than those of the outside; but of tracing all the transformations and changes, that technological evolution suggests to us to improve our environment, to the qualitative control of the built environment and its compliance with the needs of users, in the integration of old and new knowledge.

79.3 Envelope and Environmental Quality

The building, according to its morphological, dimensional, organizational, and technical-constructive characteristics, is able to establish a relationship with the external environment, such as to produce variations and significant alterations in the conditions of thermal comfort. The indoor environmental comfort depends not only on the quality, but also on the ways of using building technologies, depending on the complex of environmental variables that act outside the building.

The building envelope is no longer conceivable as a simple barrier, but rather as a selective filter, with the ability to annex and/or reject the effects induced by external environmental conditions.

Research for a low-impact technology, which is able to set the conditions for the construction of spatial and functional arrangements in controlled ecosystem, is achievable only when the operation of technical transformation is not indifferent to the places, but find its declination with respect to the physiographic and bio-ecological characteristics of the same. Therefore, the definition of the conditions of organization and structuring of the building (construction technology, size, shape, configuration, distributional characters) should not be separated from the consideration of the physical-spatial and material conditions of the surrounding environment of reference. The controlled interaction of these two factors (Özdamar and Umaroğullari 2018) can contribute (Brown 2002) to:

- improving the quality of the project, limiting the conflicting conditions of interference with elements or parts of the natural system;
- optimizing the material and technical-constructive characteristics in relation to the needs of protection (from moisture, thermal load, air infiltration), aero-illumination (field of view, air purity, spare parts, etc.);

- encouraging the natural functioning of buildings (passive lighting and natural air-conditioning systems) also through the use of hybrid passive technologies, biocompatible materials, and building components.

Opacity and transparency of the envelope, moreover, determine the onset of different problems, mainly due to the use of different materials, with their own behaviors and characteristics. Opaque walls are more critical in relation to possible indoor pollution, transparent walls have more influence on aspects related to thermohygrometric comfort.

The pollution produced by buildings depends mainly on the fact that the materials used; the substances and the manufactured articles are not sufficiently tested from the point of view of emissions and their effects on the users' health.

The concept of healthiness of a building is very articulated and complex and cannot be defined only in relation to the absence of pathologies and influencing factors, but must meet the needs of comfort and physical, psychological, and social well-being. The building is a container of activities and behaviors, and to design healthy buildings, it is necessary to think about each environment in relation to all factors, including microclimatic conditions, which have some relevance in improving or worsening the indoor air. It is already from the earliest stages of the project, that the location, orientation, size, shape, and envelope of a building, as interacting with the air-conditioning systems and techniques for the containment of energy consumption, must be verified also in reference to their indirect "harmfulness" (Zannoni 2006).

A first definition of the functioning of the technological building system must be based, therefore, on the analysis of the external environment, that is, according to the climatic characteristics at regional (macroclimate) and local scale without neglecting the possible intervention of modification of the latter to obtain a particular microclimate.

The result of this first phase is the definition of the output to be required to the technological system in terms of strategies to control ventilation, summer and winter solar radiation, and natural lighting: a behavior model to be completed with a first performance dimensioning of the various technological subsystems, in relation to the functions attributed to them.

Just as the definition of spaces and the choice of construction, materials have a significant impact on indoor air quality: with a correct distribution, it is possible to isolate and enclose the most polluting activities and make the systems more accessible, in order to facilitate their maintenance; with a conscious choice of materials and construction techniques, it is possible to keep under control the potential level of pollution.

It is, therefore, to set up a rigorous design procedure equipped with verification tools to exclude or minimize errors in air quality. An analytical design process that highlights the requirements and interactions derived from the needs of the inhabitants, especially those requirements related to the healthiness of the building.

A clear understanding of how multiple factors can affect indoor air quality, and how they should be controlled, can enable the designer to develop an effective design for indoor air quality verification. To this end, real theoretical models have been developed by several parties that define the problem from several points of view and lead the factors to be taken into account in three main categories:

- Physical: temperature, relative humidity, ventilation speed and direction, artificial lighting, solar radiation, noise, ions, presence of electromagnetic radiation fibers, and particulate matter.
- Chemical: ETS, formaldehyde, VOCs, biocides, CO_2, CO, NO_2, O_3, SO_2.
- Biological: microorganisms, bacteria, etc.

It is clear that in order to address the problem, a global approach is fundamental. A building is a system and as such should be studied and treated in the totality of its interactions: one should not act on one of its parts without considering the effects on the others, and one should not act on air quality without considering the implications in the management—including energy—of the building, and it is necessary to verify that problems are not solved because of a polluting substance or source by adopting techniques that may have negative effects on the building elements or that in turn contaminate the air. To this aim, it is necessary that for each intervention, the designer manages all aspects of the problem and is able to choose among the possible techniques, those best suited to the building/user system.

