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Technological Imagination in the Green and Digital Transition

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Foreword by Antonella Polimeni

Good afternoon to all participants, ladies and gentlemen, and welcome to Rome.

On behalf of the Community of Sapienza University of Rome, it is a real pleasure to welcome all of you to the first edition of the International Conference "Technological imagination in the green and digital transition". I am also pleased to give my best welcome to Dr Antonio Parenti, Head of the European Commission Representation in Italy, and to Prof. Mario Losasso, President of the Italian Society of Architectural Technology, as well as to all guests, students and colleagues.

The conference that we are about to open, organised by the Department of Architecture and Design and directed by Prof. Alessandra Capuano in cooperation with Sapienza Foundation, is to be a moment of methodological debate about built environments and the rise of contemporary urban challenges, so engaging for public and private institutions at national and international level.

The proposed key points of this conference—namely Innovation, Technology, Environment, Climate Changes and Health—are all interconnected priorities that cannot be further postponed, representing in the meantime strategic research and education activities for our University, perfectly aligned with the Italian National Recovery and Resilience plan, to be implemented in Italy as well as European member States, in order to overcome the present financial and social challenges.

I truly believe that Universities are, by definition, places of imagination, where planning the future is intended as an unavoidable "existential condition" as well as an essential moment of collective participation for an accomplished society.

Thank you for your attention, and I wish you a fruitful continuation of the conference.

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Foreword by Eugenio Gaudio

My warmest greetings to Dr. Antonio Parenti, Head of the European Commission Representation in Italy, to the President of the Italian Society of Architectural Technology Mario Losasso, to the Director Alessandra Capuano, and to Pietro Montani who will open with a Philosophical Lecture the Conference "Technological imagination in the green and digital transition".

A special greeting to Prof. Anna Maria Giovenale, my dear colleague and friend, who invited me to be here today. Thank you Anna Maria.

Let me also greet all other speakers as well other participant that will follow this Conference organized by the Department of Architecture and Design, together with the Fondazione Roma Sapienza.

From the very beginning, as President of the Fondazione Roma Sapienza, I supported the initiative of an international Conference on the theme of "Technological Imagination" having clear in mind that human imagination is inseparable from the "technical practice" with which it is entangled from the earliest origins of mankind, as Pietro Montani states in his book, *Technological destinies of the imagination.*

When the contents of the Conference were increasingly defined and focused around the areas of the green and digital transition, I realized that the very core of the Conference was becoming an attempt to respond to the contemporary challenges of the National Recovery and Resilience Plan, in their key role of revitalization for Research and University.

In this sense, the potential of technological culture is reaffirming its role of strategic tool for the conceiving, design and validation of future scenarios.

The sessions into which the Conference is structured, namely: Innovation, Technology, Environment, Climate Changes and Health, identified in order to outline the evolutionary scenarios of architectures and cities, allowing us to reflect at different levels on innovative models of building and management process, as well as design and products.

The goals of promoting digital transformation, supporting innovation in the production system, improving sustainability and ensuring an equitable environmental transition, find their clarification in the elaborations and experimentation presented through the contributions in the different sessions.

Modern technological innovation allowing multiple possibilities in all areas: nowadays digital technologies are enabling us to interact with people and things, all over the world.

There are astonishing, yet untapped potentials, suggesting that digitization, rather than a strict sense adaptive development, should be seen as an important evolutionary phenomenon and in the meantime a great opportunity.

Innovations connected with new technologies can provide to civil society a better quality of life, both at indoor and urban scale settings, addressing scientific development toward an effective culture of sustainability, reuse and security.

The employment of new technologies, a careful approach to the containment of land consumption as well as a careful consideration towards soil coverage modality and urban density, the recycling strategies and technological and typological redevelopment of degraded areas and buildings applying an energetic and eco-systemic approach, are the key elements for the conception of healthy and resilient urban habitats, able to adapt to the present global changes, as well as promoting prosperity, inclusiveness and social equity.

Last but not least, "health" issues, that need to be conceived at the very core of the potential determined by 'technological innovation and processes of ecological and digital transition.

The structure of the Conference is rooted on all these interrelated themes, and on that same basis also research needs to be reoriented.

