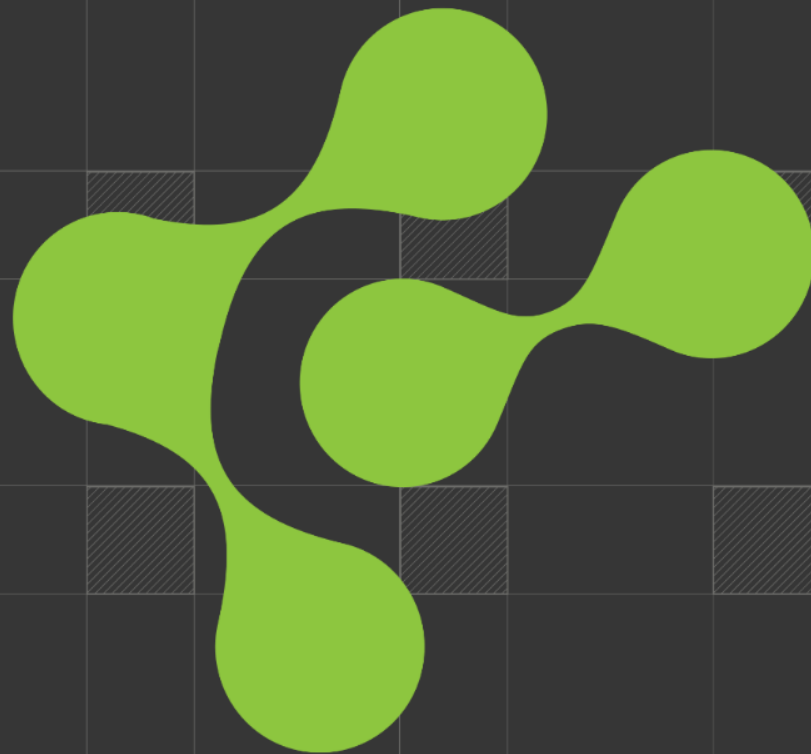


21.-23. travnja 2026. | Hotel Amadria Park, Šibenik



Industrija i država u dijalogu za
zelenu tranziciju



Kvaliteta zraka, svjetla i ugone: temelj zdravih zgrada

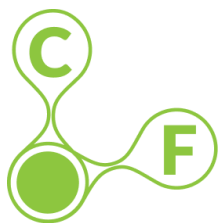
Doc.dr.sc. Vlasta Zanki

Sveučilište u Zagrebu Geotehnički fakultet
Zavod za inženjerstvo okoliša



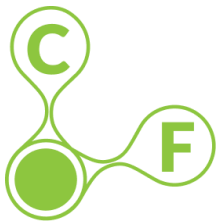
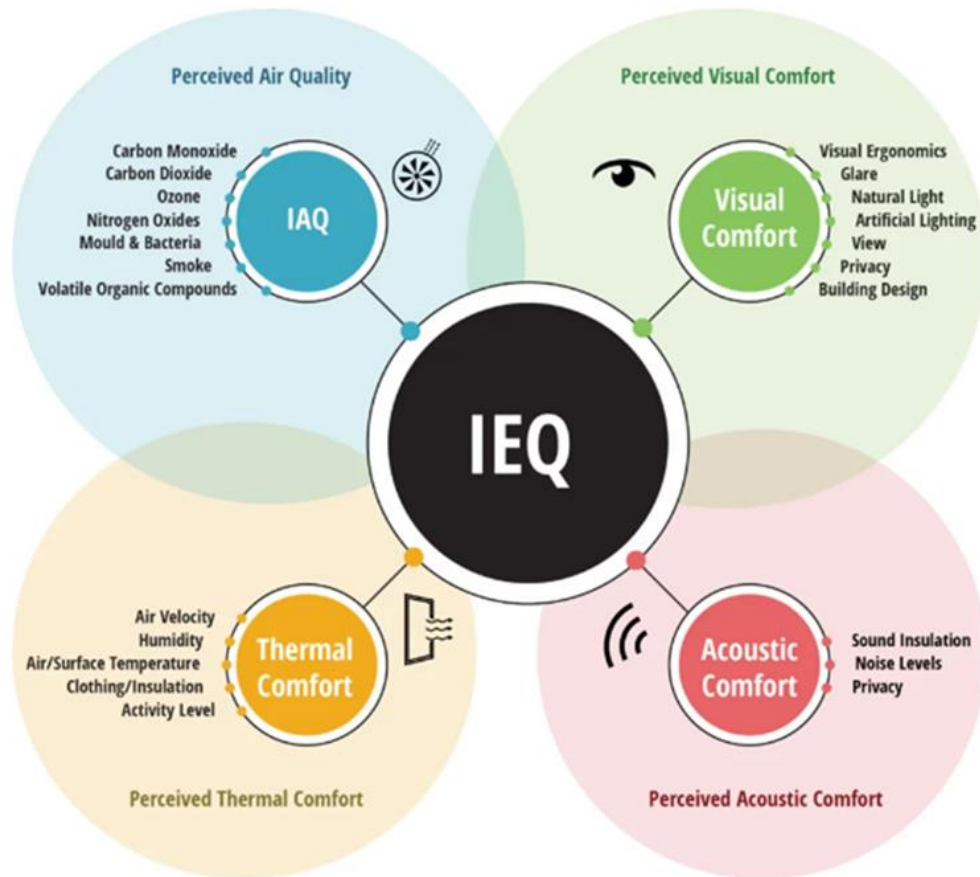


Što je zdrava zgrada?