Most of these techniques have already been used, experimentally, in the United States, Canada, and Northern Europe and tend to act directly on the polluting sources or treating the polluted air. It is clear that it is preferable to act directly on the source, avoiding those pollutants reach the air, but this is not always possible: the choice of the most suitable techniques is conditioned by technical and economic constraints or guided by strategic considerations of a more general nature, and moreover, it is often not possible to identify the pollutant source; it is therefore more frequent to resort to strategies of ventilation or air treatment.

Poor ventilation of rooms is a major cause of poor air quality problems, and ventilation standards are an important method of control, effective, above all, in removing pollutants released from indoor sources and in removing excess moisture.

If the outdoor air is of acceptable quality, ventilation can effectively reduce pollutant concentrations by diluting and expelling contaminated air with cleaner outdoor air. If the outside air should be polluted before using it, it must be treated. External air exchanges take place through: infiltration and extrafiltration mechanisms; natural ventilation; mechanical ventilation.

79.4 Parameters and Indicators for a New Scenario

In planning a scenario that encompasses the new principles of ecology, we must then consider that the objective is not to control all the variables involved, but to reflect on the main indicators, on which the achievement of sustainable quality may depend, within the more traditional construction processes: investigate new thematic areas, integrate existing ones with new specific requirements, relate the new indicators to the areas of application and the different levels of the project.

Show designers the way to improve the environmental efficiency performance of the building and to promote the use of "clean" technologies.

It is an approach that can realize its effects in the construction phase of the intervention programs and in the operations of verification on the quality of the constructions, in the intent to develop a whole series of collaborative aspects—according to common and shared methodological and operational lines—between structures that operate with technical-building competences also very different from each other.

A demand-performance approach, containing clear and measurable quality levels, possibly without specific constructional references, and giving the designer and builder the responsibility of ensuring that designs and constructions conform to the prescribed requirements.

The difficulties are not few, especially with regard to the need to prepare operators and have adequate equipment to measure performance. The problem remains open.

It is a matter of leaving the current phase and preparing an instrument for evaluating environmental quality, which does not exist today; convincing oneself that there can be no seriously managed legislation, but above all no quality policy, without adequate experimentation, without control of real quality in actual operating conditions, and without adequate technical support information.

Something complex that, among other things, requires:

- to redesign local regulations as many regions are already doing
- the congruity of local regulations with national and community constraints
- the attribution of progressive importance to the norm as a recommendation, seen as an opportunity for operators to grow technically and culturally.

The designer must be aware of the new needs to be met and guide the individual project choices toward the awareness of natural balances, toward efficient transformation interventions, using technologies and tools for bioclimatic control of the system (Paolella 2006).

In these concepts, the term efficiency refers to the measurement of the quantity and frequency of exchanges, at various levels of relationship between physical and biological systems. Inherent in the term are precise indicators:

- contextuality, understood as the ability to recognize oneself in the place by determining and enhancing it, also in terms of resources fed by the system;
- adaptability, understood as the ability of the system to adapt to environmental conditions;
- duration, or the ability to maintain itself over time;
- deconstruction, understood as the system's ability to use, produce and recover resources.

Our approach is structured through this key of interpretation, with the aim of contributing to a significant improvement of housing quality, respecting the receptive limits of ecosystems, the possibility of renewal of natural resources (especially for their conservation), the balance between natural and anthropic systems (eco-sustainable needs).

79.5 Conclusion

The new rules of living quality now inseparably include the updating and cultural actualization of the past concept of healthiness. Combining rehabilitation and redevelopment interventions with the problems of indoor air quality control will be the challenge of the coming years, and this involves a multi-level approach. I believe that the only tool today that can deal with this complexity is the *Building Regulations* on which the different scales of intervention can be brought together and in which multiple disciplines can converge with important repercussions, at a cognitive and operational level, on design activity. Because of its complexity, it can fully address what are the fundamental actions for technological control of indoor air quality:

- awareness of the context in which we intervene;
- the control over materials and products;
- control over microclimatic conditions.

The innovations of a new and current regulation could be:

- The acquisition that indoor air quality is no longer definable through ventilation and carbon dioxide content requirements alone but calls into question the many unexpected sources of pollution: from materials used to microclimatic conditions.
- A set of prescriptions on the basis on requirements to be met, referring to the needs of users, accompanied by systematic verification methods, making mandatory only a limited package of requirements related to mandatory safety and health requirements.
- Become the only instrument for regulating building activity present at the municipal level: this means that (as far as building prescriptions are concerned) it replaces and cancels any other instrument.
- Verification of conformity in place of habitability, no longer a bureaucratic act, but an effective guarantee of performance subject to risk assessment on what the designer declares in a descriptive technical sheet.

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