I am confident that this first edition of the Technological imagination conference will contribute to pave the way of an innovative and interdisciplinary scientific approach to technology and policies for built environments, considered the real human challenge of the twenty-first century.

Thank you so much for your attention and enjoy the Conference.

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Foreword by Antonio Parenti

New European Bauhaus

Good morning,

Magnificent Rector of Sapienza University of Rome Professor Antonella Polimeni
President Fondazione Roma Sapienza Professor Eugenio Gaudio,
Director Department of Architecture and Design Professor Alessandra Capuano
and others.
Ladies and Gentlemen,

It is my pleasure to address you today and to open this International Conference "Technological Imagination in the digital and green transition" organized by Sapienza University of Rome.

Let me say that the title, the contents, and the proposals envisaged by the Conference match perfectly with the main pillars of the flagship initiative shaped by the President Ursula von der Leyen and launched in September 2021: the New European Bauhaus.

The New European Bauhaus is by nature transdisciplinary: it invites architects, designers, artists, scientists, engineers, artisans and citizens to share their expertise in preparing for the future.

With the New European Bauhaus, we want to make the European Green Deal tangible and "palpable".

We want to add a cultural dimension to the economic and technological transformation. This is essential to achieve our overarching goal: making Europe the first climate neutral continent by 2050. And thus reconciling our way of life with nature.

To get there, we need both: a real transformation of our economy and society, and a debate about how we can live in respect of nature and our planet.

The historical Bauhaus was founded in Weimar and Dessau. It turned into a worldwide movement. This did not happen by chance. Some ingredients of what made the historical Bauhaus a success can also be an inspiration for the New European Bauhaus.

Let me mention three.

The first ingredient: The historical Bauhaus was created in a time of **profound transformation**. People were facing the challenges of industrialisation. Gropius and the founders wanted to respond to the emerging needs of a new era. They aimed for solutions that were functional, affordable, but also beautiful. With this principle in mind, they shaped buildings, fabrics and furniture. They always aimed higher than just innovative design. The New European Bauhaus is also striving for this mix of aesthetics and affordability. But we want to add another element: sustainability. Because the New European Bauhaus wants to match sustainability with style.

Now, the second ingredient: **The historical Bauhaus boldly promoted new materials like steel and cement**. Today, we also need to look into new building materials. But this time, it is about sustainability. It is about materials that need less CO_2 in their production process. The New European Bauhaus wants to accelerate the transition of the built environment. It wants to scale up nature-based materials, to support circular design and architecture. Buildings are responsible for 40% of our energy consumption. And if we manage to change this, we have a chance to keep global warming below 1.5 degrees.

The third important element from the historical Bauhaus is **interdisciplinarity**. We want to convene people from different backgrounds and with different competences to share and grow their ideas and visions. We can create a better tomorrow, if culture and technology, innovation and design go hand in hand.

For our New European Bauhaus, the European Commission needs scientists, activists, artists, designers, architects and entrepreneurs. We want to include the ideas and perspectives of all ages and all backgrounds.

Today, at this conference we can contribute to this evolving New European Bauhaus network.

This project is a project of hope. It is a project of change and of economic transformation.

So I hope that this conference can contribute further to making the transformation happen and to connecting more and more people who want to make it happen.

Thank you very much and have a great conference.

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Foreword by Mario Losasso

Presentation of CONF.ITECH 2022

The green and digital transition represent in the contemporary research field the two new challenges for the evolution of technology within the themes of sociotechnical innovation. Consequently, technology and innovation in contemporary world must adapt to this general objective. Innovation in its hard and digital components once again becomes a central factor in the experimental propulsion that the project is assuming within a processuality and technologies that enable its conception and implementation.

Today, research is increasingly characterised by the need to focus on specialisms that lead to and contribute to the advancement of knowledge and the predictive value of what is studied in the disciplinary fields. However, with respect to the evolving complexity of phenomena, research requires continuous disciplinary interactions to be developed because we understand that one disciplinary field cannot alone address the most important challenges of contemporary society.

New forms of coexistence must be organized in a vision of interdependence and connection, while the green transition requires the definition of the limits of design action and the characteristics of the transformation processes. The new perspective of co-evolution will have to express a design attitude that allows to repair and, where necessary, rebuild the lost links between man, technology and nature.