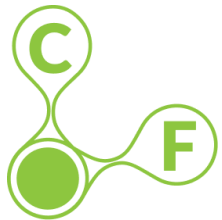


Što je IEQ (Indoor Environmental Quality)?

- IEQ = kvaliteta unutarnjeg okoliša
- Obuhvaća:
 - Toplinski ugođaj
 - Kvalitetu zraka (IAQ)
 - Vizualni komfor
 - Akustički komfor
- Utječe na:
 - zdravlje
 - produktivnost
 - osjećaj ugone



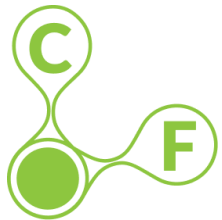
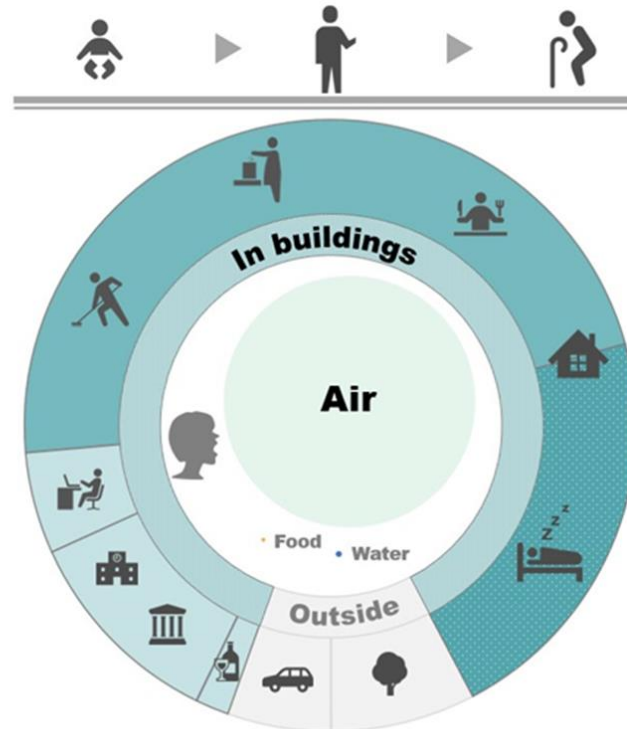
Koliko vremena provodimo u zgradama?



<https://www.buildinggreen.com/blog/we-spend-90-our-time-indoors-says-who>

Zašto je IEQ danas aktualna tema?

... >85% time is spent in buildings



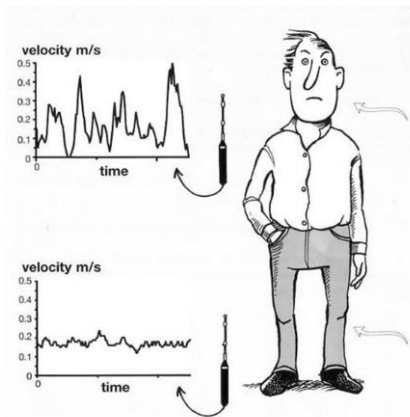
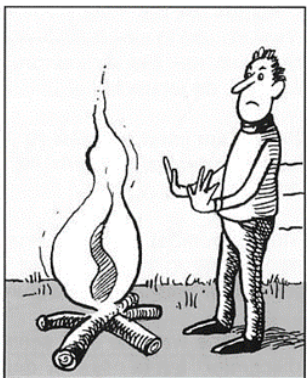
Source: Klepeis et al. (2011)

Toplinska ugodnost

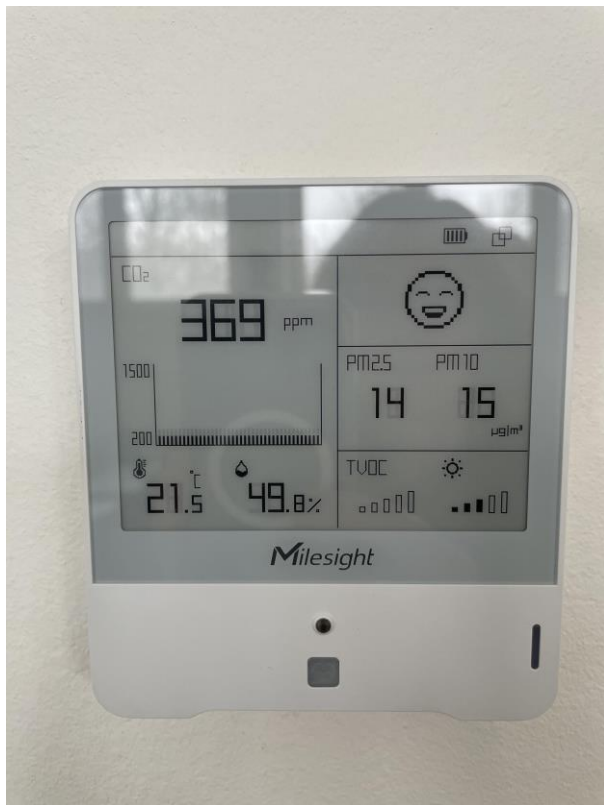
Toplinska ugodnost ima glavnu ulogu u shvaćanju ugođaja

Faktori koji utječu na toplinski ugodnost su:

- Temperatura i zračenje
- Relativna vlažnosti
- Brzina zraka i turbulencije
- Odjeća
- Drugi osobni parametri
- Percepcija toplinskog ugođaja
- Operativna i rezultirajuća temperatura



Kakva nam je kvaliteta unutarnjeg zraka?



Jesmo li svjesni utjecaja zgrada na zdravlje čovjeka?

