

Review Article

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Indoor Air Quality Criteria and Standards in LEED, BREEAM and HQE Green Building Rating Systems: Implications for Iran

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Abstract

Indoor air quality (IAQ) is an important component of building environmental performance because people spend much of their time indoors. Poor ventilation, emissions from construction materials, combustion by-products, and other pollutants can adversely affect occupant health and comfort. This paper compares IAQ criteria in three established green building rating systems: LEED (United States), BREEAM (United Kingdom), and HQE (France). A documentary review of publicly available technical guidance was conducted without field measurements. The criteria were organized into four themes: pollutant source control, ventilation, filtration, and pre-occupancy testing, enabling comparison despite differences in scoring approaches. LEED emphasizes performance-based requirements, including ventilation rates, combustion safety, parking-related emissions, radon, and low-emitting materials. BREEAM integrates IAQ within health and wellbeing and gives greater attention to occupant information and system operation after handover. HQE is notable for its attention to odor and its requirement for an air quality check before occupancy. The findings indicate that none of these systems can be directly applied to Iran because of its climatic diversity, ventilation regulations, and construction cost constraints. The study therefore proposes a staged framework for Iran, beginning with mandatory minimum requirements for ventilation and pollutant source control, followed by voluntary higher-performance measures. Such a framework should draw on international experience while being adapted to Iran's climatic, regulatory, and economic conditions and local building practices to improve feasibility, consistency, and long-term adoption across different building projects.

Keywords indoor air quality; green building certification; LEED; BREEAM; HQE;

1. Introduction

For a long time, air pollution was treated mainly as an outdoor, urban problem. That framing has shifted as more attention has turned to the time people actually spend in-

side buildings – homes, offices, schools, shops – where exposure can differ substantially from what outdoor monitoring stations record [1,2]. What happens indoors depends on a mix of factors: how tight the building enve-



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lope is, how the ventilation system is designed and run, what materials and furnishings are used, whether anyone smokes or cooks with poorly vented appliances, and how consistently the building is maintained.

Two broad pathways bring pollutants indoors: infiltration from outside and generation inside the space itself. Particulate matter, volatile organic compounds (VOCs), formaldehyde, combustion gases, tobacco smoke and radon are among the more commonly cited contaminants. How much of each accumulates depends not just on how fast it is emitted, but on air exchange rates, filtration, deposition on surfaces, chemical reactions in the air, and simply how the building is operated day to day [1,2]. None of this can be reduced to a single fix.

As construction has become more environmentally conscious, certification schemes have grown up around it, offering structured ways to judge a building's performance on energy use, water, materials, siting and, increasingly, indoor environmental quality [3–5]. Energy performance was historically the main focus of these schemes, but it has become clear that pushing energy efficiency without also addressing ventilation can backfire – tighter buildings trap pollutants unless mechanical ventilation is designed to compensate.

Among the certification systems in wide use internationally, BREEAM, LEED and HQE are three of the oldest and most influential [3,4], and each has shaped how later systems in other countries were designed.

Iran's building sector faces its own version of these pressures: serious outdoor air pollution in several cities, an energy-intensive building stock, wide climatic variation from the Caspian coast to the central plateau, and no single comprehensive framework for assessing indoor air quality. Ventilation and energy provisions exist in national codes, but they are not organized around IAQ as a coherent objective [6,7].

Simply importing one of the established international systems is unlikely to be the right answer. Climate, construction practice, the availability of equipment and skilled labor, cost, and the regulatory environment all differ enough from the countries where LEED, BREEAM and HQE were developed that a direct transplant risks either being unworkable or missing the problems that matter most locally. A comparison of what these three systems actually require – rather than simply how well known they are – gives a starting point for deciding what might reasonably be adapted for Iran.

This paper sets out to do that: to identify and compare the IAQ-related criteria in LEED, BREEAM and HQE, with particular attention to ventilation, source control, filtration, combustion products, chemical emissions, odor and pre-occupancy checks, and then to consider what these

comparisons suggest for building assessment practice in Iran.

2. Materials and Methods

2.1 Research design

The study is a comparative documentary review. Publicly available technical documentation for LEED, BREEAM and HQE was examined to identify and classify the criteria that relate, directly or indirectly, to indoor air quality. The three systems were chosen because of how long they have been in use, how widely they have been applied outside their countries of origin, and the relative depth of their treatment of indoor environmental quality [3–5].

