Personal $PM_{2.5}$ Exposure and Campus Decision Support

Portable low-cost sensors, exposure modelling and a public campus app

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Bu sunumda yer alan görüş, bilgi ve ifadelerden, sunumun hazırlanmasından ve içeriğinden yalnızca Gebze Teknik Üniversitesi sorumlu olup, sunum Yükseköğretim Kurulu'nun (YÖK) görüşlerini yansıtmaz ve Kurula herhangi bir sorumluluk yüklemez.
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Why personal exposure?

People who share the same outdoor air can inhale very different amounts of $PM_{2.5}$

1. **Fixed stations are sparse**
   Regulatory monitors describe the regional background, not the rooms, paths and hours where people spend their day.

2. **Exposure depends on where and when**
   Indoor–outdoor ratios, activity and timing change the dose that is actually inhaled.

3. **Health and climate share sources**
   Combustion-related fine particles and climate forcers come from the same activities, so cleaner air and climate action reinforce each other.

MEASURED

12.7 µg/m³

mean $PM_{2.5}$ at the campus rooftop sensor, 1 May – 12 Oct 2026 (154 complete days)

42 of 154 days

had a daily mean above the WHO 24-hour guideline of 15 µg/m³

WHO (2021) annual guideline: 5 µg/m³. Indicative comparison only: the period is not a full year.

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Approach: measure → model → decide

1 MEASURE

- Rooftop: PurpleAir PA-II on the SUMER building, every 2 minutes
- US EPA correction for low-cost sensors (Barkjohn et al., 2021)
- Personal: Atmotube PRO wearables on GPS-tagged field sessions

2 MODEL

- Exposure: C = P(hour) × R(building) × F(indoor)
- Inhaled dose: D = C × IR × t, breathing rates from U.S. EPA (2011)
- Machine-learning exposure forecast (in development)

3 DECIDE

- Public web and mobile app with an indicative Air Quality Index (Türkiye's HKİ scale)
- Personal exposure assistant: when and where to be outdoors
- Scenarios for campus management and planning

Low-cost and hardware-agnostic: the protocol is designed for transfer to schools, hospitals, public buildings and industrial sites.

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Monitoring data at a glance

MEASURED

111,578

two-minute rooftop records (PurpleAir PA-II)

154 days

complete days (≥ 18 valid h), 1 May – 12 Oct 2026; 3,751 valid hours in all

12 sessions

personal field sessions, 27–30 Apr 2026 (78.5 hours)

4,015

geolocated personal readings (Atmotube PRO)

3 teams

field teams; one session per team per day

96

campus building footprints for spatial matching



PurpleAir PA-II
fixed low-cost sensor, rooftop



Atmotube PRO
personal monitor

Quality control: A/B channel check (5 hours excluded); local time (TRT); a complete day has ≥ 18 valid hours.