SICK BUILDING SYNDROME

TOP CAUSES THAT MAKE YOU FEEL ILL

BAD HUMIDITY

Avoid excessive dampness or dryness.



TEMPERATURE

Stay away from rooms too hot or too cold.

VENTILATION

Provide adequate ventilation.



LIGHTING

Make sure light is not too bright nor too scarce.

POLLUTANTS

Prevent airborne particles or chemicals build up.



CLEANLINESS

Maintain good cleaning standards.

WHAT ARE THE SYMPTOMS?

ASTHMA

HEADACHE

FEVER

LACK OF FOCUS

NAUSEA

RASHES

DIZZINESS

COUGH

WHAT CAN BE DONE?



IMPROVE VENTILATION

Both opening windows or using fans.



HVAC MAINTENANCE

Including regular replacement of filters.



IAQ MONITORING

Using IAQ monitors to always know if there's a problem.



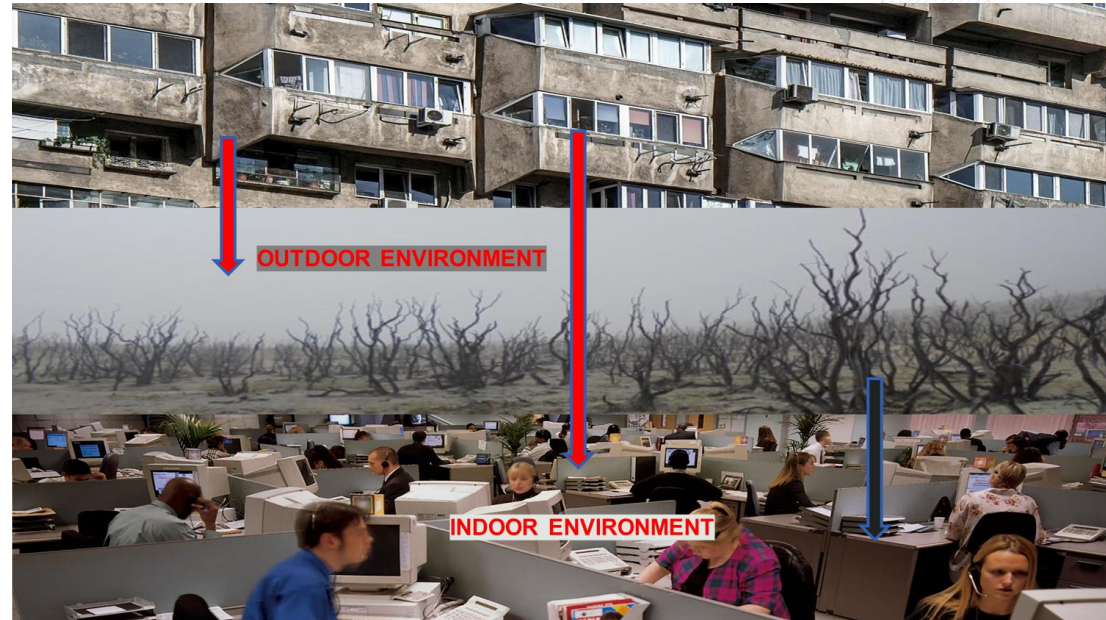
AVOID CONTAMINANTS

Spray cleaners and solvents, paints, molds or many building materials.

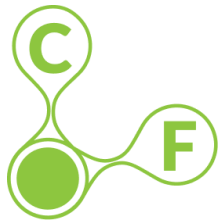


Gradovi rastu, vrijeme u zatvorenom raste — IEQ postaje pitanje zdravlja

- Oko 56 % svjetske populacije (4,4 milijarde ljudi) živi u gradovima
- Gradovi čine dvije trećine globalne potrošnje energije i odgovorni su za više od 70 % emisija stakleničkih plinova
- Više od 80 % globalnog BDP-a generira se u gradovima
- Zgrade sudjeluju s približno 40 % u ukupnoj svjetskoj potrošnji energije i 36 % u emisijama CO₂



- Kako urbanizacija raste, a ljudi sve više vremena provode u zatvorenim prostorima, kvaliteta unutarnjeg okoliša (IEQ) postaje presudan faktor koji utječe na zdravlje, produktivnost i kvalitetu života.



