ASHRAE Hellenic Chapter

ΤΕΕ

ENERGY IN BUILDINGS

EMEA 2024

Europe, the Middle East & Africa

FRIDAY - SATURDAY

NOVEMBER 22-23, 2024

@ 9:00-18:00

@ ATHENS GREECE

SESSIONS:

- SUSTAINABILITY
- HEALTH & SAFETY
- DECARBONIZATION
- TECHNICAL SOLUTIONS
- DIGITAL ENVIRONMENT
- POLICIES & LEGISLATION
- ENERGY EFFICIENCY FIRST
- RESILIENCE TO CLIMATE CRISIS

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Innovative Approaches to Optimizing Indoor Environmental Quality

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Outline/Agenda

- Introduction
- Standards for IAQ
- ENVIRA - Construction of the measuring station: sensors, their sensitivity and platform
- ENVIRA - Measurement of indoor environment quality parameters in real conditions and processing of the results
- Development of an intelligent platform for the quality of the indoor environment on the "cloud"
- Conclusions

Introduction

EU building stock

24 billion m2 floor area, around **74 % residential**

85 % of existing EU dwellings were **built before 2000**

Around **186 million** residential units are **permanently inhabited**

75 % has **poor energy performance**, of which ...

Only **11 %** of existing buildings undergo some level of **renovation** each year

... more than **85 %** will still be in place in **2050**

European Commission

Introduction - Key new elements of the revised EPBD relating to HVAC sector

According to ASHRAE Standard 62.1, *acceptable indoor air quality has "air in which there are no known contaminants at harmful concentrations, as determined by cognizant authorities, and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction".*

'**Zero-Emission Building' (ZEB)** is introduced as a new definition, replacing Nearly-Zero Energy Building (NZEB) as the standard from 2030 onwards for new buildings or those undergoing deep renovation.

A ZEB, in the current Commission proposal, is a building with a very high energy performance and where any energy needs are covered by renewable sources generated on-site and **they will need to have IAQ monitoring devices installed.**

Article 11: Technical building systems

- MS shall require the **installation of IAQ monitoring devices** in new zero emission buildings and where technically & economically feasible, in existing buildings undergoing deep renovation as well.

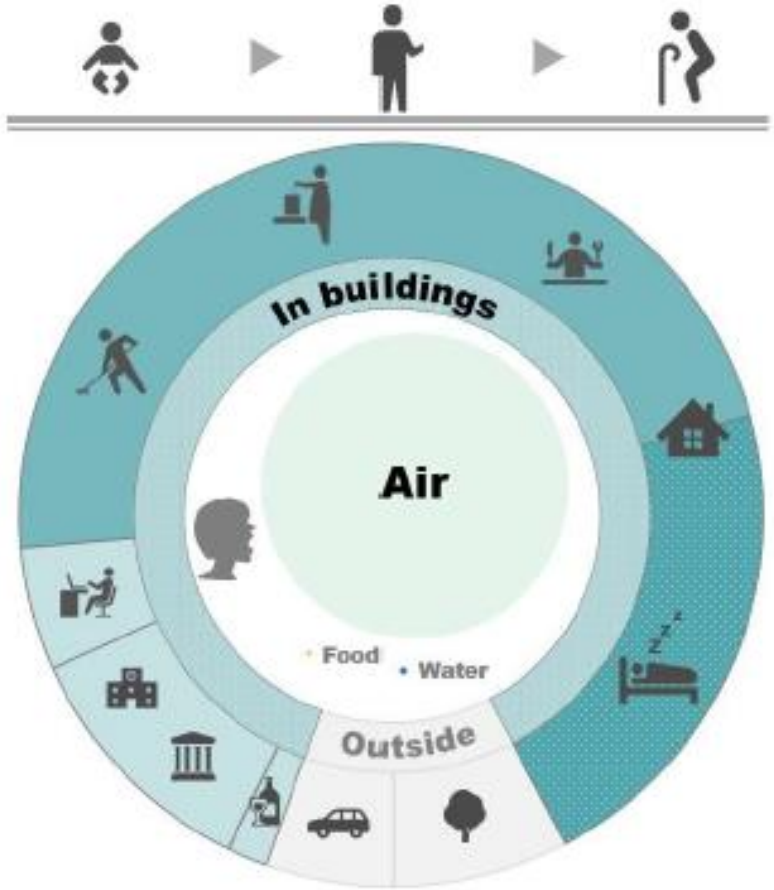
Introduction - Current human habitat are buildings

The ”Da-building”code

(>85% time is spent in buildings):

- 79 years (average life time, male EU)
- 69 years (in buildings)
- 54 years (at home)
- 26 years (sleeping)
- 4.3 years (commute)
- 6 years (outdoor air)

