

The environmental sustainability at the time of COVID-19 pandemy: an holistic approach through LEED® v4 BD+C rating system

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Abstract

The intent and metrics of LEED v4 BD+C have been taken as a reference and analysed, for a holistic approach to the energy and environmental issues emerging from the implications that COVID-19 pandemy may have on building design and urban planning.

The research comprises an overview of the LEED v4 BD+C prerequisites and credits, with a focus on the issues of air conditioning and ventilation, and the related guidance provided by the building services engineers organization.

Keywords

LEED, COVID-19, sustainability, ventilation, air-conditioning

1. Introduction

There is a wide debate about the consequences of COVID-19 pandemy on the economy and the society, with academics and organizations raising their voices to ask that the sustainability agenda should be at the center of any political decision, not least because of the long-term positive effect on people's health, currently threatened in the short-term.

A debate about how the pandemy will change buildings and cities is also emerging. According to the World Green Building Council, the building performances could and should contribute to a better response to unwilling future health emergencies: *"... It is thought that as a result of COVID-19 more attention should be paid to the health performance of buildings, in order to make a greater contribution to the response to major public health emergencies in the future..."* [1]

Architects suggest that workplaces and residences will have to be designed in a different way for health and wellness purposes. According to various studies, the air quality benefited from the lockdown and the subsequent mobility reduction, and concern is being expressed about the risk of an increase in the use of private cars in the next future.

In order to consider holistically the various issues, Authors, suggests the use of LEED® v4 BD+C as a framework. Open Project, architecture and engineering firm in Bologna, Italy, adopted LEED rating systems since 2008 (Unipol Tower, LEED Gold v2.2 certified) both as a design guide and as a tool to measure the environmental sustainability.

This research represent a framework for an analysis of the LEED v4 BD+C prerequisites and credits, under the effects and implications of COVID-19 pandemy, and the basis for further and more focused or detailed studies, topic by topic. A focus on air conditioning and ventilation has been introduced, as an urgent issue in Italy, since many commercial buildings will reopen on May 4th, following an easement of the lockdown restrictions, but limited guidance is provided. The effects of any enhanced outdoor ventilation (as a recommended measure against COVID-19 spread) on the energy consumption of the buildings, thus the planet, should later be assessed in a holistic way (such as the one suggested by LEED) in order to get a wider picture.

2. Applicability of the research

LEED v4 BD + C [2] rating system was published when the COVID-19 pandemy could have not even been imagined. A similar disclaimer [3] has been recently published by CIBSE (Chartered Institution of Building Services Engineers) with reference to the CIBSE Technical Memorandum 40, just published last March [4]: *"... CIBSE TM40 Health and Wellbeing in Building Services was published in March 2020 [...] What is understood by « health » is very broad. CIBSE TM40 focuses on providing guidance for general situations and the general population. It does NOT provide comprehensive guidance for environments such as healthcare buildings, for people with medical conditions, or for acute situations such as the current pandemic. In addition, TM40 was produced before the current coronavirus pandemic..."*

Furthermore, the reference of the following analysis is the LEED v4 BD+C New Construction rating system. Similar considerations could be applicable to Core and Shell buildings, and to a smaller extent to Schools or Hospitality buildings, not to residential buildings. The following analysis is not applicable to Healthcare facilities. The research reflects Authors' opinion and do not substitute any U.S. Green Building Council statement or document.

3. A review of LEED v4 BD+C prerequisites and credits, following COVID-19 pandemia

LEED v4 BD+C categories, prerequisites and credits are listed below.

If a prerequisite or credit is not mentioned, Authors do not see any significant impact by COVID-19 pandemia.

In general, metrics such as Regular Building Occupants will have to be revised to consider any limited temporary or permanent restriction, both for employees and visitors, and the calculations for various prerequisites and credits will have to allow for such special circumstances. It may also be appropriate to reconsider the definitions of regularly occupied spaces and densely occupied spaces.

a. IP, Integrative Process

- IP credit, Integrative Process

At a first glance, this credit may appear as not affected, apart from the Goal-Setting Workshop, that currently (and in the very next future) will have to use videoconferencing, with an impact on the way the project team works.