Europe's air quality status 2024

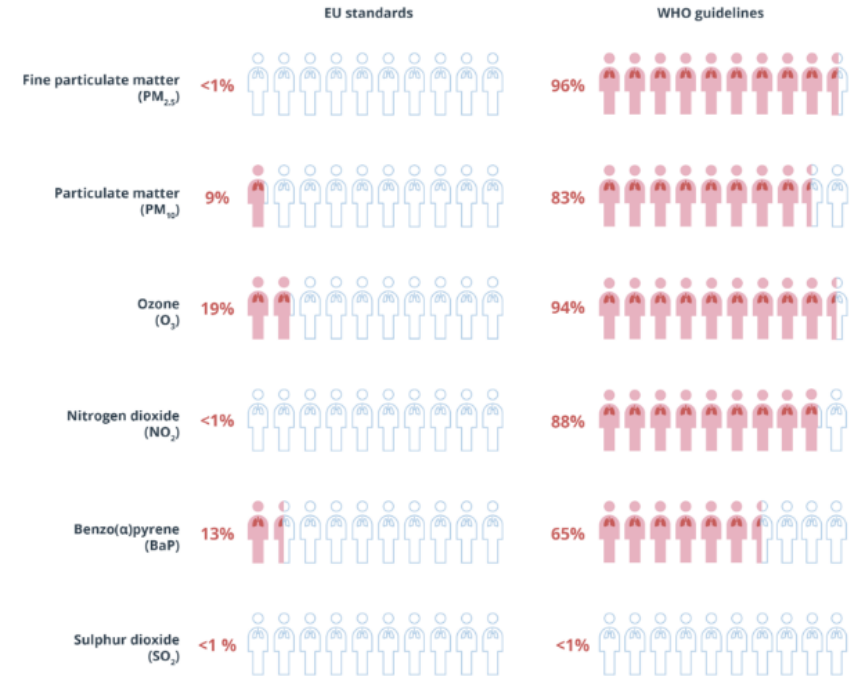
Key messages

- Despite ongoing overall improvements in air quality, current EU standards are still not met across Europe.
- **96% of the EU's urban population is exposed to unsafe concentrations of fine particulate matter (PM_{2.5}).**
- The new EU air quality standards introduced in the revised ambient air quality directive — proposed to come into force in 2030 — are more ambitious than the current ones.



Italy's northern Lombardy region imposed severe antismog measures in February. - AP Photo/Luca Bruno

Figure 1. Share of the EU urban population exposed to air pollutant concentrations above certain EU standards and WHO guidelines in 2022



<https://www.eea.europa.eu/publications/europes-air-quality-status-2024>

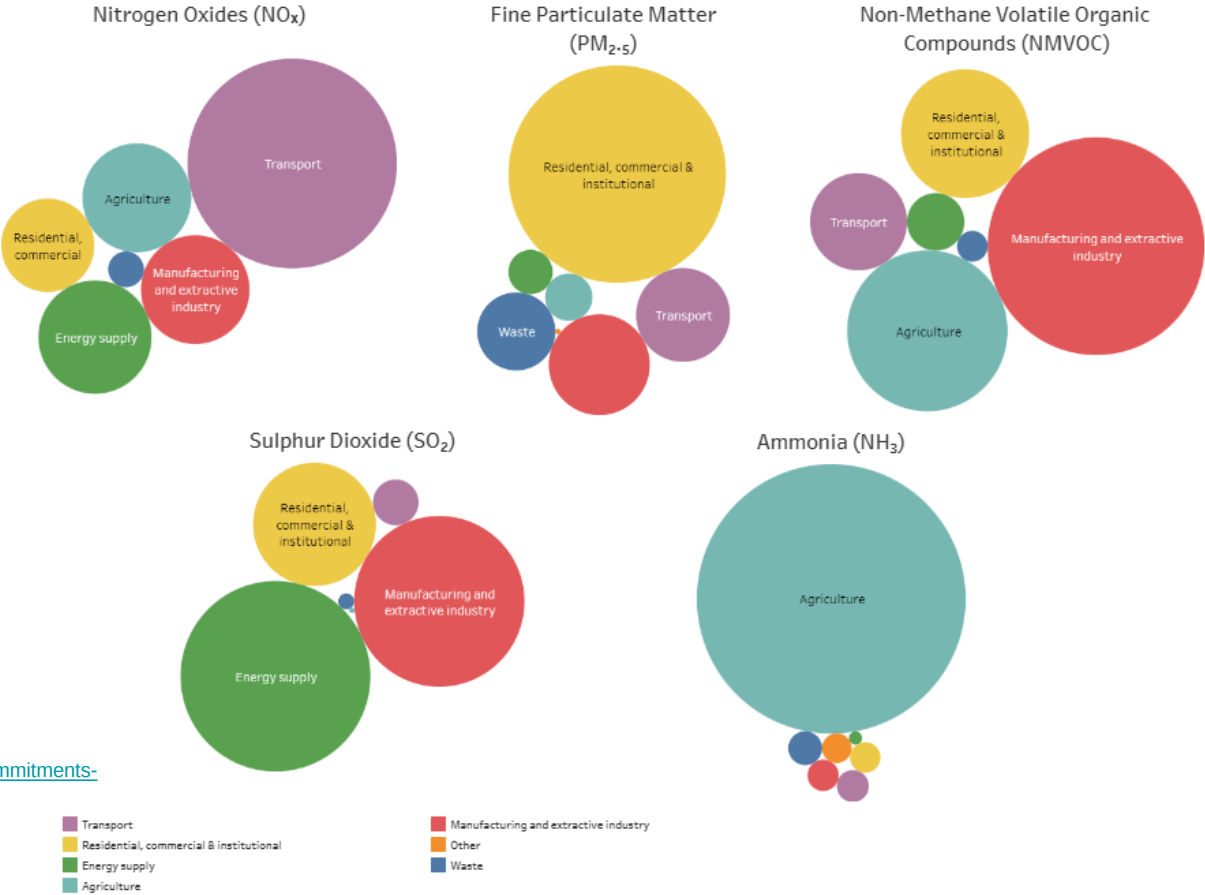
<https://www.euronews.com/green/2024/03/13/europes-air-quality-has-improved-but-still-doesnt-meet-who-guidelines-study-says>

Contributing sectors and activities to the five regulated air pollutant emissions in EU Member States

Figure 3. Contributing sectors and activities to the five regulated air pollutant emissions in EU Member States

Residential, commercial and institutional sector contribution:

- NOx – 9,62%
- SO₂ – 18,3%
- PM_{2,5} – 61,72%
- NMVOC – 15,98%
- NH₃ – 1,2%



Contributing sectors and activities to the wider group of air pollutant emissions in EU Member States

Residential, commercial and institutional sector contribution:

- BaP – 91,3%
- Black Carbon (BC) – 35,99%
- CO – 43,44%
- PM10 – 43,02%

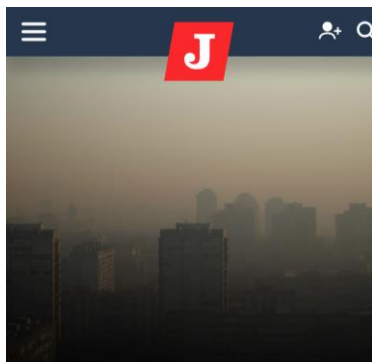
<https://www.eea.europa.eu/publications/national-emission-reduction-commitments-directive-2024>

Figure 4. Contributing sectors and activities to the wider group of air pollutant emissions in EU Member States



Zagađenje zraka i troškovi javnog zdravstva

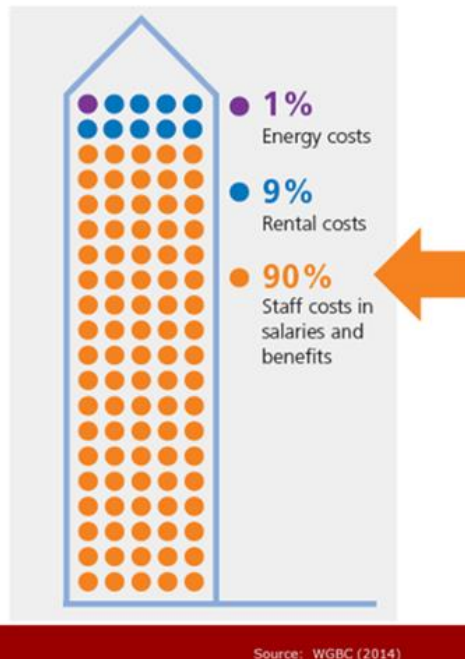
- Zagađenje zraka uzrokuje oko 300.000 prijevremenih smrti godišnje u EU (prema European Environment Agency)
- Procijenjeni troškovi za zdravstvo i gospodarstvo iznose **stotine milijardi eura godišnje**
- Prema World Health Organization, troškovi povezani s bolestima uzrokovanim zagađenjem zraka u Europi procjenjuju se na oko **600+ milijardi € godišnje** (uključujući zdravstvene troškove i gubitak produktivnosti)
- Zagađenje zraka povećava troškove zbog:
 - hospitalizacija
 - liječenja kroničnih bolesti
 - bolovanja i smanjene produktivnosti
- **Zagađenje zraka nije samo ekološki, već i ozbiljan ekonomski i zdravstveni problem**



ALARMANTNI PODACI

Prešli smo crvenu liniju: Izvješće o kvaliteti zraka u Zagrebu otkriva opasnu pojavu, najgore u tri kvarta

Piše: Krešimir Antunović
Objavljeno: 19. travnja 2026. 12:16



Dekarbonizacija zgrada ne smije ugroziti IEQ



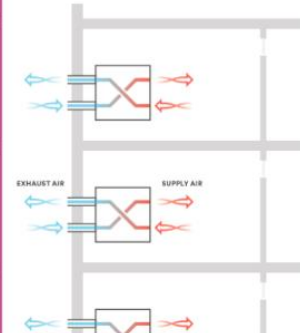
centralized

Centralized ERV systems serve the entire building. ERV units are typically located on the roof, with ducts exhausting spent air from the building interior and replacing it with fresh air.



decentralized

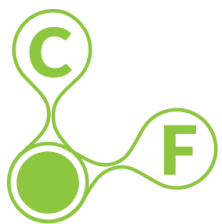
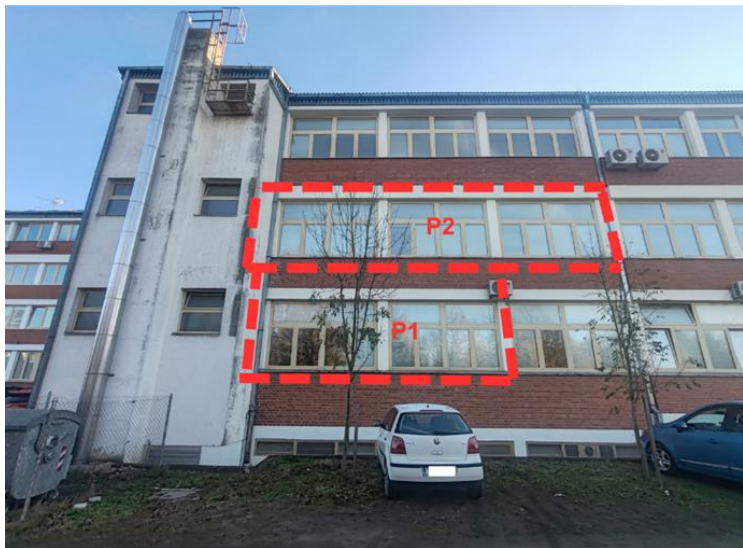
Decentralized ERV systems serve specific areas of the building, generally floor-by-floor or room-by-room.



Example of a balanced centralized system vs. a decentralized system. Centralized systems serve the entire building, with mechanical units typically located on the roof. Decentralized or unitized systems serve specific areas of the building, typically on a floor-by-floor or unit-by-unit basis.