We inhale 13 kg of air daily much more than we eat and drink

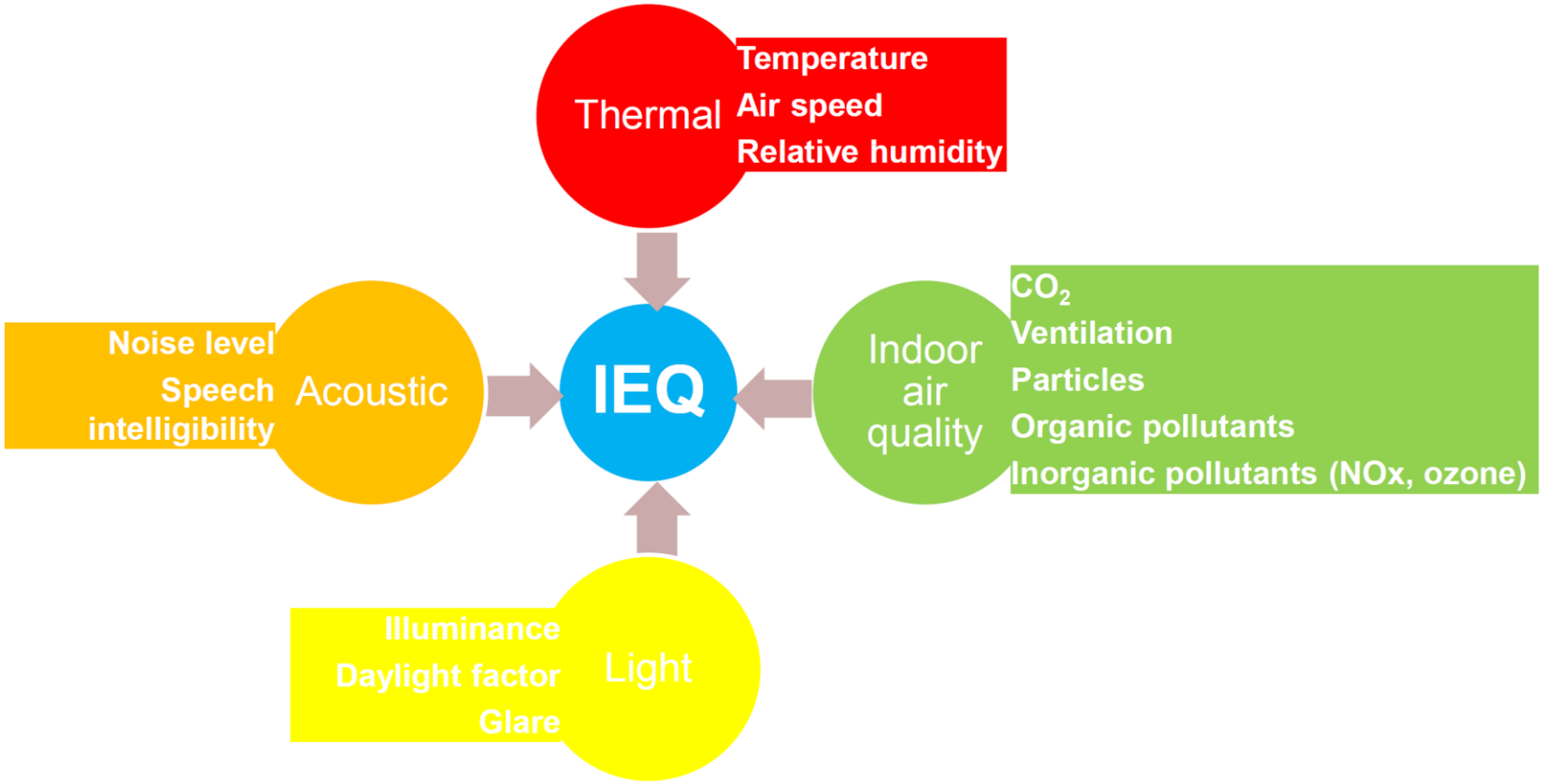


Source: Klepeis et al. (2011)

Introduction – main goal for buildings

- **Buildings are for people** - they must follow sustainability principles in any activity and decision process during their design, construction, operation and maintenance (*Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs*)
- **Buildings must ensure conditions** that do not create the risks for health and promote health and healthy behaviors of their occupants
- **Buildings must be climate neutral** by minimizing their carbon footprint when constructed, retrofitted and operated

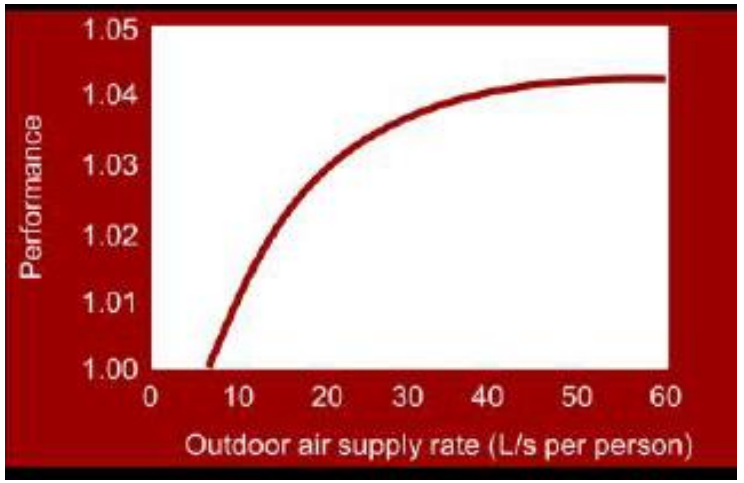
Introduction – IEQ definition



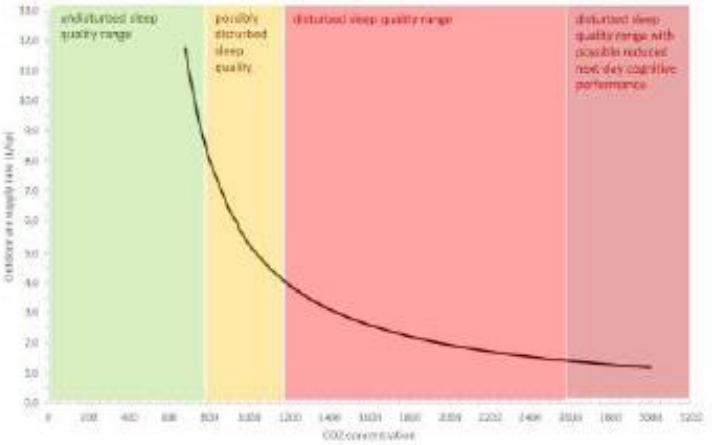
Indoor environmental quality (IEQ) can be broadly categorized as a multitude of indoor environmental components: thermal comfort, indoor air quality (IAQ), acoustics, visual comfort, interior layout, biophilia, building's location, and connection to services, etc.