However, a redefinition of project goals may be required for projects. In fact, any strategies for energy-related systems may be affected by the layout and schedule of the internal spaces, that may be heavily affected by the social distancing measures "... Programmatic and operational parameters. Assess multifunctioning spaces, operating schedules, space allotment per person, teleworking, reduction of building area, and anticipated operations and maintenance..." [2].

b. LT, Location and Transportation

- LT credit, LEED for Neighborhood Development Location

Reading the intent in time of lock-down is self-explanatory about the COVID-19 pandemia implications: "... To reduce vehicles miles traveled. To enhance livability and improve human health by encouraging daily physical activity..." [2].

Authors will expand the research by reviewing the issues specific to the Neighborhood Development certification.

In fact, most of the following credits also applies to an higher scale (for example, the energy efficiency of the buildings would result in the energy efficiency of the neighborhood), but the opposite is not correct, because most of the LEED ND Neighborhood Pattern and Design category cannot be examined if referring to a single building or a group of buildings.

- LT credit, Surrounding Density and Diverse Uses

Part of the intent is the same of the previous credit: "... To promote walkability, and transportation efficiency and reduce vehicle distance traveled. To improve public health by encouraging daily physical activity..." [2]

Density and Proximity are between the most debated topics in the current thoughts about the cities and their future, during and after the COVID-19 pandemia. Refer to [5], [6], [7], [8].

The mix of use is one of the topics through which urban planning and spaces outside buildings can contribute to health and wellbeing, according to CIBSE TM 40 [3]

Synergies between the health and environmental agendas

There are very strong links between 'healthy' and 'environmentally sustainable' buildings and places. Strategies to benefit health and wellbeing can also bring environmental benefits, and vice versa, as illustrated in Figure 3.8.

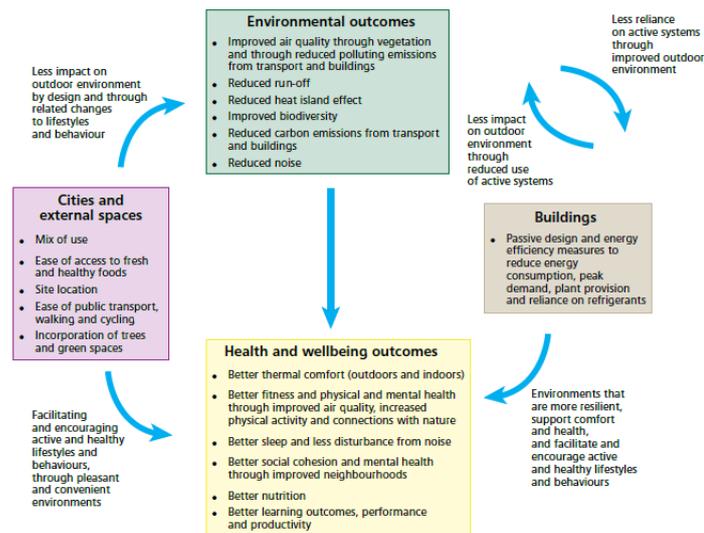


Figure 3.8 Examples of built environment influence on health and wellbeing, also showing synergies and potential conflicts with environmental issues (non-exhaustive, for illustration only)

Figure 1, from [3]

Awaiting for proposals from more qualified experts, two side notes to the discussion, not including any health issues.

The first one refers to the concept of mixité, and the food and books purchase habits in the last weeks.

During lockdown many citizens discovered the importance of vicinity grocery shops, closer or more accessible than the supermarkets often showing hours-long queues. Others found that their habitual farmer's market had to shut down due to the fear of uncontrolled overcrowding. Other citizens started to buy food on-line, not only due to health concern.

In Italy, bookshops had to shut down for one month (March 15 to April 14th), while e-commerce and delivery of books was still allowed, and shopping on-line is often criticized as a responsible for the crisis of local businesses.

Also, most of the diverse uses (especially "Services" and "Civic and community facilities") will gradually start to reopen.

The second one is a note about the importance of measuring.