Criteria touching on ventilation, filtration, pollutant source control, chemical emissions, combustion by-products, tobacco smoke, radon, parking-related pollution, odor, and IAQ measurement or verification were all included in the review.

2.2 Comparative framework

To make the three systems comparable despite their different structures, the identified criteria were sorted into ten broad categories:

1. pollutant source control
2. ventilation and outdoor air supply
3. filtration and particulate control
4. chemical pollutant emissions
5. combustion-related pollutants
6. environmental tobacco smoke
7. soil- and parking-related pollutants
8. odor control
9. IAQ measurement and verification
10. occupant health and comfort

The comparison focuses on what each requirement actually asks for rather than on converting scores from one system into another. LEED, BREEAM and HQE differ enough in scoring logic, certification procedure and terminology that a numerical comparison would be misleading.

2.3 Scope and limitations of the documentary approach

Because the analysis relies on published guidance documents, it describes what each system requires on paper, not what pollutant concentrations are actually measured in certified buildings. Where a system states a criterion, that does not by itself confirm the criterion is met consistently in practice.

3. Green Building Rating Systems: Background

BREEAM, introduced in the United Kingdom in 1990, is usually credited as the first comprehensive environmental

assessment method for buildings [3]. LEED followed in the United States, developed by the U.S. Green Building Council, and HQE emerged in France during the 1990s [4,5]. Since then, a number of other national and regional systems have appeared – CASBEE in Japan, Green Star in Australia, DGNB in Germany, Green Globes in North America, and various adaptations across the Middle East and Asia. Their categories and scoring differ, but the underlying aim across all of them is much the same: to structure environmental performance into something that can be assessed and certified.

LEED, BREEAM and HQE were selected here on the strength of their track record, their reach outside their home countries, and the comparative depth of what they say about indoor environmental quality.

4. Indoor Air Quality Criteria in LEED

LEED, the voluntary certification system run by the U.S. Green Building Council, covers a range of building and project types and has gone through several revisions. Indoor Environmental Quality (IEQ) is one of its core assessment categories, and it is where most of the requirements bearing on occupant-level air quality sit [4]. Reading through the guidance, these requirements cluster around a handful of themes.

Ventilation. LEED sets out requirements for outdoor air supply and ventilation system performance, with additional, enhanced-ventilation provisions in some project types. The underlying goal is enough outdoor air to keep

moisture and pollutants from building up.

Combustion products. Because combustion appliances can generate carbon monoxide and other gases, LEED includes requirements meant to keep those gases from reaching occupied spaces – through separation, exhaust design, or detection and control equipment.

Parking-related pollution. Attached or enclosed parking can be a source of carbon monoxide and particulates. LEED addresses the risk of these pollutants migrating into occupied areas through separation, exhaust and ventilation measures.

Radon. In locations where radon is a known risk, LEED includes measures aimed at limiting occupant exposure, since radon can enter from contaminated soil and build up where ventilation is poor.

Filtration. Mechanical filtration reduces the entry of particulates, though how well it works depends on filter grade, system design, pressure drop and how consistently filters are maintained and replaced – filtration is treated as one part of a ventilation strategy, not a standalone fix.

Tobacco smoke. Restrictions on smoking indoors, along with proper placement of outdoor air intakes relative to smoking areas, reflect a source-control logic: prevent the pollutant rather than manage it afterward.

Table 1. Major IAQ-related criteria in LEED

Criterion	Main objective
Ventilation	Adequate outdoor air supply; control of pollutant build-up
Enhanced ventilation	Outdoor air supply beyond minimum requirements
Combustion gas control	Keeping combustion pollutants out of occupied spaces
Parking-related pollution control	Limiting pollutant transfer from parking areas
Radon control	Reducing soil-related radon exposure
Air filtration	Reducing particulate matter entering via ventilation
Environmental tobacco smoke control	Preventing exposure to tobacco smoke
Zoning and air transfer control	Limiting pollutant transfer between spaces
Low-emitting materials	Reducing chemical emissions from building products

Zoning and air transfer. Pressure relationships and zoning limit the movement of pollutants from high-emission spaces into occupied areas.