Introduction – main effects of IEQ

- Reduced comfort and well-being – reduced quality of life
- Increased prevalence of acute non-clinical health symptoms (e.g., headache)
- Reduced work performance, expected loss is at least up to 5%
- Increased absenteeism and presenteeism
- Reduced learning of children, expected loss of up to 10-15%
- Disturbed sleep, poor sleep quality => reduced health, cognitive performance



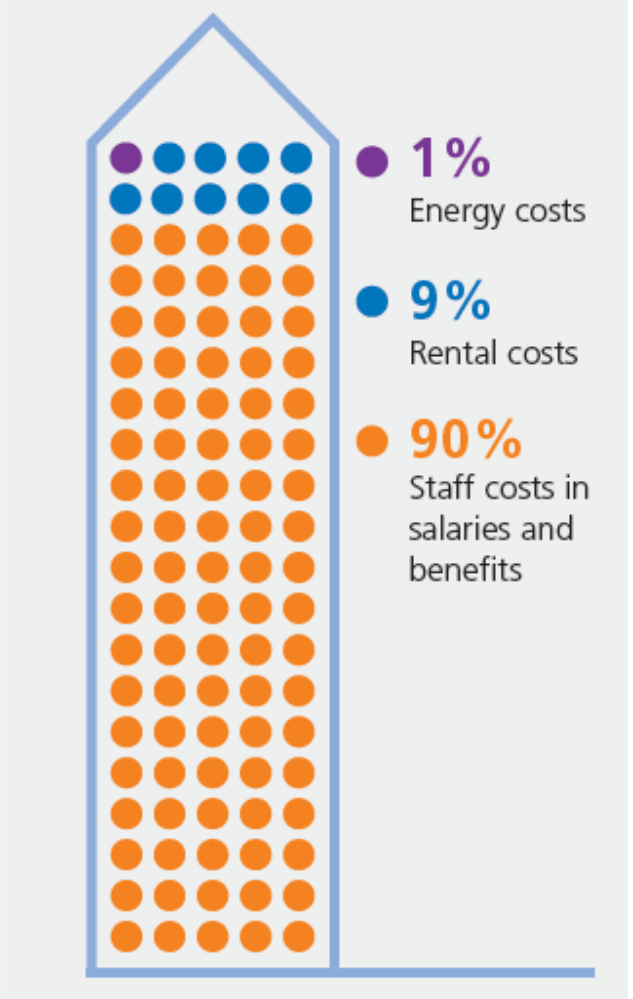
Source: Seppanen et al. (2006)



Source: Sekhar et al. (2020)

Introduction – economic implications

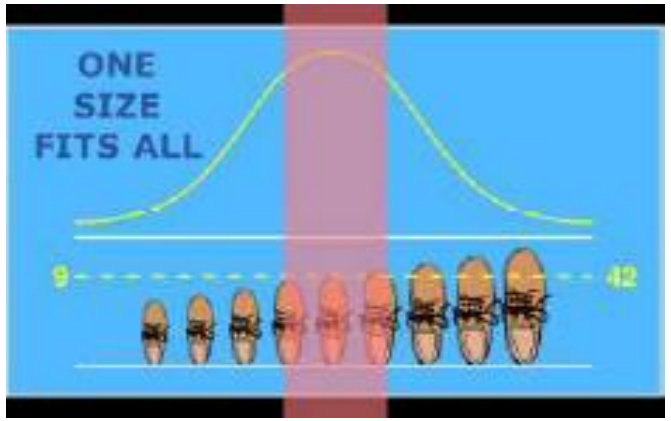
- Modest gains in work performance can deliver significant financial benefits – even 1% increase in productivity is cost-effective
- Pay-back times are usually <1 (max. 2) years
- Crude estimate: Too short sleep (<7 hours) causes 3.7- 6 working days lost per year
- Exposure in buildings estimated in EU to cause >2 mil. healthy-life years lost due to poor IAQ (ca.€200 billion annually)
- This effects is comparable with, e.g. road traffic injuries, cost similar to GDP of Cyprus
- 200 million in Europe live with allergies, asthma…



Source: WGBC (2014)

Standards for IAQ

- They are not sufficiently ambitious
- Address needs for an average person
- Neglecting individual preferences and differences
- Comfort (satisfaction) main design criteria
- Do not address combined effects
- Only risk reduction
- No strive for an innovation



<u>Standards should ensure:</u>

1. Resilience
2. Flexibility
3. Diversity
4. Preferences
5. Monitoring/ Compliance Education
6. Promote health and well-being

IAQ - The main unsafe exposures

- Carbon monoxide
- Nitrogen dioxide
- Benzene
- Formaldehyde
- Naphthalene
- Trichloroethylene
- Tetrachloroethylene
- Polycyclic aromatic hydrocarbons (PAHs)
- Radon
- PM2.5
- PM10
- Sulphur dioxide
- Ozone
- Infectious agents (airborne pathogens)

We must agree on and select pollutants for monitoring

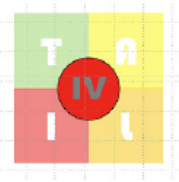
- Carbon dioxide (CO_2)
- Ventilation rate

- Nitrogen dioxide (NO_2)
- Benzene
- PM2.5
- Formaldehyde (HCHO)
- Radon
- Ozone

WHO Air Quality Guidelines

- Ozone (chemical transformations and harmful by-products)

ALDREN TAIL index (Wargocki et al., 2019).

TAIL index	Component quality	Overall quality	Parameters	
	Green – high quality Yellow – medium quality Orange – moderate quality Red – low quality	I – high quality II – medium quality III – moderate quality IV – low quality	Temperature Sound level Vent. rate CO_2 $PM_{2.5}$ Benzene	Formaldehyde Radon Relative humidity Visible mold Illuminance Daylighting

Standards for IAQ

Parameters affecting indoor air quality and their maximum allowed tolerances for human recognized in different World regions.