The green and digital transition represent the two new challenges for the evolution of technology within the themes of social innovation. The Italian society of architectural technology SITdA has been working for a long time on the topics of the relationship between technology and urban and building development within a process-oriented and eco-systemic approach. In the field of technological design of architecture, the scientific society of the technology of architecture has activated research and training sensitivities on the themes of design experimentation framed within process and ecosystem dynamics, aimed at optimising the efficiency of products and processes by reducing inefficiencies and waste.

The SITdA supports research and spin-off outcome on territories through the activities of its scientific clusters. The Scientific Society SITdA has granted its patronage to the CONF.ITECH 2022 Conference, sharing its importance and topicality in view of the new challenges identified in the urban construction and environmental fields by the Next Generation EU Programme and the implementation programmes in the various nations of the European Union.

The topics that will be addressed during the three-day conference are fascinating and challenging, linking innovation, technology, environment, climate change and health.

These topics are strongly interrelated themes in which we are realising that it is impossible to deal with them separately, arriving in the most recent reflections at considering a single health for human beings and for the entire environment which is their living environment.

I would like to remind that the topic of digital culture, nature and technology was the central topic of the SITdA Naples 2020 Conference held last July with a delay due to pandemic difficulties, while the 2022 Conference of the Scientific Society is focused on the topic of the centrality of processes. As we can see, the work carried out in the Departments of Architecture and by the Scientific Societies in the area of architecture is an activity that has picked up significantly, foreshadowing new approaches, new fields of enquiry and new paradigms necessary for the new complexities that constitute the reference scenario of the future.

The experience of this Conference can provide a significant contribution to the sustainable and environmental evolution of the design area in its trans-scalar, multidisciplinary and challenging dimension, overcoming technocratic responses to a demand that requires the integration of the humanistic and technical-scientific dimensions.

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Foreword by Orazio Carpenzano

Welcoming Address from the Dean

On behalf of the Faculty, I wish to thank the organisers for asking me to give this opening address, while congratulating them on their efforts to bring together, in an international encounter, various perspectives on topics of such decisive importance for the future of our respective territories, as well as their people, living organisms and architecture.

My thanks go to Anna Maria Giovenale, Fabrizio Cumo, Eugenio Arbizzani, Carola Clemente, Eliana Cangelli and Francesca Giofrè, who will be giving talks on technological innovation, the environment, climate change and public health.

Thinking of energy in terms of how it relates to architecture during the green and digital transition means cultivating a *technological imagination*, a topic which leads to the broader question of the man–nature relationship and the possibility that architecture, by applying innovative ideas and concepts while promoting a growing social and emotional intelligence of its own, can contribute to inventing of new types of habitat for mankind on the planet earth, under a new pact for survival that allows all elements, both artificial and natural, to coexist in a sustainable balance which can serve as a preventive measure against the intrinsic destructive force of the Cosmos, an especially pressing problem where mankind has neglected certain methods for dissipating the energy of calamitous events made available by both ancient wisdom and scientific advances.

The 2021 Architecture Biennial, entitled "How Will We Live Together?", implicitly drew the attention of visitors to the need for a new approach to the man–nature relationship, following a thorough review of its historical and ethical premises. Hashim Sarkis, the curator of the exposition's seventeenth edition, passed on the following message: "In a scenario of exasperated political divisions and growing economic inequality, we call upon architects to imagine spaces in which we can all live in fruitful fellowship".

The man–nature relationship has always been a distinctive feature of humanistic and artistic thought on things technical, expressed in the construction of the *civitas*, the physical and political synthesis of civilisation. Medieval mysticism viewed nature as a foreboding wilderness, while the Renaissance redeemed the sense of *technè*, and the Romantic Period, with its high-strung, emotive outlook, led to the elaboration of the concept of the sublime.

Controlling and putting to use the energy generated by nature through sources of heat and movement (wind, sun, water), first through manual effort and then using the tools and machines produced by human ingenuity, was also a topic and challenge that led architecture to express, during the Modern Movement, boundless enthusiasm for the theories of Taylorism, which Corbusier summed up by interpreting human dwellings as machines of habitation.