Low-emitting materials. Adhesives, sealants, coatings, paints and furnishings can all off-gas VOCs and other compounds, so LEED brings source control into material selection through low-emitting product requirements.

5. Indoor Air Quality Criteria in BREEAM

BREEAM, launched by the Building Research Establishment in 1990, has grown into a broad environmental assessment framework spanning Management, Health and Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use and Ecology, Pollution, and Innovation [3]. Rather than treating IAQ as a narrow question of pollutant concentration, BREEAM places it within Health and Wellbeing, alongside ventilation, emissions, occupant information and comfort – categories that, in practice, interact with one another.

Indoor pollutants. Formaldehyde and total volatile organic compounds (TVOCs) are the chemical pollutants given explicit attention, reflecting emissions from paints, adhesives, sealants, flooring and other products.

Ventilation. Requirements cover incoming air rates as well as how ventilation systems are controlled and maintained – a design airflow figure on paper is only useful if installation, commissioning and ongoing maintenance

actually deliver it.

Cooking and combustion emissions. Cooking is a recognized source of particulates and VOCs, so BREEAM emphasizes adequate ventilation and local extraction, particularly in residential settings.

Occupant information. A distinguishing feature of BREEAM is the weight it gives to what occupants are told. IAQ outcomes depend partly on how a building is operated and used, so information about ventilation systems, pollutant sources and correct system use becomes part of the assessment itself.

6. Indoor Air Quality Criteria in HQE

HQE (Haute Qualité Environnementale), developed in France, sets environmental performance within a wider frame that includes energy, comfort and health, and has been applied to both residential and non-residential buildings [5]. Compared with LEED and BREEAM, the HQE guidance reviewed here gives noticeably more explicit attention to air quality, odor and checks carried out before a building is handed over.

Odor control. An unpleasant odor is not necessarily a sign of toxicological risk, but it does affect how occupants perceive the space, and HQE treats identification and control of odor sources – both external and from indoor activities such as cooking – as a distinct concern. In housing, this often comes down to kitchen exhaust design and where outdoor air intakes sit relative to potential odor sources.

External pollution sources. Site conditions matter: exter-

Table 2. Major IAQ-related criteria in BREEAM

Criterion	Main objective
Indoor pollutant control	Reducing exposure to chemical and other indoor pollutants
Formaldehyde control	Reducing emissions from building products
TVOC control	Reducing total volatile organic compound emissions
Ventilation	Adequate outdoor air supply
Ventilation rate	Verifying adequate air exchange
Cooking emission control	Reducing emissions generated during cooking
Ventilation control and maintenance	Sustaining ventilation performance during operation
Occupant information	Improving awareness and correct building operation

Table 3. Major IAQ-related criteria in HQE

Criterion	Main objective
External pollution source control	Identifying and reducing outdoor pollution entering the building
Odor source control	Reducing exposure to unpleasant odors
Kitchen exhaust	Controlling emissions from cooking
Ventilation design	Appropriate choice of natural or mechanical ventilation
Air exchange	Meeting specified ventilation rates
Air filtration	Reducing particulate pollutants
Ventilation effectiveness	Verifying that ventilation performs as designed
Pre-occupancy IAQ measurement	Catching IAQ problems before occupancy

nal pollution sources are meant to be identified during design and factored into how ventilation and air intakes are positioned. Where soil contamination is found, it is expected to be remediated or controlled before occupancy – prevention over reliance on indoor removal after the fact.

Ventilation. HQE addresses both natural and mechanical ventilation, covering air exchange rates, opening design, ventilation of wet rooms, filtration, and verification that the system actually performs as intended.

Pre-occupancy assessment. Perhaps the most distinctive element of the HQE approach reviewed here is its emphasis on checking indoor air quality before the building is occupied, which allows problems traceable to materials, ventilation design or pollutant sources to be caught before anyone is exposed to them.

7. Results and Discussion

7.1 What the three systems have in common

Despite their different structures, LEED, BREEAM and HQE start from the same basic premise: indoor air quality matters enough to be built into how a building's environmental performance is judged. Where they diverge is in how that premise gets turned into specific, checkable requirements.

