

Perspective

Urban Digital Twins to achieve Blue Zones in a Circular Built Environment

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Abstract

In our modern era, the “Blue Zones” concept represents regions inhabited by people with remarkable longevity, often reaching centenarian ages. In Europe, people spend 90% of their time in indoor environments. At the same time, the European Commission warns that indoor environments can be twice as unhealthy as outdoor spaces. The challenge lies in transforming buildings into metaphorical “blue” havens. Based on that, this perspective contemplates how the built environment can contribute to creating these desired Blue Zones, especially buildings and circular practices within the construction industry. Furthermore, it drives assumptions about Urban Digital Twins (UDTw), which target the Energy Performance of Buildings Directive (EPBD) and Smart Readiness Indicators (SRI). These assumptions intersect with crucial elements of circular construction within the European Union, including initiatives like the Green Deal (aiming for 55% emissions reduction) and the ambitious Renovation Wave (with plans to renovate 35 million buildings by 2030).

Keywords: Built Environment · Green Deal · Renovation Wave · Circular economy · Human-Centric

1. INTRODUCTION

Nowadays, Netflix teaches us how to target a “Blue Zone” (Dan Buettner, 2023). Blue Zones are territorial lands with people with centenarian prevalence longevity (Fastame et al., 2022; Marston et al., 2021; Najafi et al., 2023). The challenge is to colour our zone in blue. In Europe, people spend 90% of their time encapsulated in indoor environments (European Commission - Press Release, 2003). And, by guessing, people are probably using digital devices most of the time. European Commission by the Joint Research Centre (JRC) highlights that indoor environments can be twice as unhealthy as outdoors, meaning we are poisoning ourselves 90% of our lifetime (European Commission - Press Release, 2003). Finally, European initiatives target reducing pollution emissions and improving indoor and outdoor environmental conditions (European Commission - Press Release, 2003; European Commission, 2010, 2020, 2021).

Instigated by this, from the perspective of increasing people's longevity, urges concern about how the built environment, mainly buildings, and the construction industry's circular actions can contribute to achieving the wanted Blue Zones. In addition, the digital transition over the lens of Industry 5.0 targeting human-centric and sustainability should also support that vision (European Commission. Directorate General for Research and Innovation., 2021). Finally, it raises some practical questions:

- How can longevity be achieved if people's homes are unhealthy, if there is no good ventilation, and if people suffer from cold? How can people be happy if their workplace does not give them quality habitability?
- How can a circular built environment enhance people's quality of life?
- How can a digitally built environment support people's better life?

It is necessary to raise awareness of the importance of improving the quality of the indoor environment for people, targeting increased health for elderly occupants. This opinion highlights the necessity of aligning

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European initiatives to rethink buildings and cities, targeting a circular environment using sensing technologies to collect people's feedback and measure indoor quality indicators continuously. People's longevity in dense urban cities may be increased by providing "blue buildings zones".

Next, targeting achieve these purposes, it highlights some assumptions regarding Urban Digital Twins (UDTw) targeting the Energy Performance of Buildings Directive (EPBD) (European Commission, 2010) and obtaining the Smart Readiness Indicators (SRI) (European Commission, 2018) linked to key elements of circular construction in the European Union (EU), such as the Green Deal (fit for 55%) (European Commission, 2021) and the Renovation Wave (renovate 35M buildings by 2030) (European Commission, 2020). Circular construction applies circular economy principles to the building and construction industry, promoting sustainable practices and minimising environmental impacts (Ghufran et al., 2022).