But it is from the time of Vitruvius that architecture, engaged more or less explicitly with the triad of *utilitas-firmitas-venustas*, has addressed the problem of dissipating heat (or thermal inertia), as well as kinetic and elastic energy (in the case of earthquakes), at various latitudes of the globe, drawing on the available resources and raw materials. Historic Italian buildings, for example, built with walls roughly a metre thick and a structural layout measuring 4×4 or 5×5 m, have offered excellent thermo-hygrometric performance (in terms of energy consumption), as well as structural dependability (against seismic risk). In both cases the objective is to "mitigate", a term used by many modern-day scholars, the dissipation of different types of energy.

The history of architecture is filled with archetypes that need to be updated and reinvented. Think of the ingenuity it took to build Venice atop a giant underwater forest, or the aesthetic quality of the Tu'rat walls constructed by Southern Italian peasants, the windmills of Northern Europe and countless other magnificent examples of *swarm intelligence* collected by Bernard Rudofsky in his well-known book *Architecture without Architects: a short introduction to non-pedigreed architecture*, published by Doubleday & Company Inc., Garden City, (in 1964), following an exhibition at New York's Museum of Modern Art. Though, in truth, Roberto Pane and Gino Capponi had already touched on the topic in articles on the architecture of Ischia published in "Architettura e Arti decorative" in 1927, as did Giuseppe Pagano at the Milan Triennial "Rural Italian Architecture", published in the Notebooks of the Milan Triennial by Hoepli in 1936.

Looking beyond the confines of architecture, a recent reconsideration of the topic of Cinema and Energy can provide potentially useful points of affinity with architecture, especially in the collection of essays found in issues 7 and 8 of the periodical Imago, under the title *Cinema & Energy. Interdisciplinary Outlooks Combining Science, Aesthetics and Technology*, edited by Marco Maria Gazzano and Enrico Carocci (and published by Bulzoni in 2013). In an essay entitled *Dissipation and Aesthetic Experience*, the physicist Giuseppe Vitiello, in commenting on the film Transeurope Hotel by Luigi Cinque, writes: "The brain [which leads me to think of *swarm intelligence*] is described as an open system engaged in continuous exchanges

with its surrounding environment. In both models and films, antinomies such as information/knowledge, feeling/knowing, blend with each other in the aesthetic experience, the favourable connection between 'me and the object' that characterises our existential dimension."

Dissipation, therefore, should be seen as part of the evolution of our ecosystem, of our contemporary habitat. It gauges the possibilities for losing and exchanging, through a rekindling of collective emotional intelligence and technical and intellectual micro-revolutions. It is a risk that we must continue to face, as otherwise architecture will die, depriving man of an indispensable tool for managing the complexity of the physical habitat through creativity, in order to transfigure energy in a way that, at times, can prove so unreal, and yet so effective and indispensable, that it leads to the construction of new values and sublime beauty.

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Chapter 15
Sustainable Workplace: Space Planning Model to Optimize Environmental Impact

Alice Paola Pomè, Chiara Tagliaro, and Andrea Ciaramella

Abstract The construction sector is one of the main sources of environmental degradation in the world. Data demonstrates that commercial assets are the most intensive consumers of resources. Among those, the largest amount of buildings' emissions comes from office building operations. Buildings' impact on the environment does not depend only on energy and material consumptions; but several studies demonstrate that sustainable savings could be achieved through occupants' trainings. To develop a model for assessing the sustainable performance of office buildings which accounts also for occupants' behavior, authors worked with the Real Estate Center of Politecnico di Milano and the Joint Research Center PropTech of Fondazione Politecnico di Milano. Through this cooperation, a tool is under development that:

I. Assesses the quantity of space needed by organizations, based on the employees' ways of working; and
II. Evaluates how much space occupancy and utilization may influence the sustainable performances of office buildings.

This paper describes the general functioning of the tool and looks at the contribution that PropTechs (Properties Technologies) can give to its implementation. Even if PropTechs are introducing digitalization in several real estate processes, few of them are focusing on the environmental. This study reviews the existing Italian PropTechs and selects those that could add value to the proposed tool. The analysis allows to define strengths and limits of the existing tools, helpful for implementing a new tool based on real needs of building managers. The tool aims to reduce the environmental impact of office buildings by suggesting more sustainable and user-oriented strategies.