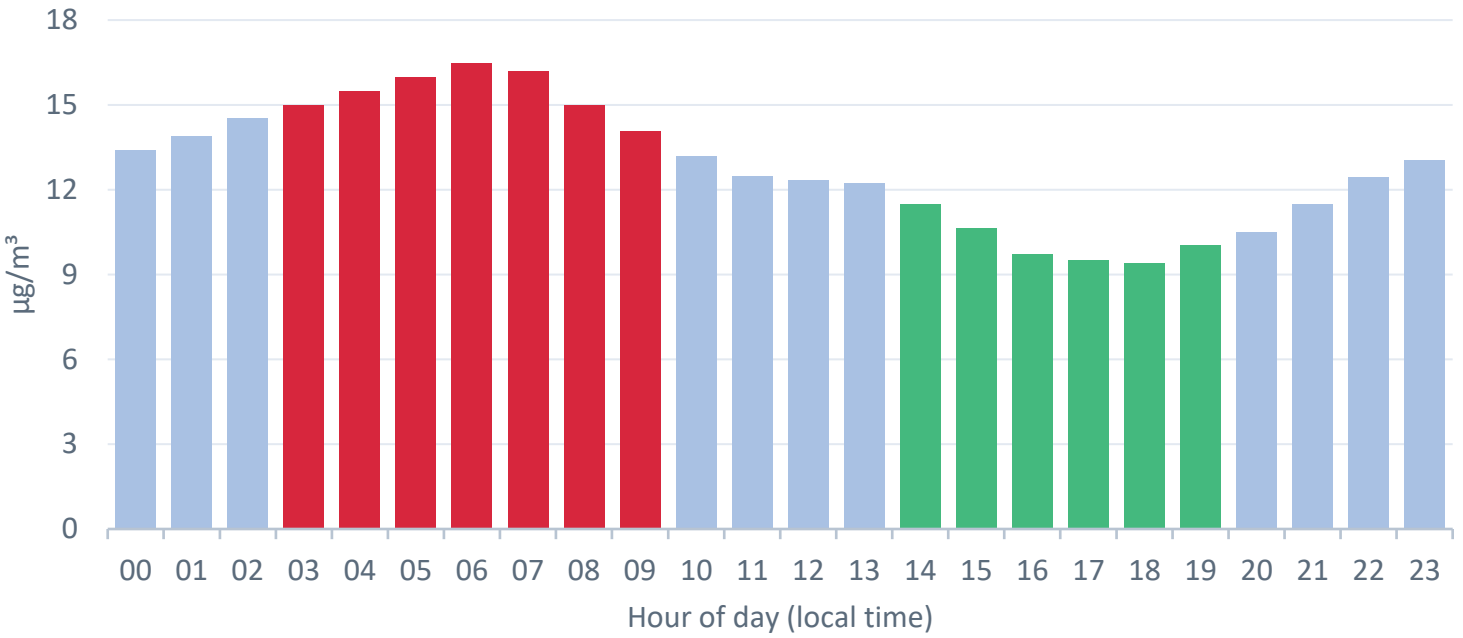
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When: $PM_{2.5}$ builds up overnight and peaks at dawn

MEASURED

Hourly mean $PM_{2.5}$ by hour of day



Hourly mean by local hour; PurpleAir PA-II, US EPA-corrected; 1 May – 12 Oct 2026; n = 3,751 h. Red: 03–09 h, green: 14–19 h.

06:00 highest hourly mean: 16.5 µg/m³

18:00 lowest hourly mean: 9.4 µg/m³

54.8% of the worst 5% of hours fall between 03:00 and 09:59; only 7.4% between 14:00 and 19:59

70.8% of days had their worst hour outside campus hours (08–18)

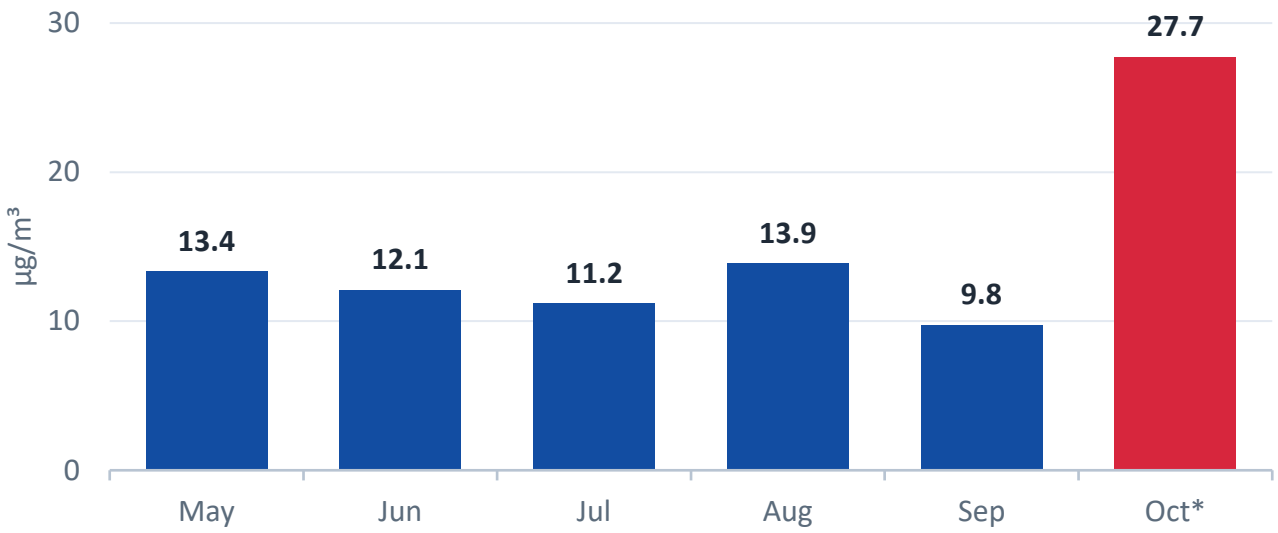
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Monthly pattern and the October 2026 episode