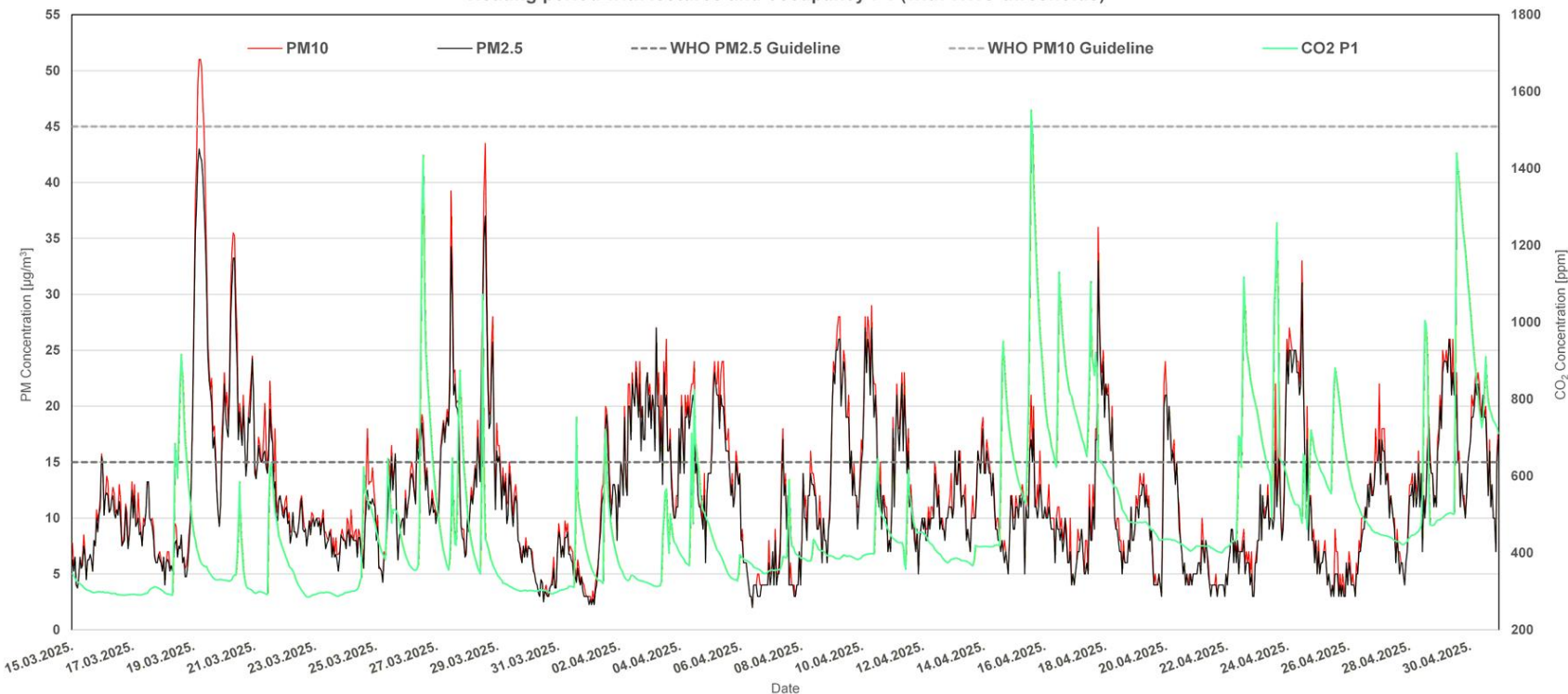
<https://be-exchange.org/report/better-ventilation-playbook/>

„Living lab” na Geotehničkom fakultetu



Mjerenja stanja unutarnjeg zraka u „Living lab” na GFV

Heating period with lectures and occupancy P1 (with WHO thresholds)