Parameter		Region																	
		USA						EUROPE						CHINA			JAPAN		
temperature of air	LIMIT	22.5–26 °C in summer						22–27 °C in summer						22–28 °C in summer			17–28 °C		
		20.0–23.5 °C in winter						20–23 °C in winter						16–24 °C in winter					
	REFERENCE	ANSI/ASHRAE						WHO						AQSIQ			MHLW		
relative humidity	LIMIT	40–60% in summer						25–45%						40–80% in summer			40–70% as 8–h		
		30–60% in winter												30–60% in winter					
	REFERENCE	ANSI/ASHRAE						WHO						AQSIQ			MHLW		
air flow	LIMIT	0.25 m/s						0.25 m/s						0.3 m/s in summer			0.5 m/s		
														0.2 m/s in winter					
	REFERENCE	WHO						WHO						AQSIQ			MHLW		
ventilation (external air)	Recommended according to the space or number of occupants depending on the type and purpose of the facility.																		
carbon dioxide	LIMIT	8h	outdoor ambient					1h	8h	24h				24h			24h		
		5000 ppm	<700 ppm (1800 mg/m3) above					10 000 ppm	5000 ppm	1000 ppm				1000 ppm			1000 ppm		
	REFERENCE	ASHRAE/ACGIH						WHO/MAK						AQSIQ			MHLW		
carbon monoxide	LIMIT	1h	8h	max				30 min	8h					1h			1h	24h	
		35 ppm	9 ppm	200 ppm				60 ppm	30 ppm					10 mg/m3			20 ppm	10 ppm	
	REFERENCE	ASHRAE/OSHA/EPA						WHO/MAK/HSC						AQSIQ			MHLW		
formaldehyde	LIMIT	30 min	1h	8h				5 min	30 min	8h				1h			5h		
		0.081 ppm	76 ppb	27 ppb				1 ppm	0.081 ppm	0.3 ppm				0.08 ppm			0.08 ppm		
	REFERENCE	ASHRAE/OSHA/EPA						WHO/MAK/HSC						AQSIQ			MHLW		
nitrogen dioxide	LIMIT	15 min	1h	1 yr				1h	1yr					1h	1yr		No current consensus		
		5 ppm	3 ppm	0.05 ppm				0.1 ppm	0.02 ppm					240 µg/m3	80 µg/m3				
	REFERENCE	AGGIH/NAAQS/EPA						WHO/MAK						AQSIQ, SEPA					
ozone	LIMIT	1h	8h					8h	max					1h			No current consensus		
		0.1 ppm	0.05 ppm					0.064 ppm	0.05 ppm					0.16 mg/m3					
	REFERENCE	ASHRAE/OSHA/EPA						WHO						AQSIQ					
sulfur dioxide	LIMIT	8h	1yr					1h	24h	1yr				1h			No current consensus		
		2 ppm	80 µg/m3					0.133 ppm	0.048 ppm	0.012 ppm				0.5 mg/m3					
	REFERENCE	ASHRAE/OSHA/EPA						WHO/MAK						SEPA					
total volatile organic compounds	LIMIT	No current consensus						8h						8h			No current consensus		
								300 µg/m3						0.6 mg/m3					
	REFERENCE							UK						AQSIQ					
paniculate matter less than 2.5 µm in size	LIMIT	8h	24h	1yr				24h	1yr					No current consensus			No current consensus		
		3 mg/m3	35 µg/m3	15 µg/m3				25 µg/m3	10 µg/m3										
	REFERENCE	ASHRAE/OSHA/EPA						WHO											
particulate matter less than 10 µm		8h	24h	1yr				8h	24h	1yr				24h			No current consensus		
		10 mg/m3	150 µg/m3	50 µg/m3				4 mg/m3	50 µg/m3	20 µg/m3				0.15 mg/m3					
		ASHRAE/ACGIH/EPA						WHO/MAK						AQSIQ					
total suspended particles	LIMIT	8h						No current consensus						No current consensus			No current consensus		
		15 µg/m3																	
	REFERENCE	OSHA																	
extremely fine particles <1.0 microns	LIMIT	No current consensus						No current consensus						No current consensus			No current consensus		
	REFERENCE																		

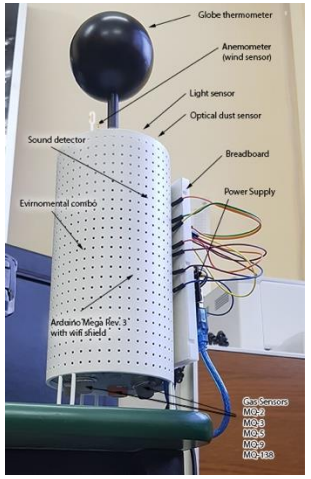
ENVIRA - Construction of the measuring station: sensors, their sensitivity and platform

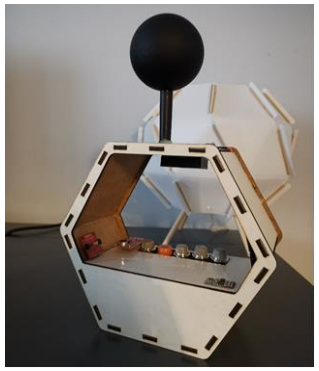
CURRENTLY, THERE ARE NO LOW BUDGET IEQ MONITORS AVAILABLE ON THE MARKET!