MEASURED

Monthly mean $PM_{2.5}$



Days above 15 µg/m³ (WHO 24-h guideline): May 12 · Jun 9 · Jul 3 · Aug 12 · Sep 2 · Oct* 4 — 42 of 154 days

Mean of daily means (complete days). *Oct = 1–12 October, 6 complete days.

8–12 October 2026 episode

33.3–41.8 µg/m³

daily mean on each of the five days (10 Oct: 17 h of data)

50.4%

of hours in the AQI class (HKİ scale) “Unhealthy for Sensitive Groups” or worse

82.3 µg/m³

highest hourly value (11 October, 22:00)

Such episodes are when timely, local advice matters most.

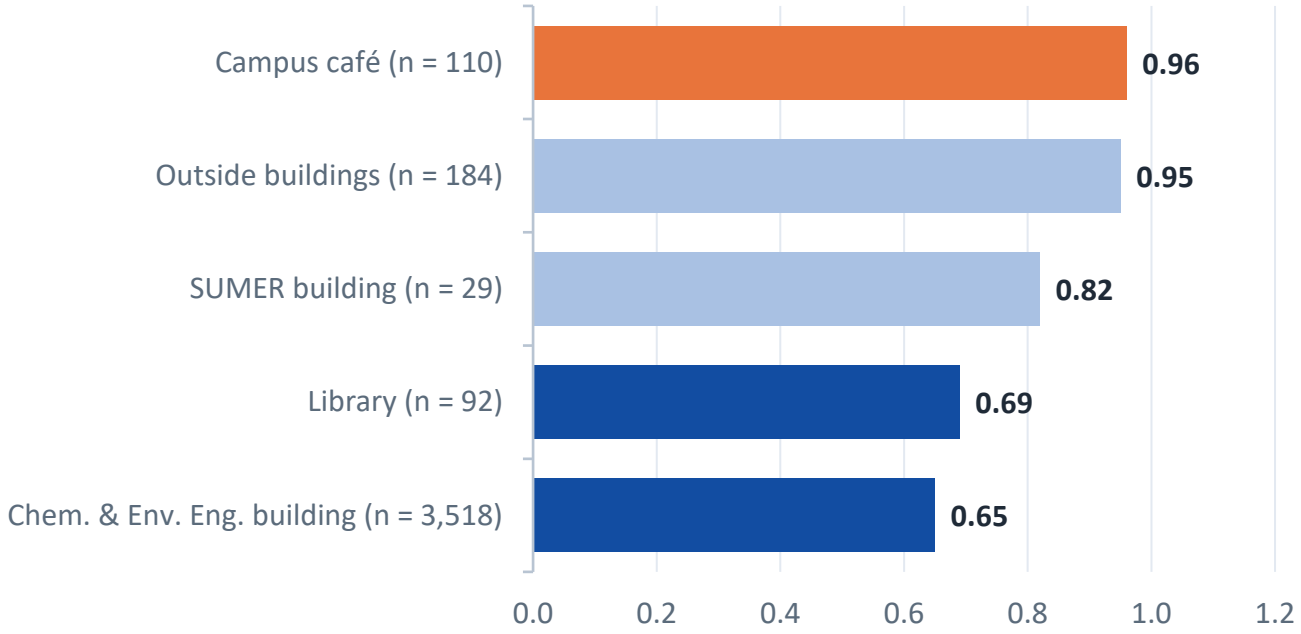
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Where: personal exposure versus the rooftop sensor