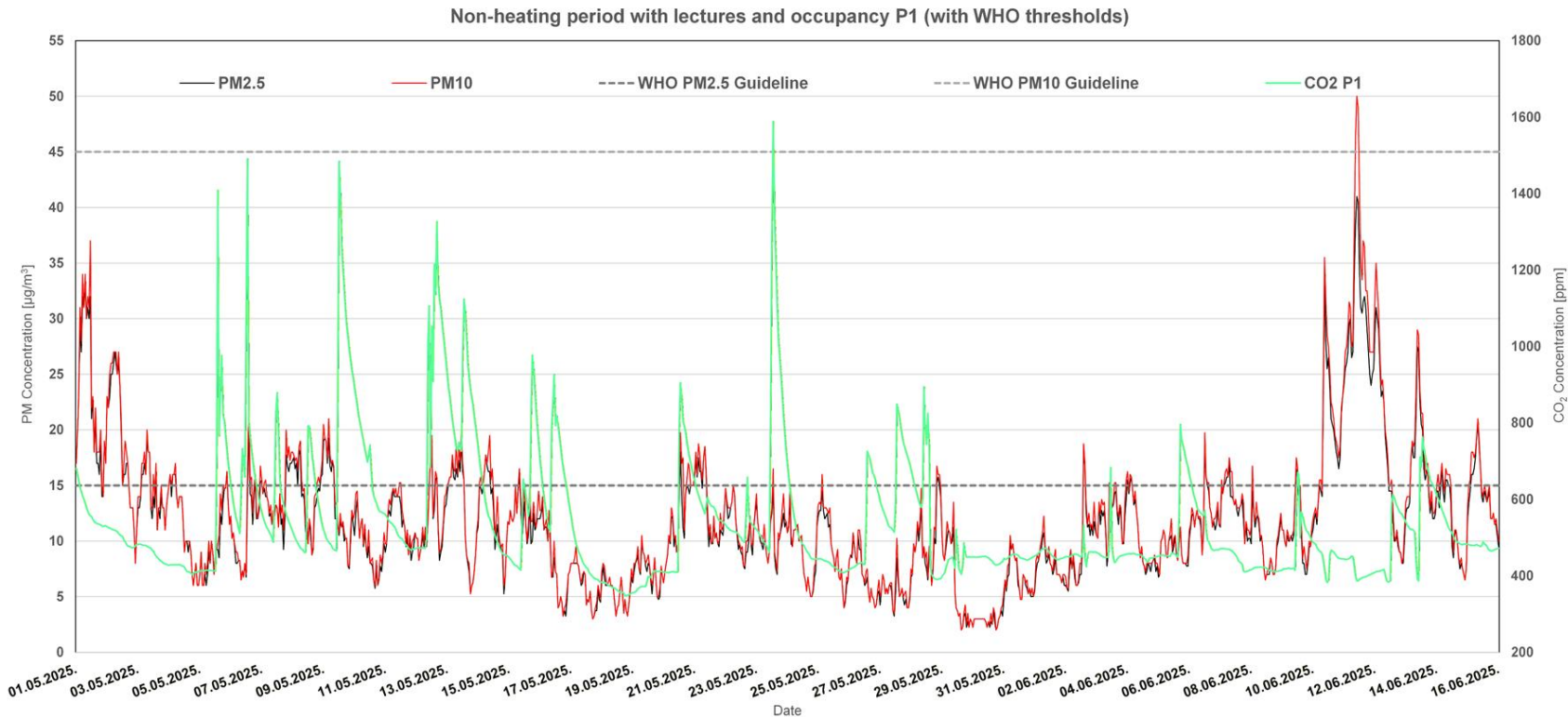


- Usporedba s WHO PMx pragovima: PM10 = 45 $\mu\text{g}/\text{m}^3$ i PM2.5 = 15 $\mu\text{g}/\text{m}^3$

Environmental effects on indoor air quality and data-driven natural ventilation strategies for advanced energy management: Evidence from a classroom living-lab study; Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, Volume 48, Issue 1 <https://www.tandfonline.com/eprint/EATCCXNNV6HKDND9TIZ/full?target=10.1080/15567036.2026.2652471>



Mjerenja stanja unutarnjeg zraka u „Living lab” na GFV

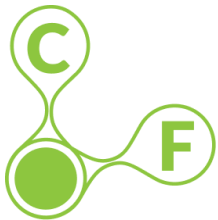


- Usporedba s WHO PMx pragovima: PM10 = $45 \mu\text{g}/\text{m}^3$ i PM2.5 = $15 \mu\text{g}/\text{m}^3$

Environmental effects on indoor air quality and data-driven natural ventilation strategies for advanced energy management: Evidence from a classroom living-lab study; Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, Volume 48, Issue 1 <https://www.tandfonline.com/eprint/EATCCXNNV6HKDND9TIZ/full?target=10.1080/15567036.2026.2652471>



Regulatorni okvir i alati za dekarbonizaciju zgrada i poboljšanja uvjeta unutarnjeg okoliša i zdravlja ljudi



EPBD 2024 i IEQ

- Iskorak u odnosu na dosadašnju direktivu → smanjenje klimatskih promjena kroz prilagodbu zadržavanja vanjskih i unutarnjih uvjeta
- HVAC → kvaliteta unutarnjeg okoliša
- *„kvaliteta unutarnjeg okoliša” znači skup parametara povezanih sa zgradom, uključujući kvalitetu zraka u zatvorenom prostoru, toplinsku ugodnost, osvjetljenje i akustiku, a koji utječu na zdravlje i dobrobit korisnika zgrade*
- Uključeno u cijelu direktivu kao ključni cilj
- Država članica mora uključiti zahtjeve za svoje tehničke instalacije, uključujući kontrolu i mjerenje kvalitete unutarnjeg okoliša, počevši od svibnja 2026.
- EPC mora uključivati preporuke za poboljšanje IEQ
- Nacionalni plan obnove može uključivati politike i mjere za poboljšanje kvalitete unutarnjeg okoliša.



EU taxonomy law - Sustainable finance taxonomy - Regulation (EU) 2020/852

Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088

AT A GLANCE

The EU Taxonomy is a tool to help investors, companies, issuers and project promoters navigate the transition to a low-carbon, resilient and resource-efficient economy.

The Taxonomy sets performance thresholds (referred to as 'technical screening criteria') for economic activities which:

- make a substantive contribution to one of six environmental objectives (Figure 1);
- do no significant harm (DNSH) to the other five, where relevant;
- meet minimum safeguards (e.g., OECD Guidelines on Multinational Enterprises and the UN Guiding Principles on Business and Human Rights).

The performance thresholds will help companies, project promoters and issuers access green financing to improve their environmental performance, as well as helping to identify which activities are already environmentally friendly. In doing so, it will help to grow low-carbon sectors and decarbonise high-carbon ones.

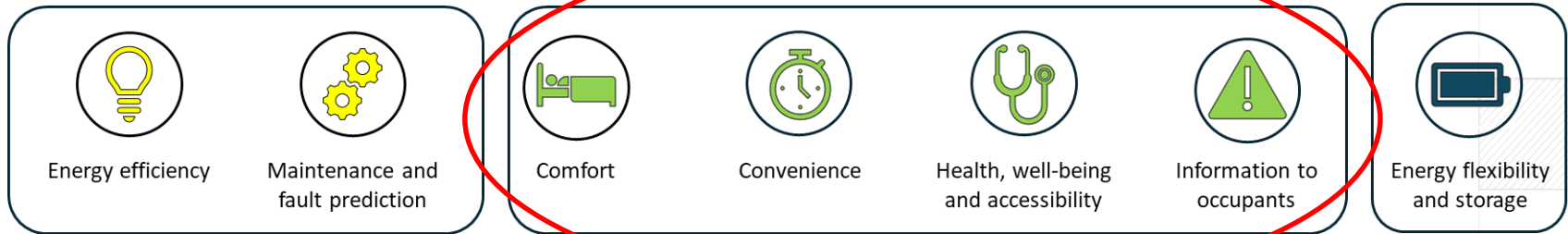
The EU Taxonomy is one of the most significant developments in sustainable finance and will have wide ranging implications for investors and issuers working in the EU, and beyond.