During the lock down, the Italian government allowed individual sport activities (e.g. walking) only in proximity of the house, but many local ordinances (Veneto Region and Piemonte Region, for instance) reinforced this by fixing a 200m maximum allowed distance, well below the 800m walking distance to shops and diverse uses considered by this credit. How a walking distance considered by this credit as small enough, could allow for any sport activities?

- LT credit, Access to Quality Transit

Irrespective of the number of transits, social distancing will be the main topic about the use of public transports after the lockdown. How to promote the use of public transport, when the private car appears to be the best option from an health and safety point of view? How to take into account, on the other side, the positive effect of lock down on outdoor air quality (especially on PM₁₀ and PM_{2.5} concentration), and the reduction of respiratory diseases?

- LT credit, Bicycle Facilities

Differently from the credit intent, in Italy the bicycle is more often associated with recreational physical activity than with sustainable transportation. In the last month, various non governative organization recommended strategies to temporarily increase the use of bicycle instead of private cars, in compliance with the social distancing policies, such an increase of the width of the main cycle routes. However, the issues related with insufficient secure bike parking and the scarce availability of showers and lockers (as well as their sanification) may still discourage potential new bicycle users.

- LT credit, Reduced Parking Footprint

The reduction of the available space for private cars parking may be an issue if the main alternative (public transport) will become less efficient, although teleworking may contribute to minimize it, at least for the next few months. Since car pooling may not be allowed because of social distancing directives, at least the preferred 5% parking spaces for car pooling may be reserved to the employees that cannot be requested to cycle to work.

c. Sustainable Sites category

- SS credit, Open Space

The intent "...To create exterior open space that encourages interaction with the environment, social interaction, passive recreation, and physical activities..." [2] may be revised, since any open space adjacent to an office building may also work as a temporary meeting room, under certain weather conditions.

- SS credit, Heat Island Reduction.

Any effective use of outdoor space in summer, for any of the purposes of the credit above, should depend on the reduction of the Heat Island effect. This would be beneficial in any unwilling case of further lockdown.

d. WE, Water Efficiency

- WE prerequisite and credit, Outdoor Water Use Reduction

Self-sustaining vegetated spaces, or automated irrigation, may be useful if gardeners were not allowed during lockdown.

- WE prerequisite and credit, Indoor Water Use Reduction

In terms of recommendation for future projects, automated fixtures (such as no-touch toilet flush systems or no-touch washbasin faucets) may not only be recommended for water use reduction, but also for health reasons.

In order to reduce water consumption, high efficiency flow fixtures (generally considered less important than the flush fixtures) would be beneficial, since a more frequent hand washing (more than 3 times a day for) is recommended.

In general, under a LEED certification perspective only, the number of FTEs (Full Time Equivalents) and the associated number of fixture uses per day will have to be revised in case of teleworking or multiple shift, as required by social distancing policies. In case of a reduced number of employees, services such as rainwater storage tanks may then become oversized.

e. EA, Energy and Atmosphere

- EA prerequisite, Minimum Energy Performance; EA credit Optimize Energy Performance

The calculations for this prerequisite and credit may be reconsidered in case of any change due to a revised working schedule (e.g. multiple shifts) or a partial occupancy (in this case, high efficiency under partial loads may be beneficial). Generally speaking, energy efficiency and increased mechanical ventilation are in contradiction. Therefore, any requirement to run the HVAC system on 100 % outdoor air mode may have a huge impact on the energy consumption. Refer to EQ prerequisite Minimum Indoor Air Quality and the following paragraph for the notes about the ventilation strategies, that will have to be considered carefully to avoid any contamination by COVID-19 within the buildings.

- EA credit, Advanced Energy Metering

The more the available energy consumption data, the easier for the Facility Manager to minimize the energy consumption in any reduced occupancy scenario.

f. MR, Materials and Resources

This category is the least affected one.

Authors only suggest a discussion about the importance of "*Regional Materials*" in the building sectors, highlighted by the increased transportation costs, and the uncertainties on the supply chain due to the jeopardized lockdown duration.

g. EQ, Indoor Environmental Quality

This category appears to be the most affected one by the COVID-19 pandemia.