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15.1 Introduction

The U.S. Energy Information Administration (2013) reported that office buildings are responsible for 20% of total commercial buildings' energy consumption. This is not just an American issue, but office buildings represent the largest consumer of energy in all countries (Lin et al. 2022). The great challenge of the new Millennium will be to integrate sustainable development in all sectors of the global market. Sustainable development is a balance between technologies, innovation strategies, and ecosystems (Vollenbroek 2002). However, a literature review on sustainability in the construction field (Limac et al. 2021) shows that most sustainable applications focus on optimizing materials and construction systems during the design and construction phases. This represents a limit of the existing literature, especially considering that the in-use stage is the most resource consuming (Menassa 2011). In addition, the studies that look at environmental impact of in-use buildings focus on the reduction of energy consumptions (Yeheyis et al. 2013). Improving energy efficiency has a positive influence, but energy is just one component of consumption.

In defining the "human impact", Wackernagel and Rees (1996) considered the number of people (i.e., population), the average amount of consumed resources (i.e., affluence), and the intensity of resources' production (i.e., technology). Therefore, to examine the interactions between users, nature, and the built environment, the concept of smart sustainable buildings emerges (Belani et al. 2014). Smart sustainable buildings are a combination of technology and materials that provides users with flexible, productive, interactive, integrated, and dynamic environment (Belani et al. 2014). Buckman et al. (2014) individuated adaptability as the major feature of smart sustainable buildings. Hence, to introduce sustainable strategies in office management, an approach that translates the needs of employees into space requirements is needed to make offices adaptable overtime (Thuvander et al. 2012).

The interest in improving the sustainability performance of office buildings increased due to the disruptive effect brought by COVID-19 pandemic. The pandemic has drastically changed the ways of working of employees, integrating more flexibility (Tagliaro and Migliore 2021).

This change is redefining the demand and configurations of offices (Seugbeom et al. 2021). Workplace managers have to adapt buildings to the new needs of employees by integrating technology. The digital transformation of the built environment needs to include the digitalization of the building management. In the facility management, digital technologies are brought by PropTech, abbreviation for Property Technologies. PropTech companies introduce digital solutions for improving the effectiveness of the processes (Baum et al. 2020).

The general aim of this study is to acknowledge the potential of technology to improve workplace management toward a more sustainable use of office buildings. The research presents a tool for workplace sustainable evaluation, which is composed

of two modules. The Workplace Space Quantification focuses on assessing the effectiveness of space planning, while the Workplace-Integrated Ecological Footprint Assessment evaluates the ecological footprint of the in-use office building.

After a literature review on the already developed digital tools in the Italian real estate market, the tool is presented and discussed. Finally, the conclusion presents the limitations and future developments of the work.

15.2 State of the Art

The term PropTech indicates all technologies that are impacting the real estate market (Braesemann and Baum 2020). It increases operations' effectiveness and efficiency (Siniak and Kauko 2020). PropTech companies are usually startups and scaleups (but, also consolidated companies) that bring into the real estate innovation, digital development, and transparency (Baum et al. 2020). Authors collaborated with the Italian PropTech Network (IPN) of Politecnico di Milano, that mapped 184 companies (Bellintani et al. 2021).

PropTech taxonomy clusters companies according to the proposed solutions (Baum 2017).

The cluster relevant for the purpose of this research is Smart Real Estate, which describes digital platforms that facilitate the real estate assets' operations (Baum et al. 2020). These platforms may provide and aggregate information of buildings or facilitate the control of building services. According to IPN, Smart Real Estate focuses on companies that manage the built environment through high-tech platforms (Bellintani et al. 2021). Among the 184 Italian PropTech companies, 19% are recorded in the Smart Real Estate, which is divided into two sub-clusters, namely Immersive Visualization and Experience, and Smart Building and Operations. The former includes solutions that support promotion of properties, and the latter includes solutions that support operators and managers during the in-use phase.