2. URBAN DIGITAL TWINS TO ACHIEVE BLUE ZONES IN A CIRCULAR ENVIRONMENT

2.1 The Blue Zones

Let's begin the discussion by focusing on the blue zones in relation to the built environment. Of course, the attitude of centenary people toward happiness and health is much more about the surroundings than the buildings themselves. That is about physical activities, healthy food and diet, access to healthcare, social and family connections, a sense of community, and a sense of purpose and meaning in living (Fastame et al., 2022; Marston et al., 2021; Najafi et al., 2023). These pieces of blue land are in Sardinia - Italy (Density of 37 inhabitants/Km²); Okinawa - Japan (1050 inhab./Km²); Nicoya Peninsula - Costa Rica (67 inhab./Km²); Ikaria - Greece (31 inhab./Km²); and Noma Linda - United States (3130 inhab./Km²) (Fastame et al., 2022; Najafi et al., 2023). Only Noma Linda is inserted in an urban district on a mesoscale (Najafi et al., 2023).

The low density in most blue zone areas demonstrates that dense urban cities and indoor environments are not prone to give inhabitants longevity. Mainly, the inhabitants of these zones still have agricultural work tasks, a close connection with nature, and walking habits (Dan Buettner, 2023). However, this perspective does not deeply address how to rebuild cities, considering the most extensive urban zones and dense geographic areas, as it is a massive and quite utopic task to be done. Significantly, if people spend 90% of their time in indoor environments, making pollution and energy poverty a reality, it is mandatory to rethink building performance first.

3. EUROPEAN INITIATIVES

Circular actions on refurbishment projects are crucial to reuse and recycle materials so as to be better prepared for the next waves of building renovation. Additionally, a circular environment targeting reducing greenhouse gases (GHG) and promoting cleaner air will positively impact human health and well-being. The Green Deal aims to reduce GHG emissions by 55% by 2030 and is a landmark of the climate-neutral goal (European Commission, 2021). Further, at an urban scale, affording more green spaces, providing sustainable transportation options, and reducing exposure to harmful pollutants can contribute to people's healthier lifestyles. At the same time, local circular actions, such as shared transportation vehicles (e.g., bicycles, electric scooters) and shared community vertical gardens, can strengthen social bonds and enhance people's well-being. In summary, circular actions can contribute to reducing GHG emissions and positively impact human health by creating healthier living spaces, which may create opportunities for urban blue zones.

EPBD is a legislative directive of the European Union that was first approved in 2002 and aims to promote improvements in the energy performance of buildings (European Commission, 2020). The EPBD directive also supports better air quality, the digitalisation of building energy systems, and the development of infrastructure for sustainable mobility (European Commission, 2020). The renovation of buildings at the European scale must tackle energy poverty and decarbonise heating and cooling systems targeting EPBD compliance (European Commission, 2020). The EPBD directive introduces requirements for deploying automation and control systems in buildings, targeting temperature regulation at room levels (European Commission, 2010). EPBD contributes to healthier living environments by optimising indoor air quality in buildings, which can reduce health risks and increase occupants' longevity.

The SRI assessment evaluates the buildings' performance based on nine technical domains: dynamic building envelope, ventilation, lighting, domestic hot water, electricity, electric vehicle charging, heating and cooling, monitoring and control (European Commission, 2018). The performance of each technical domain is assessed against seven desired impacts of a desired smart building: comfort, convenience, health, energy efficiency, maintenance/fault prediction, well-being/accessibility/information to occupants, and energy flexibility/storage (European Commission, 2018). The smart-ready assessment results are aggregated into an overall SRI class and SRI score, which expresses and classifies buildings' smartness. Further, the SRI assesses buildings' ability to optimise energy efficiency and overall in-use performance, adapting operations to occupants' needs and responding to grid signals such as energy flexibility (European Commission, 2018). The systematisation provided by SRI can allow adapted indoor ambient for occupants to increase satisfaction, motivating them to perform healthier practices such as home exercises.

Age-friendly environments targeting Blue Zones should allow the creation of an indoor exercise area (Marston et al., 2021). Stimulating physical activity is crucial to increase people's longevity (Fastame et al., 2022; Herbert et al., 2022; Marston et al., 2021). Another example is taking care of plants at home as a form of physical activity (Marston et al., 2021). From the perspective of hedonic and eudaimonic, well-being correlates with various factors, including marital status, sociocultural environment, and perceived physical health. The improvement of eudaimonic (e.g., personal growth and meaning construction) and hedonic (e.g., emotional regulation and life satisfaction) motivations contribute to people's well-being (Fastame et al., 2022). Living in habitable conditions while having the opportunity to express (dis)contentment can structure an environment of growth, meaning and satisfaction.