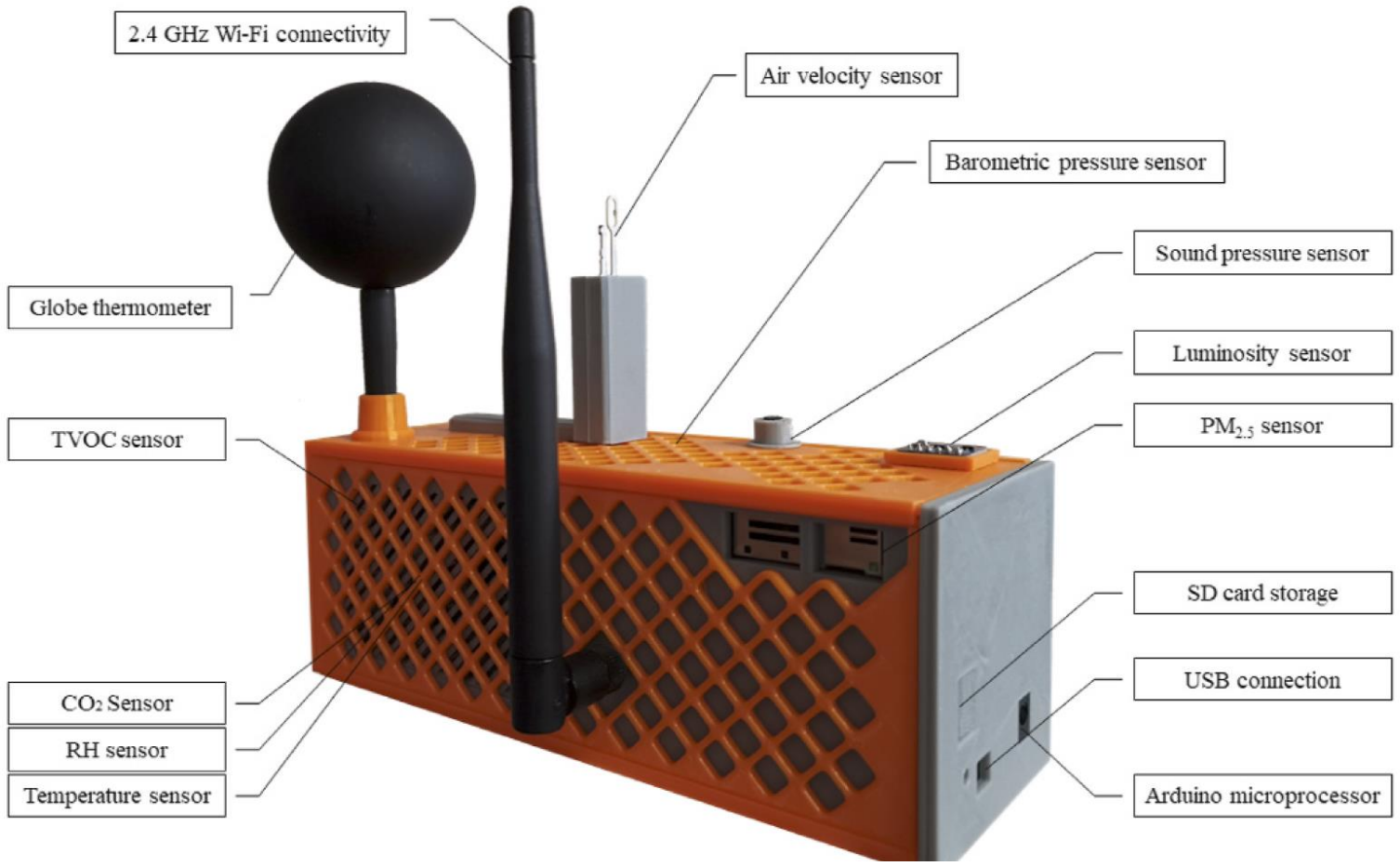
Commercially available low-cost IEQ sensing units.

Name			SAMBA	SERINUS	IEQ Chek	True Blue IEQ	Sensedge	IAMS	IEQ fixed system	Omni	Awair 2nd Edition
Organization			The University of Sydney	Serinus Technology	Bacharach	Bapi	Kaiterra	IOT Factory	LSI LASTEM	Awair	Awair
measuring capabilities	thermal comfort	Air temperature	□	□	□	□	□	□	□	□	□
		radiant temperature	□	□					□		
		airspeed	□	□					□		
		relative humidity	□	□	□	□	□	□	□	□	□
	indoor air quality	CO_2	□	□	□	□	□	□		□	□
		CO	□	□	□	□					
		NO_x			□	□					
		O_3			□						
		particulate matter	□	□	□		□			□	□
		Formaldehyde	□	□		□					
		TVOC	□	□	□	□	□			□	□
	lighting	horizontal illuminance	□	□				□			
	acoustics	sound pressure level	□	□							

ENVIRA - Construction of the measuring station: sensors, their sensitivity and platform







ENVIRA - Construction of the measuring station: sensors, their sensitivity and platform

ENVIRA sensor overview, measurement range, calibration accuracy and calibration instrumentation.

IEQ parameter	Company	Model	Range	Calibrated[a] accuracy	R^2	Reference instrument
Globe temperature	–	NTC Thermistor	−40 to 100 °C	±0.3 °C (10–35 °C)	0.99	Testo 480, K type thermocouple
Dry Bulb temperature	Sensirion	SCD30	−40 to 70 °C	±0.3 °C (10–35 °C)	0.99	Testo 435, Hot-Wire Anemometer
Relative humidity	Sensirion	SCD30	0–100%	±2%	0.98	LI-COR LI-850 HOBO logger MX1102
Air velocity	Modern device	Rev. P	0–10 m/s	±5%	0.97	Testo 435, Hot-Wire Anemometer
Carbon dioxide	Sensirion	SCD30	400 to 10,000 ppm	±30 ppm ±3%	0.98	LI-COR LI-850
TVOC	Sensirion	SGP30	0 to 60,000 ppb	–	[b]	GrayWolf AdvancedSense Pro - IQ-610
$PM_{2.5}$	Sensirion	SPS30	0 to 1000 μg/m^3	–	[b]	GRIMM - Model 1371 (miniWRAS)
Sound pressure	DFROBOT	SKU:SEN0232	30 to 130 dBA	±1.5 dB	0.99	UNI-T UT352
Illuminance	Adafruit	TSL2561	0.1 to 40,000 lux	±3 lux	0.99	Testo Lux probe
Barometric pressure	Bosch	BME280	300 to 1100 hPa	±3 hPa	0.99	Testo 511

[a] Accuracy evaluated after the initial 30-min warm-up of the unit sensors.