Even if PropTech companies listed in the Smart Real Estate cluster aim to improve the in-use management of buildings, they look at different aspects. Some solutions help to reduce energy consumptions of buildings. For example, solutions are available, powered by Artificial Intelligence, to control autonomously the Heating, Ventilating, and Air Conditioning systems of a building (e.g., *Brainbox AI*). Real-time modifications allow to optimize in-use energy consumption. Other solutions focus on the indoor environmental quality (IEQ). Platforms acquire IEQ data from sensors, process the information, and produce reports of possible improvements (e.g., *Nuvap*). Building managers can evaluate the healthiness of the environment dynamically and continuously. Others concentrate on the maintenance of buildings by integrating management platforms in support of property data, maintenance activity, and energy consumption (e.g., *Facilio*). Others look at the level of occupancy of space by elaborating data, collected through sensors (e.g., *iComfort*). Managers may improve the

space planning of the buildings by understanding users' preferences. Finally, other platforms control the building accessibility through check-in and check-out systems (e.g., *Sofia Locks*). These solutions propose a smart access control system which helps to manage through flexibility co-living, workspaces, healthcare facilities, and retail spaces.

Smart Real Estate PropTech companies try to optimize building management through several approaches. However, the adoption of sustainability in the built environment, and especially in office buildings, means going further the energy aspect or the analysis of combined data. A sustainable office building management means including social and economic implications (Jiménez-Pulido et al. 2020). This requires a holistic approach that involves into the process stakeholders (such as building users and employees) (Jiménez-Pulido et al. 2020). Moreover, none of the PropTech listed in the Smart Real Estate directly focuses on workplace management. Therefore, to overcome the sustainable management limit, the present research develops a digital tool to support workplace managers in integrating employees' needs into the space planning and to evaluate the effects of employees' occupation and behavior in the assessment of environmental sustainability.

15.3 Methodology

Authors collaborated with the Joint Research Center—PropTech between Fondazione Politecnico di Milano and for companies operating in Italy, namely Covivio, Vodafone, BNP Paribas Real Estate, and Accenture, to develop a new tool in support of a more sustainable workplace management. To meet the goal of the research, the following steps have been implemented by authors:

1. Literature review and benchmarking analysis to define the type and number of spaces in support of different ways of working;
2. Literature review on the sustainable indices able to assess the effects of users on buildings' environmental impact;
3. Definition of the WSP and WIEFA structure and calculations;
4. Development of the online platform with digitalization of the WSP calculations;
5. First experiments of calculations on 3 case studies;
6. 5 meetings with office buildings managers for testing the WIEFA;
7. 4 meetings with the partners of the project for test all the processes.

Finally, the tool is structured into two models, namely Workplace Space Quantification (WSP), and Workplace-Integrated Ecological Footprint Assessment (WIEFA). First, the tool assesses the space quantification through the analysis of the ways of working of employees. Second, the environmental impact of the office is assessed by using a specific sustainable index, the Ecological Footprint (EF).

Table 15.1 Workplace Space Quantification—space classification

Spaces	Capacity [n° users]	Average m^2
Not assigned open individual workstation	1	6
Assigned open individual workstation	1	6
Open team workstation	1	4
Workstation in closed shared office	1	7
Touchdown	6	24
Coffee point	10	35
Meeting point/waiting area	8	20
Small meeting space (open)	6	9
Large meeting space (open)	8	25
Study/phone booth	1	4
Brainstorming room	8	24
Small meeting room	3	9
Medium meeting room	8	28
Large meeting room	14	48
Client business lounge	1	24
Filing cabinet	1	0.5
Storage space	1	1
Archive	1	1
Locker area	1	0.5

Source Tagliaro (2021)

15.3.1 Workplace Space Quantification

The Workplace Space Quantification tool has been already implemented online.[1] WSP estimates the number and the m^2 of spaces needed by an organization according to the ways of working of its employees, which are gathered through a 11-question survey submitted to either the individual employees or group managers. WSP identifies nineteen different spaces, as reported in Table 15.1, for which benchmarked size (m^2) and capacity (number of people hosted in the space) have been defined through the literature.

The questions characterize the way of working based on the time spent on different activities (such as "In a working week, how long does the group work in the office?") and the number of people involved in different activities (such as "On

[1] Available online: https://www.braveworkplace.it/login.

average, how many people attend the meetings you hold for collaboration activities on concentration work?") performed in the office.