Source control comes through most strongly across all three. LEED targets pollutant-generating materials, tobacco smoke, combustion by-products, parking emissions and radon; BREEAM concentrates on emissions from products and indoor activities; HQE frames the issue around identifying external and internal sources, including odor. This shared emphasis matters because controlling a pollutant at its source reduces how much has

to be handled afterward through ventilation or filtration – which is one reason material choice, source separation and intake placement tend to come up early in the design process rather than as an afterthought.

Ventilation is the second point of overlap. All three systems treat adequate air exchange as central to controlling pollutant concentrations, though the emphasis differs: LEED leans toward measurable performance criteria; BREEAM ties ventilation to health, comfort, maintenance and occupant information; HQE folds it into a broader air-quality-and-comfort objective.

Filtration is the third area where the systems converge, at least in principle. It is recognized as useful where outdoor air itself carries a significant particulate load, but none of the three systems treats it as a substitute for proper ventilation design or source control.

7.2 Where the systems diverge

LEED's relative strength is in measurable, performance-based requirements, which makes verification and comparison across projects easier but also demands fairly detailed technical documentation and commissioning. BREEAM's broader framing – IAQ nested inside health and wellbeing – brings in occupant information and post-handover operation in a way the other two do not emphasize as much, a reminder that a well-designed system can still underperform if it is run or maintained poorly. HQE puts more weight on perceived environmental quality, odor in particular, and on pre-occupancy verification. That focus has some logic to it: the absence of a noticeable smell does not mean pollutant concentrations are safe, but a persistent odor is often a fairly reliable sign that a source or a ventilation problem has gone unresolved. None of this points to one system being simply "better"

than the others – they reflect different starting assumptions and priorities. For practical use, drawing selectively from more than one is likely to be more useful than adopting any single system wholesale.

7.3 Source control, ventilation, filtration: a rough hierarchy

Reading the three systems together suggests a natural order of priority. Pollutant generation should be reduced first, through material choice and control of combustion and smoking. What cannot be eliminated should then be diluted or removed through ventilation. Filtration comes in as a third layer, where ventilation on its own is not sufficient.

This ordering has particular relevance for Iran, where outdoor particulate pollution is high in several cities. Simply increasing outdoor air supply without regard to outdoor air quality can end up raising indoor exposure to particulates rather than lowering it. In polluted urban settings, ventilation strategy needs to be paired with filtration and some awareness of outdoor conditions, not treated as a stand-alone solution.

7.4 What this means for Iranian buildings

Iran's building stock sits in a different set of conditions from those the three systems were designed around: sharp climatic contrasts, considerable regional variation in outdoor pollution, patterns of energy use, uneven construction quality, differences in mechanical ventilation capacity, and tighter cost margins.

The climate alone argues against a single national ventilation requirement. Humid conditions near the Caspian and arid conditions on the central plateau call for different strategies – natural ventilation may work reasonably well in some regions, while heavily polluted cities probably need mechanical ventilation paired with effective filtration.

There is also a tension between energy efficiency and IAQ that needs to be managed rather than ignored. Tighter building envelopes cut energy use, but if mechanical ventilation is not designed to compensate for reduced infiltration, pollutant concentrations can rise. The two objectives need to be treated as connected, not separate line items.

7.5 Regulatory and technical constraints

Putting any of this into practice depends on a regulatory framework that spells out minimum acceptable performance. Iranian building codes already touch on services, ventilation and energy, but they do not yet bring these together around IAQ as an integrated objective [6,7]. Cost is a real constraint. Better filtration, mechanical ven-

tilation, monitoring, low-emission materials and commissioning all add to upfront construction cost, and judging measures purely by that upfront cost overlooks the potential payoff in occupant health, lower exposure and fewer operational problems down the line.

Technical capacity is a further limiting factor. Applying these criteria in a way that means something requires designers, contractors, commissioning specialists and testing capacity able to measure and interpret IAQ parameters. Without that capacity, requirements risk staying on paper rather than shaping how buildings are actually built and run.

7.6 Toward an Iranian framework

Taken together, the comparison points toward building a framework for Iran that borrows selectively from these three systems rather than adopting any one wholesale.