https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

Smart Readiness Indicator - SRI

- Seven impact criteria:



Optimise energy efficiency and overall in-use performance

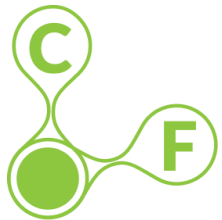


Adapt their operation to the needs of the occupant

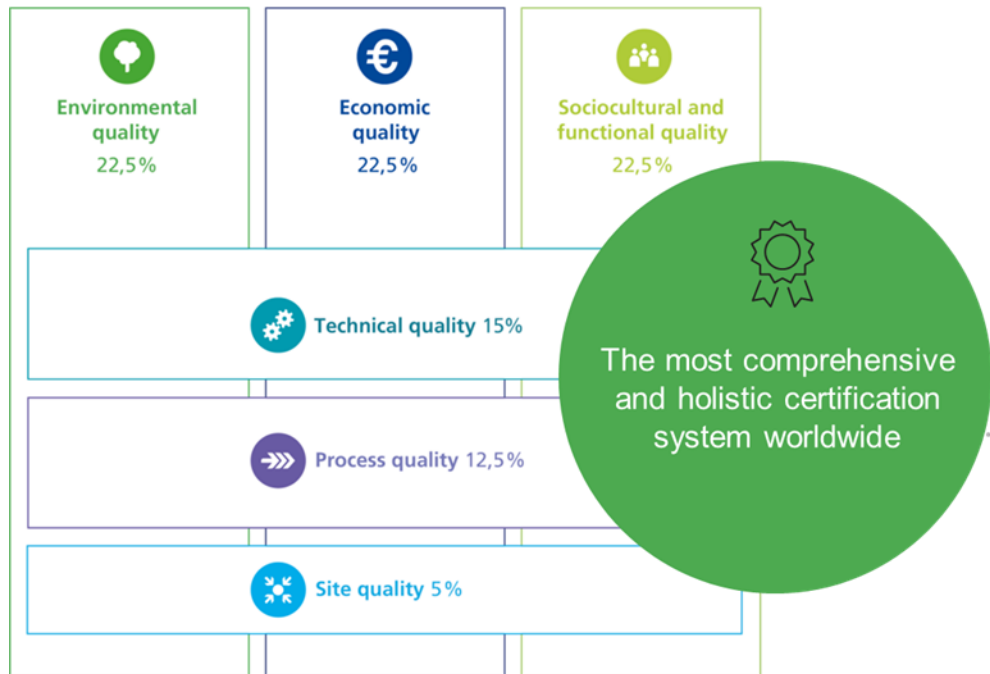


Adapt to signals from the grid (energy flexibility)

Three key functionalities:



DGNB sustav certificiranja za zelene zgrade



> **Optimization tool:** to increase real sustainability in buildings and districts

Profitability: low life cycle costs, flexibility and usability, commercial viability and long-term value retention
> **Investment oriented**

EU standards and legislations are the basis of the DGNB Certification System
> **Planning oriented**

> Internationally recognized and applied in more than 40 countries
Quality - Made in Germany



DGNB kriteriji za IEQ



Sociokulturna i funkcionalna kvaliteta

QUALITY	CRITERIA GROUP	CRITERIA NAME	WEIGHTING FACTOR	SHARE OF TOTAL SCORE
SOCIOCULTURAL AND FUNCTIONAL QUALITY (SOC)	HEALTH COMFORT AND USER SATISFACTION (SOC1)	SOC1.1 Thermal comfort	4	4.1%
		SOC1.2 Indoor air quality	5	5.1%
		SOC1.3 Acoustic comfort	2	2.0%
		SOC1.4 Visual comfort	3	3.1%
		SOC1.5 User control	2	2.0%
		SOC1.6 Quality of indoor and outdoor spaces	2	2.0%
		SOC1.7 Safety and security	1	1.0%
	FUNCTIONALITY (ENV2)	SOC2.1 Design for all	3	3.1%

Što svaka zgrada mora ispuniti: DGNB minimalni kriteriji

1. Indoor Air Quality

Measurement of TVOC levels according to criterion SOC1.2

Evidence of real, clearly defined measurements

2. Design for All

Minimum requirements according to criteria SOC2.1 are fulfilled

3. Fire Safety

The building complies with current legal requirements and approval procedure, including fire protection.

SOC1.2

Indoor air quality



Objective

Our aim is to ensure that indoor air is of sufficient quality not to adversely affect users' health and well-being.

Benefits

Nowadays humans spend up to 90 percent of their time in closed rooms. The indoor air quality therefore plays a significant role concerning performance and health. Ensuring high air quality in rooms by using low-emission products and providing an adequate air exchange rate increases users' well-being, productivity and satisfaction.

Contribution to overriding sustainability goals



Significant

CONTRIBUTION TO SUSTAINABLE DEVELOPMENT
GOALS (SDGS) OF UNITED NATIONS (UN)

CONTRIBUTION TO THE GERMAN
SUSTAINABILITY STRATEGY

3.4 Reduction of premature death,
promotion of good health/well-being
3.9 Effects of chemicals, air, water and soil
contamination
12.4 Environmentally friendly handling of
chemicals and waste

3.1.a/b Health and food
3.2.a Air pollution



Hvala na pozornosti!