The tool allows to calculate the needed spaces for a single group of employees or add together more groups to estimate the general need of the entire organization. Alternative scenarios can be created and compared showing the overall number and m^2 of spaces needed by the organization, and the specific number and m^2 of spaces by each group for each space, as reported in Figs. 15.1 and 15.2.

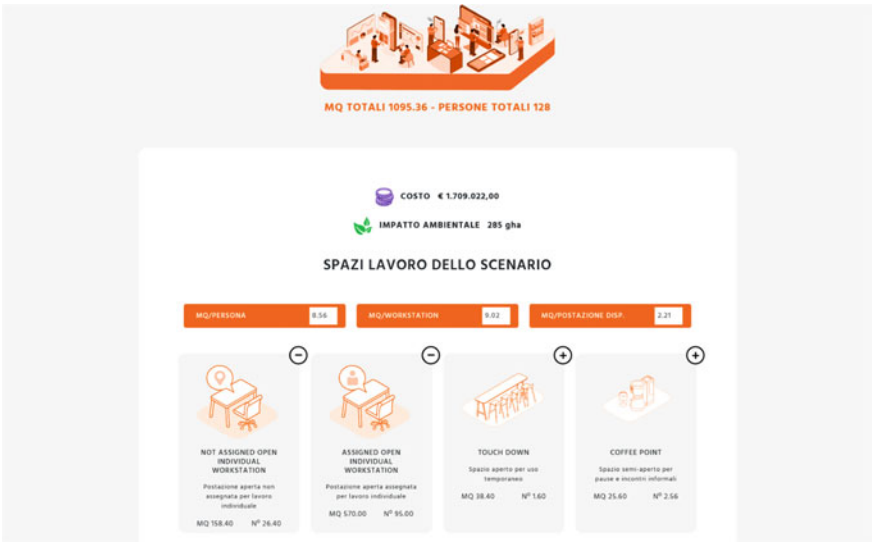

Fig. 15.1 Workplace Space Quantification: the scenario of the workplace. Retrieved from https://www.braveworkplace.it/login

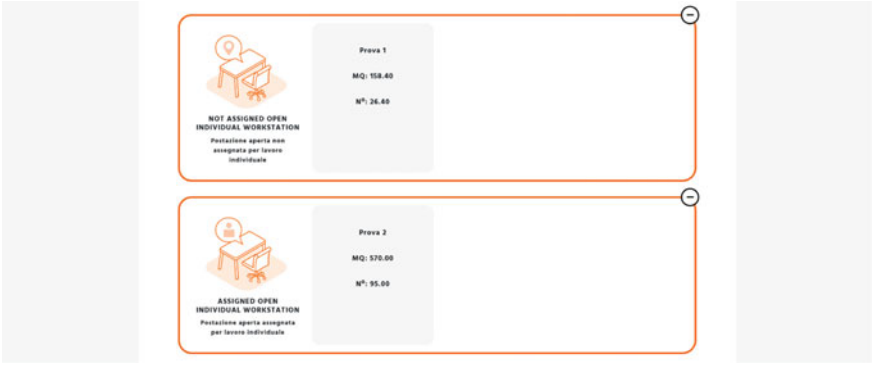

Fig. 15.2 Workplace Space Quantification: a focus on the two spaces. Retrieved from https://www.braveworkplace.it/login

WSQ is not only helpful in the design stage of offices, but it can be used to verify the appropriateness of the workplace in monitoring employees' ways of working during the in-use stage and inform potential spatial rearrangements to better meet the needs of employees. Based on the results of WSQ, office sustainability can be assessed through the WIEFA.

15.3.2 Workplace-Integrated Ecological Footprint Assessment

To evaluate environmental impact of office buildings, authors are reasoning on the Ecological Footprint (EF) index, which is a solution-oriented approach, capable to assess the (in-)efficiency of buildings' use. EF has been developed by Wackernagel and Rees (1996) to compare the demand with the supply of resources. The demand side is the population of a system (such as the building), while the supply side is the ecosystem in which the population lives (such as the Earth). EF converts consumptions and emissions in global hectares [gha]. Global hectares represent the land of Earth that can restore or absorb humans' consumptions or emissions. These lands are built-up land, forest land, fishing land, pastureland, cropland, and CO_2 sink factor.