When returning to their offices, any responsible employees may check the distance from his colleagues, may be afraid of the air conditioning system, may require for the windows to be kept open, or may comply about the thermal comfort if the facility management decided to kept the fan coil units shut down.

Any of the above will probably increase the energy consumption of the building per employee.

To get a wider picture, Indoor Environmental Quality and Minimum Energy Performance should also be considered with reference to employees' other office, e.g. the house where they are working from remote. Refer also to [9]

In terms of LEED certification only, the definitions of densely occupied spaces may need to be revised.

- EQ prerequisite, Minimum Indoor Air Quality Performance

The prerequisite Intent "... To contribute to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ)..." [2] may be considered insufficient, due to the paramount health concern.

Refer also to the following paragraph, where the air conditioning, ventilation and filtration topics will be further detailed. In terms of LEED certification only, prerequisite compliance could only take advantage by the reduced occupancy rates.

- EQ prerequisite, Environmental Tobacco Smoke Control

Designated outside smoking area may be considered as assembly places, and a maximum occupancy could be suggested not to compromise the social distancing between smokers.

- EQ credit, Enhanced Indoor Air Quality Strategies

This appears to be the single credit with the greatest opportunity of further research.

Should the management of COVID-19 pandemic within any office building be considered as an Enhanced IAQ strategy?

The following notes focus on a Mechanical Ventilation system. It should be made clear that any instruction about opening the windows would not be enough to guarantee an effective Natural Ventilation. According to CIBSE Application Manual AM 10 [10], in summer condition the effectiveness of a window is limited to less than 2 times the room height:

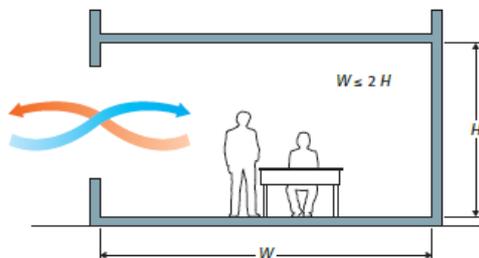


Figure 2.18 Single sided ventilation, single opening

Figure 2, from [10]

Could the control measures of *Option 1, B. Interior Cross-Contamination Prevention* be applicable to different zones in a building, just to separate groups of employees, in order not to compromise the COVID-19 positive people tracking?

Mitigation of viral transmission through BE air delivery systems is most often reliant on inline filtration media, which effectiveness against pathogens such as COVID-19 is limited due to their particle size [11]

With the only aim of contributing to the general awareness about filtration issues, *Option 1, C. Filtration* may suggest a non-accurate comparison between the filtration requirements to outdoor air (meant to minimized the PM₁₀ and PM_{2.5} particulate egress into the building), the filtration of indoor air recirculation or fan coil units (typically much lower than the previous one) and the filtration of face masks (much higher). Even a MERV 13 or higher and Class F7 or higher do not ensure a filtration comparable with the one required for effective face mask, classified as FFP2 or FFP3 according to EN 149, which filter respectively 92% or 98% of the test aerosol.

With reference to an open plan office, compliance with the Minimum IAQ prerequisite and a significant reduction in the occupation could result in a +30% outdoor air (depending on the ratio between the room area and the number of occupants), making it compliant with *Option 2, B, increased ventilation*.

Could *Option 2, C. Carbon Dioxide Monitoring* be useful in any occupied spaces (thus not limited to *within all densely occupied spaces*), to check ventilation effectiveness?

Could *Option 2, D. Additional Source Control and Monitoring* be applicable, in analogy, to sensors designed to detect suspect COVID-19 virus positives (e.g. termoscanner to measure the people temperature) for spaces where air contaminants are likely?

- EQ credit, Low-Emitting Materials

This credit would suggest a debate about where people will work from remote: a LEED certified office building or their own kitchen, where VOC emissions may have not been the primary concern?

- EQ credit, Indoor Air Quality Assessment

Could *Option 1, Flush-out* offer some guidance for the sanification of workplaces, with reduced outdoor rates of course?