A reasonable structure would set a mandatory minimum covering basic ventilation, combustion safety, tobacco smoke control, pollutant source control and acceptable indoor pollutant concentrations, with a voluntary second tier introducing enhanced filtration, low-emission materials, commissioning, and pre- and post-occupancy testing. Regional differentiation would also help – adjusting ventilation and filtration requirements by climate, outdoor pollution level, building use, occupancy density and available infrastructure, rather than applying one national standard uniformly.

Useful indicators for such a framework would likely include particulate matter, carbon monoxide, carbon dioxide (as a proxy for ventilation adequacy), formaldehyde, TVOCs, radon where relevant, temperature, relative humidity and ventilation rate – chosen on the basis of health relevance, how feasible they are to measure, and whether matching national standards already exist.

7.7 Summary comparison

Table 4. Comparative characteristics of IAQ assessment in LEED, BREEAM and HQE

Aspect	LEED	BREEAM	HQE
Primary orientation	Building performance and IEQ	Health, wellbeing and building performance	Environmental quality, health and comfort
Source control	Strong	Strong	Strong
Ventilation	Strong emphasis	Strong emphasis	Strong emphasis
Filtration	Explicit	Part of broader IAQ strategy	Part of ventilation strategy
Chemical pollutants	Low-emitting materials	Formaldehyde and TVOCs	Source identification and control
Combustion pollutants	Explicit	Addressed	Addressed via source control
Odor	Limited	Indirect	Explicit
Occupant information	Present in relevant criteria	More explicit	Present, within a broader approach
Pre-occupancy assessment	Depends on criterion	Depends on criterion	Relatively prominent
Adaptability to Iran	Needs contextualization	Needs contextualization	Needs contextualization

8. Limitations

A few limitations are worth flagging. The analysis draws on published documentation rather than on measurements taken in certified buildings, so a criterion appearing in a rating system does not confirm that the corresponding performance is actually achieved on the ground.

The three systems reviewed are also only part of the picture; CASBEE, DGNB and Green Star, among others, take their own approaches to IAQ that were not covered here.

The paper does not set out pollutant concentration thresholds specific to Iranian buildings – that would require empirical data and health-based analysis that falls outside its scope.

Finally, all three rating systems are revised periodically, so the specific wording, scoring and applicability of individual credits described here may not match the current version by the time this is read. Anyone using these systems for actual certification should check the latest official documentation.

9. Conclusions

Indoor air quality sits at the intersection of building sustainability and occupant health, and the comparison here shows that LEED, BREEAM and HQE all recognize that reducing pollutant exposure means source control, adequate ventilation and sound building design and operation working together – even though each system organizes and weights these elements differently.

LEED offers a fairly explicit, performance-based set of requirements across ventilation, filtration, combustion products, parking-related pollution, radon, tobacco smoke and low-emitting materials. BREEAM situates IAQ within a broader health and wellbeing framework, with more attention to maintenance and occupant information. HQE combines source control, ventilation, odor management and pre-occupancy verification inside a wider environmental quality framework.

For Iran, adopting any one of these systems outright would leave gaps that reflect the country's own climate, economics and regulatory setup. A more workable path is a framework built specifically around Iranian conditions, taking what these systems share in common and adapting the rest: prioritizing source control, setting minimum ventilation requirements, adding filtration where outdoor pollution warrants it, controlling emissions from materials and combustion, and introducing pre-occupancy IAQ checks for new buildings, with post-occupancy evaluation added at a later stage as capacity allows.

Energy efficiency and IAQ need to be planned together rather than separately – measures that cut energy use should not come at the cost of ventilation or higher pol-

lutant concentrations, which means integrated design, commissioning, monitoring and maintenance all have a role to play.

A staged rollout looks more realistic for Iran than trying to adopt comprehensive certification requirements all at once: setting minimum mandatory IAQ requirements, building up measurement and inspection capacity, training the people who will apply these criteria, collecting national indoor air quality data, and only then introducing higher-performance voluntary criteria.

Future work could usefully focus on measuring IAQ in a representative sample of Iranian building types, developing climate-specific ventilation and filtration requirements, weighing the costs of IAQ improvements against their benefits, and looking more closely at how indoor conditions relate to occupant health and productivity – all of which would help ground a national framework in something more than documentary comparison.

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