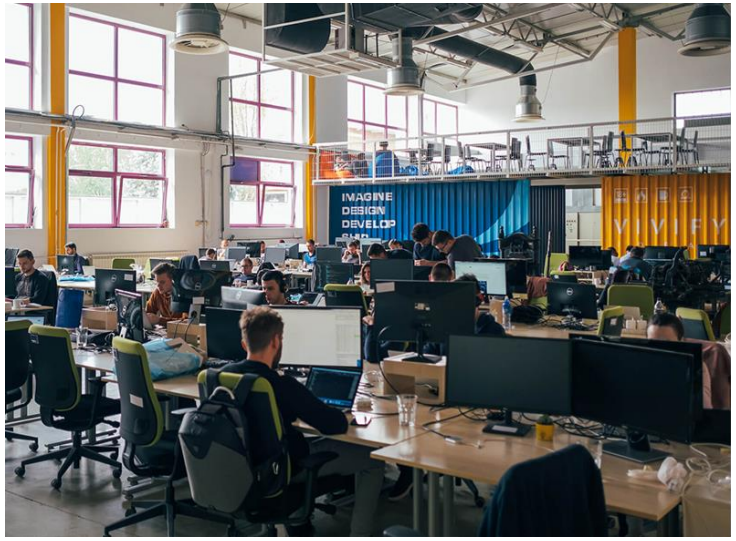
[b] No calibration accuracy is given as it can be significantly influenced by an air pollution source (Demanega et al., 2021).

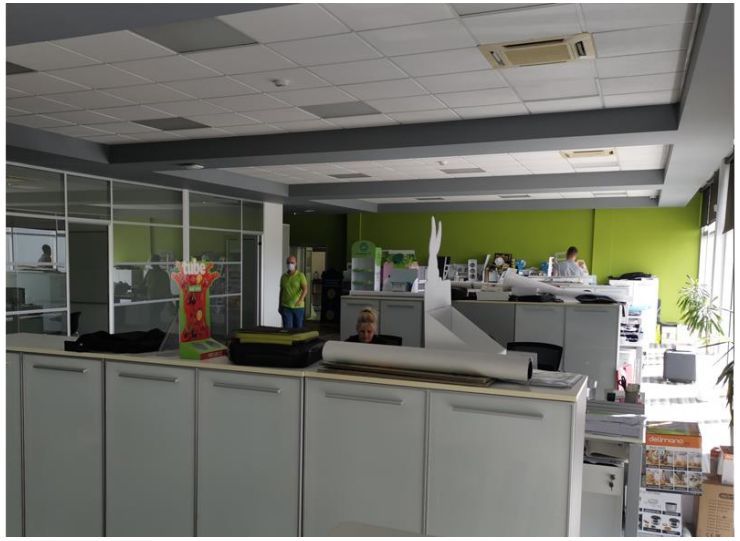
Мерна станица	Малоп. цена		Темп.	Рел. влажност	PM опсег	PM концентрација	TVOC	CO_2
AirVisual Pro	$269	Oncer	-10 – 40 °C	0 – 95%	0,3 – 2,5 μm	-	-	400 - 10.000 ppm
		Сензор	Sensirion SHT30		AirVisualM25b		-	SenseAir S8
Awair 2nd Edition	$199	Oncer	-40 – 125 °C ± 0,2 °C	0 – 100% ±2%	0,3 – 2,5 μm	0 – 1.000 μg/m^3 ±15 μg/m^3 или ±15%	0-60.000 ppb ±10%	0 - 60.000 ppm ± 10%
		Сензор	Sensirion SHT30		Honeywell HPMA115S0-XXX		Sensirion SGP30	Amphenol Telaire T6703-5K
Clarity Node[c]	$1000	Oncer	15 – 45; ±1 °C	30 - 85, ±5%	0,3 - 10 μm	0 – 1.000 μg/m^3 ±10 μg/m^3 или ±10%	-	-
		Сензор	Није специфиц.	Није специфиц.	Plantower PMS 6003		-	-
Foobot	$199	Oncer	15 – 45 °C ± 1 °C	30 - 85% ± 5%	0,3 – 2,5 μm	0 – 1.300 μg/m^3 ±20%	±10%	на основу TVOC
		Сензор	Sensirion SHT20		SHARP GPY1010AU0F		iAQ-Core C	iAQ-Core C
Kaiterra Laser Egg + CO2	$199	Oncer	20 – 60 °C ± 8%	0 - 100% ± 8%	0,3 – 2,5 μm	1 – 999 μg/m^3 ±8%	-	400 – 5.000 ppm ±8%
		Сензор	Sensirion SHT30		Plantower PMS 3003		-	SenseAir S8
uHoo	$329	Oncer	-40 – 85 °C ± 0,5 °C	0 - 100% ± 3%	0,3 – 2,5 μm	0 - 200 μg/m^3 ±15 μg/m^3 или ±10%	0-1.200 ppb ±10 ppb или ±5%	400 - 10.000 ppm ±50 ppm или ±3%
		Сензор	Bosch BME280		Shinyei ppd42		CSS811	ELT T110
Netatmo inside	$165	Oncer	0 – 50 °C ±0,3 °C	0 - 100% ±3%	-	-	-	0 - 5.000 ppm ±5%
		Сензор	Sensirion SHT20		-	-	-	MH-Z14 NDIR CO2 Module
Netatmo outside		Oncer	-40 – 65 °C ±0,3 °C	0 - 100% ±3%	-	-	-	-
		Сензор	Sensirion SHT20		-	-	-	-