- EQ credit, Thermal Comfort

In general, reduced HVAC systems operation (e.g., outdoor air only) may impact on thermal comfort. According to ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers "...*Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection...*"^[12]. However, thermal comfort will probably be given a lower priority than health issues.

- h. IN, Innovation

The COVID-19 pandemia poses new challenges, from the introduction of termoscanners and a deeper integration of the IoT within the building, to the Green Cleaning procedures to be revised to incorporate the sanification issues.

- i. RP, Regional Priorities

No significant changes, although this could be the category where to take into account any local-specific issues.

4. Air conditioning and mechanical ventilation: Minimum Indoor Air Quality

The easement on lockdown measures and the very next reopening of most workplaces (in Italy, and abroad) originated unprecedented queries about the air conditioning and ventilation systems: would any HVAC system be beneficial against COVID-19 or will represent an additional risk for building occupants?

The following is a brief review of the following: two published case studies from China and Corea, highlighting the risks; an academic paper about Built Environment Considerations To Reduce Transmission; the position papers of the main HVAC associations.

- a. Case studies from China and Corea

Among the 83 customers that were in the same restaurant in China on January 24, 10 became ill with COVID-19^[13]. The research suggested that the virus transmission could not have been explained by droplet transmission alone, but airflow from the air conditioner could have propagated droplets from table to table, as per the following figure.

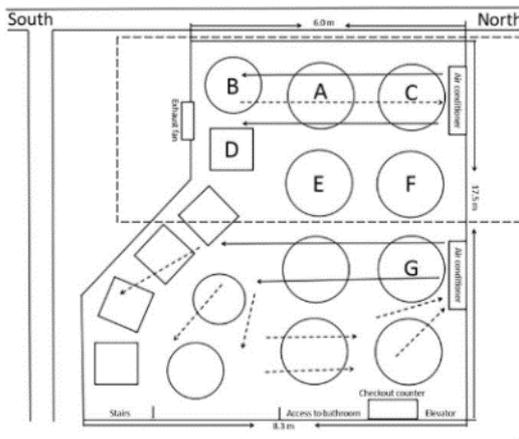


Figure 3, from ^[13]

In a call center in Corea, 8.5 % out of the 1143 people tested for COVID-19 (922 employees, 201 residents, and 20 visitors) had been confirmed as positive, the 96.9% of which were working on the same floor and on the same side of the building. Although proximity and contact may be the main reason behind the spread of COVID-19, the article ^[14] suggested a deeper investigation about the role of air conditioning and ventilation.

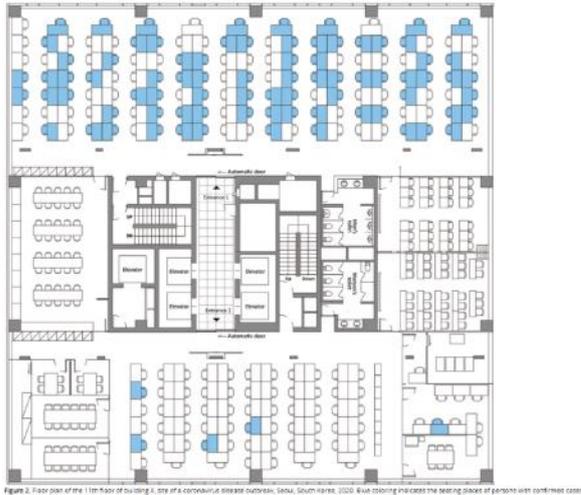


Figure 4, from [14]

b. Academic research

Air flow and how many vents are in the room can exacerbate the risk of coming into contact with COVID-19 droplets. And the more people in the room, the more likely air conditioning can play a negative role, given the limited effectiveness of HVAC filtration media when compared to the droplets size [11].