4. UDTW TO ACHIEVE BLUE ZONES IN A CIRCULAR BUILT ENVIRONMENT

Multiple requirements from IoT to optimise in-use performance lead to the buildings being placed on a Digital Twins (DTw) level of automation. There is no Digital Twin without digital data. Digital Twin concepts are associated with the two-way data exchange between the physical assets and their digital representations (Boje et al., 2020; Sacks et al., 2020; Tchana et al., 2019). At the same time, a DTw deployment may be oriented for multiple different spectrums, such as socio-technical (Boje et al., 2020) and data-processing (Sacks et al., 2020).

Acquiring and exchanging digital data is fundamental to a digitally built environment. Incremental DTw approaches emphasise the capability of model learning, from simulations to full automation (Boje et al., 2020; Mèda et al., 2021). Beyond this, human-data interaction (HDI) is a key element when deploying DTw on an urban scale (Calvetti et al., 2023). Also, DTw can improve the Life Cycle Sustainability Assessment (LCSA) (Boje et al., 2023). From the inhabitants' perspective, DTw should support and advise energy use and air quality parameter adjustments (e.g., turn on/off system, close/open windows), and most importantly, collect people's feedback. Better understanding the people's feelings of health and happiness using the buildings is crucial for the process of learning and assertive play the DTw. Also, the Internet of Things (IoT) can be used to measure and evaluate the “smart age-friendly ecosystem (SAFE) framework and the Blue Zones® checklists” (Marston et al., 2021).

Finally, a cycle of actions targeting improved performance, and smarter buildings can support increased quality of life for urban inhabitants. Figure 1 is meant to illustrate the vision of Urban Digital Twins to achieve Blue Zones in a Circular Environment. It conceptualises the integration of UDTw and the European initiatives for a circular' building environment from a human-centric perspective, chasing people's longevity.