ENVIRA - Construction of the measuring station: sensors, their sensitivity and platform

GRIMM - Модел 1371		Гасни анализатор LI-COR LI-850		Testo 435 са Testo анемометром са топлом жицом (Ø 7,5 mm)	
Мерени параметар	PM_{10}, $PM_{2,5}$, и PM_1 према EN 481	Мерни опсег за CO_2	0 до 20.000 ppm	Опсег мерења температура	-20 до +70°C
Маса прашине	0,1 µg/m³ - 100 mg/m³	Прецизност	у 1,5% мерења	Грешка	±0,2°C
Распон величина честица	10 nm - 35 µm	Релативна влажност	0% - 100%	Опсег мерења брзине ваздуха	0 до +20 m/s
Број кошева	41 укупно	Грешка	± 2% (20 - 80 %)	Грешка	±(0,03 m/s + 5% од мерене вредности)
GrayWolf AdvancedSense Pro - IQ-610		**Aeroqual Photoionization Detector**		**Testo 435 са глобус термометром Ø 150 mm, термопар тип K**	
Опсег VOC	0,02 -20 ppm Резолуција 1 ppb, LOD <5 ppb	Распон VOC	0 - 20 ppm	Опсег мерења температура	0 до +120 °C
		Грешка фабричке калибрације	<±0,2 ppm + 10%	Класа тачности	1
Testo 545 Lux сонда		**UNI-T UT352**		**Testo 51**	
Опсег мерења	Од 0 до +100.000 lx	Опсег мерења	30 - 130 dB	Опсег мерења	300 од 1.200 hPa
Класа тачности	Ц	Грешка	± 1,5 dB	Грешка	±3 hPa

ENVIRA - Measurement of indoor environment quality parameters in real conditions and processing of the results






In order to be able to calculate the index I_IEQ, a combination of field measurements and surveys of facility users was applied. Three facilities were selected for case studies:

1. two business buildings with open-plan offices and
2. one educational institution - the amphitheater of the Faculty of Technical Sciences.

ENVIRA - Measurement of indoor environment quality parameters in real conditions and processing of the results

Field measurements, selection of facilities and survey of users

Упитник о квалитету унутрашње средине

Обавезно прочитати пре попуњавања упитника

Овај упитник има за циљ да пружи оцену утицаја параметара унутрашње средине на перцепцију корисника објекта о квалитету унутрашње средине. На квалитет унутрашње средине примарно утичу:

- термички комфор
- квалитет унутрашњег ваздуха
- ниво осветљења
- бука

Обрадом резултата упитника, стећи ће се дубље сазнања о повезаности ових фактора и њиховог утицаја перцепцију корисника објекта о квалитету унутрашње средине. Први део упитника се бави искључиво тренутном оценом горе поменутих фактора при специфичном сезонском режиму рада Система - Грејана сезона (Новембар - Април), сезона хлађења (Мај - Октобар). У другом делу упитника су постављена питања у вези са полом старосном доби и здравственим проблемима који могу утицати на перцепцију квалитета унутрашње средине.

1 2 3 4 5

- Упитник је потпуно анониман
- Одговоре треба давати субјективно,
- Када је у питању дата скала, поставите "X" на било ком месту на скали од 1 до 5. *Пример*

1 2 3 ✖ 4 5

Питање 1 - Тачно време је ____:____

Питање 2 - Унутрашње окружење
Да ли је квалитет унутрашње средине прихватљив за Вас ТРЕНУТНО?
(заокружите један од понуђених одговора)

ЈЕСТЕ **НИЈЕ**

Питање 3 - Унутрашње окружење
Како би тренутно по Вашем мишљењу оценили квалитет унутрашње средине ТРЕНУТНО?
(поставите "x" било где на скали)

1 2 3 4 5

Питање 4 - термички комфор
Како би оценили ваш тренутни термички осећај на вашем радном месту ТРЕНУТНО
(заокружите један од понуђених одговора тј. бројева)

ВЕОМА ХЛАДНО	ХЛАДНО	ПРОХЛАДНО	НЕУТРАЛНО	МАЛО ТОПЛИЈЕ	ТОПЛО	ВРУЋЕ
-3	-2	-1	0	+1	+2	+3

Питање 5 - Ниво контроле унутрашње средине
Колико сте задовољни нивоом контроле параметара термичког комфора на вашем радном месту ТРЕНУТНО.
То, на пример, подразумева подешавање термостата, сенчење прозора завесама, паљење и гашење вентилације, употреба локалне грејалице, могућност отварања и затварања прозора, итд.

Сасвим Незадовољан/на | Мало Незадовољан/на | Мало Задовољан/на | Сасвим Задовољан/на

Питање 6 - Бука тј. акустика
Како ТРЕНУТНО перципирате позадинске нивое буке у вашем радном окружењу?
(поставите "x" било где на скали)

1 2 3 4 5

Неприхватљиво Прихватљиво

Питање 7 - Бука тј. акустика
Како би описали позадинске нивое буке у вашем радном окружењу ТРЕНУТНО?