The transport of droplet nuclei over larger distances is primarily driven by ambient flows, and indoor environments pose a particular challenge for disease transmission, due not only to the presence of recirculatory flows driven by ventilation systems but also anthropogenic thermally-driven flow effects [15].

c. Recommendations from the HVAC international organizations

The main HVAC organization have issued and have been updating position papers about air conditioning and ventilation systems use. As summarized by REHVA (The Federation of European Heating, Ventilation and Air Conditioning associations): "... The key aspect is the amount of fresh air supplied per person. If, due to smart working utilization, the number of employees is reduced, do not concentrate the remaining employees in smaller areas but maintain or enlarge the spacing among them in order to foster the ventilation cleaning effect..." [16]

- AICARR (Associazione Italiana Condizionamento dell'Aria, Riscaldamento e Refrigerazione)

In Italy, AICARR position paper provides different general guidance for different HVAC system types (all-air systems serving a single space or large buildings, or all-air system with recirculation, and primary air system), and conclude by saying that "... Air conditioning systems can help reducing the risk, if the outdoor air flow rate is increase ..." [17] (http://www.aicarr.org/Documents/Normativa/COVID19/200406_PP_AICARR_COVID-19%20ENG.pdf).

The statement about the increase of the air flow rate appears to be the most critical issue, since most existing buildings may already had an insufficient outdoor air flow rate, and the HVAC system may not allow for increasing it. In this scenario, reducing the occupancy may be the only feasible option.

Refer also to the previous paragraph, EQ prerequisite Minimum Indoor Air Quality Performance.

- CIBSE (Chartered Institution of Building Services Engineers)

In the UK, CIBSE assess that "... The most likely situation in ventilation systems with filtration is that filters will be aimed at fine particles ($PM_{2.5}$ and PM_{1}), which are larger than virus particles....". In general, CIBSE make reference to the REHVA guidance.

- REHVA (The Federation of European Heating, Ventilation and Air Conditioning associations)

In Europe, REHVA [16] guidance recommended the following: supply as much outside air as reasonably possible; keep exhaust ventilation systems on 24/7, and make sure that underpressure is created, especially to avoid any potential faecal-oral transmission; do not use recirculation; turn off decentralized systems such as fan coil units to avoid resuspension of virus particles at room level when rooms are used normally by more than one occupant.

- ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers

In the U.S., ASHRAE issued last April, 20th, two general statements ^[12]. The first one assesses that “...*Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled...*”. The second one assesses that “... *Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus. HVAC filters, along with other strategies, help to reduce virus transmission while removing other air contaminants that may have health effects...*”

Thus, ASHRAE guidance appears to Authors more general than the REHVA one, and less oriented a maximum safety approach. It should be observed that a previous guidance issued by ASHRAE ^[18] provided more detailed operating instructions, such as increasing outdoor ventilation, disable demand-controll ventilation, improve demand-controlled ventilation and keep systems running longer hours.

5. Research development

This research will be the framework for more detailed studies about any LEED v4 BD+C prerequisites and credits. Authors, also accredited as LEED © AP ND in 2011, intend to futher develop the research with reference to the peculiarity of the LEED for Neighborhood Development, for more long-term projects.

6. Conclusions

Despite the implications on building design of COVID-19 pandemia, LEED v4 BD+C remains one of the most comprehensive reference for an environmentally sustainable design and construction of commercial buildings and neighborhoods, with very few key concepts, such as density and proximity, that it may be appropriate to debate. Also, a number of LEED metrics may have to be revised to comply with the prerequisites and credits intent, when taking into account the health issues emerged with COVID-19 pandemia.

The LEED v4 BD+C prerequisite Minimum Indoor Air Quality will be the most discussed one in the upcoming weeks, because of the need for outdoor air ventilation, in order to minimize the spread of COVID-19 in the workplaces that will reopen after lockdown.

At the moment, the approaches in the EU and US appear to be different, as emerged by a comparison of the position papers by their respective building services engineers associations REHVA and ASHRAE.

More detailed guidances about air conditioning systems design and management, ventilation and filtration could be valuable not only from an engineering perspective, but especially for health and wellbeing purposes.

Authors Contributions

Marco Capelli developed the concept for the research and wrote the paper.
Francesco Conserva carried out a critical review of the structure and content.

Conflicts of Interest

Authors declare no conflict of interest.

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