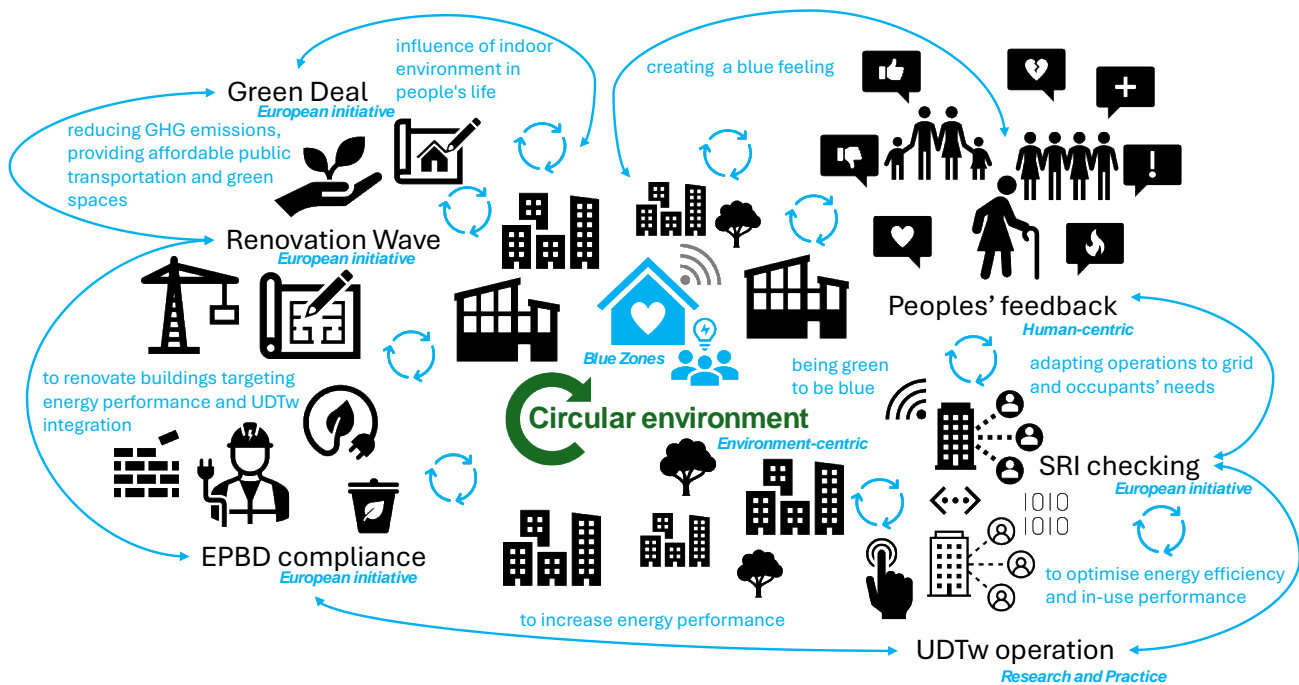


Figure 1: Blue-EU-Zone

In summary, circular actions in the building's renovation are crucial to a better indoor environment for Europeans and achieving the Green Deal goals. The Urban Digital Twins is a critical element in fulfilling the EPBD requirements and a valuable tool for assessing SRI. Most importantly, the DTw should collect/receive people's opinions about indoor health and overall satisfaction regarding buildings at home and at the workplace.

5. REMARKS

To begin with, the first practical question raised is a rhetorical negative consideration. Objectively, achieving longevity with poor indoor ventilation and heating conditions is quite impossible. Indubitably, there is a low perception of happiness in living in inadequate homes. In this, by answering the second question, it is possible to envisage that a circular built environment following EU principles such as the Green Deal can enhance people's quality of life. By reducing GHG emissions and providing affordable public transportation and green spaces, people should perceive improved quality of life. Finally, addressing the third practical question, conceiving that a digitally built environment would support a twin transition monitoring and enhancing people's comfort is possible.

In our modern era, the “Blue Zones” concept represents regions inhabited by people with remarkable longevity, often reaching centenarian ages. In Europe, people spend 90% of their time in indoor environments. At the same time, the European Commission warns that indoor environments can be twice as unhealthy as outdoor spaces. The challenge lies in transforming buildings into metaphorical “blue” havens. Based on that, this perspective contemplates how the built environment can contribute to creating these desired Blue Zones, especially buildings and circular practices within the construction industry. Resource circular efficiency targeting a healthy environment is a critical factor in the longevity and well-being observed in Blue Zones. A circular built environment should be adaptable and resilient to climate change. As a result, it ensures that inhabitants can maintain their health and well-being even in the face of environmental challenges.

Furthermore, it drives assumptions about Urban Digital Twins (UDTw), which target the Energy Performance of Buildings Directive (EPBD) and Smart Readiness Indicators (SRI). These assumptions intersect with crucial elements of circular construction within the European Union, including initiatives like the Green Deal, aiming for a 55% emissions reduction of greenhouse gas emissions and the ambitious Renovation Wave with plans to renovate 35 million buildings by 2030.

Further research should investigate how UDTw, SRI, and EPBD can effectively promote healthier behaviours (e.g., physical activity and nutrition) in alignment with Blue Zone principles. At the same time, explore tools such as apps and wearables in a UDTw platform that encourages sustainable lifestyle changes and can monitor social interactions and community well-being in real-time. Also, examine how EPBD can incorporate Blue Zone criteria (walkability, green spaces) for urban planning. Develop platforms that connect individuals within Blue Zones, fostering social bonds and collaboration, leveraging technology to create virtual communities centred around health, purpose, and longevity. Finally, further research should address concerns about privacy, data ownership, and the potential exclusion of certain populations.

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AUTHOR CONTRIBUTIONS

Diego Calvetti: Conceptualisation, writing – review & editing

DECLARATIONS

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