1 2 3 4 5

Веома тихо Веома бучно

Питање 8 - Осветљење
Како ТРЕНУТНО перципирате ниво осветљења у вашем радном окружењу?
(поставите "x" било где на скали)

1 2 3 4 5

Неприхватљиво Прихватљиво

Питање 9 - Осветљење
Како би описали јачину осветљења коју имате на вашој радној површини ТРЕНУТНО?
(поставите "x" било где на скали)

Питање 10 - Квалитет унутрашњег ваздуха
Како ТРЕНУТНО перципирате квалитет ваздуха у вашем радном окружењу?
(поставите "x" било где на скали)

1 2 3 4 5

Неприхватљиво Прихватљиво

Питање 11 - Квалитет унутрашњег ваздуха
Како би описали нивое загађења на вашем радном окружењу које перципирате ТРЕНУТНО?
(поставите "x" било где на скали)

1 2 3 4 5

Неосетно загађење Висок ниво загађења

Питање 12 - Да ли имате ТРЕНУТНО неки од симптома
(поставите "x" било где на скали)

Зачепљен нос		**Потпуно чист нос**
Сув нос		**Цурење из носа**
Сува уста		**Влажна уста**
Суво грло		**Влажно грло**

Питање 13 - локални фактори који утичу на нелагоду
(маркирајте "x" у кућицу поред тврдње)

- **„промаја" - струјање топлог или хладног ваздуха** ☐
- **хладни подови** ☐
- **хладна опрема за рад** ☐
- **различит осећај температуре од „главе до пете"** ☐
- **нелагода услед зрачења топлоте…радијатори, машине, хладни зидови…** ☐

Питање 14 - Пол

Молим вас закружите ваш пол: мушки / женски

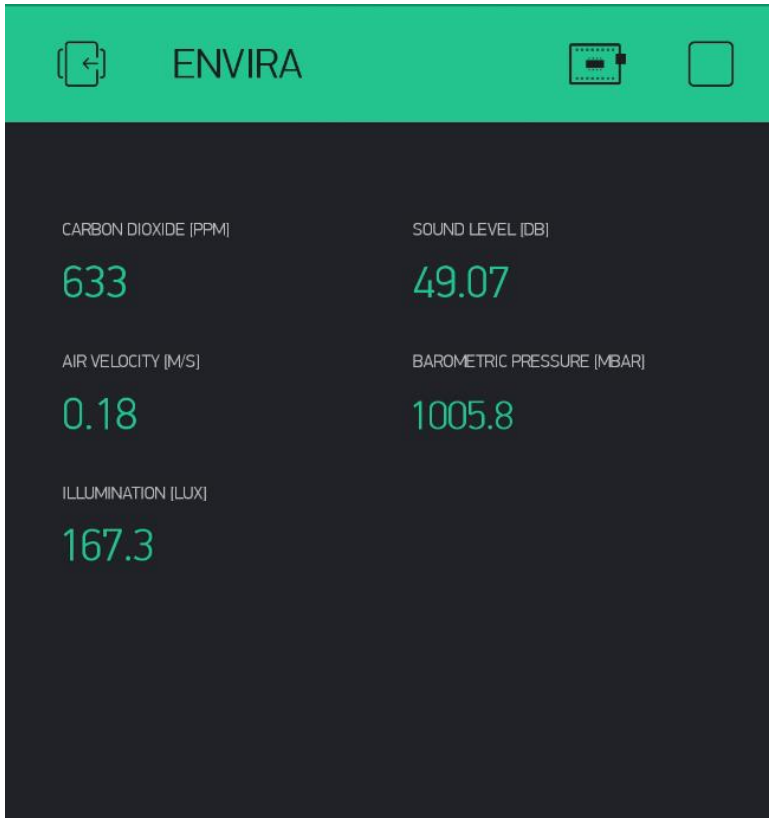
Питање 15 - Молим вас да маркирате „x" поред ваше старосне групе

18 - 25	☐
26 - 35	☐
36 - 45	☐
45 - 55	☐
+ 55	☐

ENVIRA - Measurement of indoor environment quality parameters in real conditions and processing of the results

In this study, the research methodology for the development of a low-cost continuous IEQ sensing platform "ENVIRA" was presented, followed by its deployment in three case study buildings (two offices and one educational building). Through a combination of continuous measurements of individual IEQ parameters (thermal comfort, indoor air quality, lighting, and acoustics) and survey-based occupant IEQ perceptions data, this study provides new results of the importance of the individual parameters used to assess overall IEQ performance. Total of 125 occupants participated in the field studies – 69 in two open offices and 56 in the educational building. The results from occupant survey regression analysis show that occupants had similar preferences in office-type buildings. When the results are averaged for both buildings, indoor air quality is observed as the most critical environmental parameter with the weight of 0.35 followed by thermal comfort (0.285) acoustics (0.195), and illumination (0.17). The preference of occupants differed in the educational building where thermal comfort was seen as most important (0.31) followed by indoor air quality and acoustics equally (0.25), and lighting as the least important (0.19). Calculated overall IEQ index and occupant perception results showed good agreement with mean absolute error of <3%. At present, some green building certification programs assume equal importance among the four IEQ categories. Further research is needed to understand the weight of individual IEQ components, especially in relation to different building typologies.

Development of an intelligent platform for the quality of the indoor environment on the "cloud"



In the near future, the ENVIRA platform will be adapted to use the Zigbee network, which is currently favored in the building management system (BMS) industry. Thus, the platform will be capable of BMS integration.
Furthermore, the platform will be developed to support multiple devices in parallel operation mode and data monitoring that will enable complex spatio-temporal analyses.

Conclusion

Healthy buildings => create healthy environment for occupants

- A healthy building should not compromise the basic human requirements of every building occupant and foster high quality of life, good health, optimal physical and mental activity, and sleep quality
- IEQ in buildings is crucial part in efforts achieving to secure public health and sustainability.
- Decarbonization of buildings should not compromise IEQ, because consequences can be costly.
- Monitoring IEQ in all buildings should be mandated as a benchmark, to provide information on performance (compliance), to improve and advance methods for IEQ control, and last but not least to inform the public.

We must think of clean air as we think of clean water and fresh food. Here we do not compromise, nor should we do so with the indoor climate

ASHRAE Hellenic Chapter

ΤΕΕ

ENERGY IN BUILDINGS

EMEA 2024

Europe, the Middle East & Africa

FRIDAY - SATURDAY

NOVEMBER 22-23, 2024

@ 9:00-18:00

@ ATHENS GREECE

THANK YOU!

Q & A

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