WIEFA tried to overcome the limitations of previous studies (Acosta and Moore 2010; Gottlieb et al. 2012; Husain and Prakas 2018; Martínez-Rocamora et al. 2016; Solìs-Guzmàn et al. 2013) that tried to implement EF in the environmental impact assessment of buildings. Indeed, WIEFA puts together all the different impact sources defined by previous studies and evaluates the users' effect on environmental impact through a new impact source, Occupant. WIFE articulates 9 impact sources that show the consumption of the built environment, namely Built-up, Energy Consumption, Water Consumption, Material Consumption, Food and Drink, Mobility, Waste Generation, Recycle Potential, and Occupant. These are converted into global hectares [gha], through two conversion factors. World Yield Factor (WYF) translates impact sources in tons of CO_2 equivalence. While Equivalence Factor (EQF) converts CO_2 equivalence into gha. Both the factors are defined globally by the Global Footprint Network.[2] The 9 converted impact sources, defined addenda, are algebraically sum together, as shown in Fig. 15.3.

Built-up, Energy Consumption, Water Consumption, Material Consumption, Food and Drink, Mobility, and Waste Generation are summed together as they represent consumed resources and emitted pollutants. While Recycle Potential and Occupant are subtracted, they represent recreated benefits. Recycle Potential assesses the materials reuse in the building. For example, if the building produces electricity through a photovoltaic plant, the energy consumed over the year will be reduced. Occupant highlights the benefit of simultaneous building's occupation by multiple users.

[2] Available online: https://www.footprintnetwork.org/.

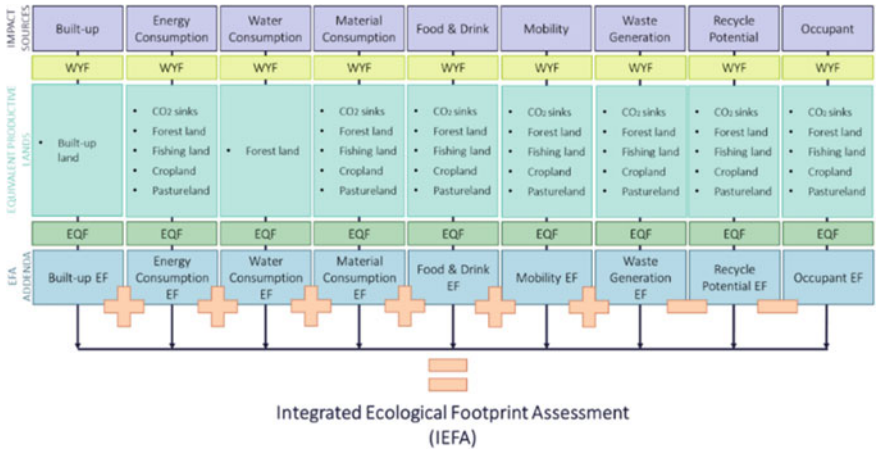

Fig. 15.3 Workplace-Integrated Ecological Footprint Assessment model—elaboration by authors

15.4 Conclusions

The proposed tool intends to support workplace managers in defining which is the effect of employees in the use of space and resources of an office. The integration of WSQ and WIEFA allows to develop a specific tool for office buildings, that evaluates environmental impacts of the in-use stage. Previous solutions focus only on energy consumption or look at the buildings' performance, without estimating the impact of users' occupation and behavior. However, the present tool can help workplace managers to adapt office buildings to changes in users' needs.

The tool still presents some limitations and room for improvement. First, the Workplace-Integrated Ecological Footprint model still needs to be refined and digitalized. Second, the science of sustainability does not look only at users and environment, but it aims to achieve an economic sustainability, which would be important to add to the current model. An additional section of the model will need to be implemented to look at the operational costs associated with the use of offices. This third addition will add the economic sustainability to the tool and will help workplace managers to understand not only the environmental effects of users, space utilizations, and resources' consumption, but also economic effects.

The model would need to be tested through a case study to assess its reliability and effectiveness. In order to offer seamless functionality and assure precision of the data, ideally the tool should automatically retrieve the information from sensors and periodically prompted questionnaires to building users, which would encompass integration with a number of PropTech solutions.

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