MEASURED

Personal / rooftop ratio K (median); 1.0 = outdoor rooftop level



Field sessions 27–30 Apr 2026. 87.8% of points were inside one building, so spatial coverage is limited. Raw wearable vs corrected rooftop: ratios are provisional until co-location.

0.80 personal / rooftop ratio over all 12 sessions (95% CI 0.73–0.88); clearly below 1 on 7 of 12 person-days, above on none

1.89 relative index G at the campus café, the highest among surveyed buildings (95% CI 1.43–2.57); G compares each point with its own session median, mostly indoors

87.6 µg/m³: highest 15-minute personal mean; on 28 April short peaks caused most of the gap between participants

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Modelled scenario: setting and timing change the dose

MODELLED

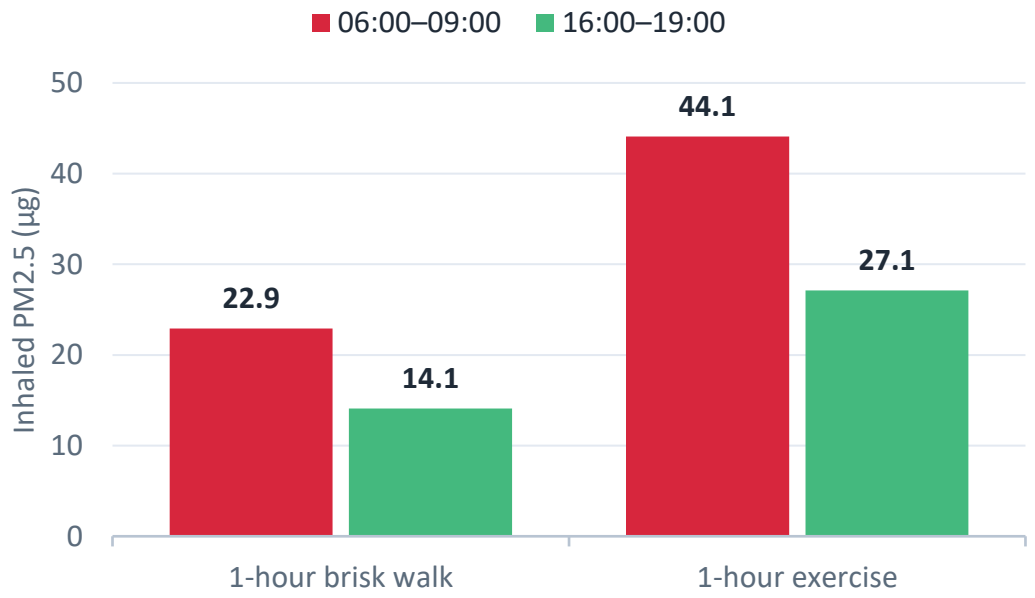
A typical weekday on campus (5 May 2026, 8 hours)

Scenario	Mean exposure	Inhaled $PM_{2.5}$
7 h indoors (windows closed) + 1 h walking	**7.0 µg/m³**	**32.4 µg**
Same 8 h entirely outdoors	**12.3 µg/m³**	**43.0 µg**

67% of the inhaled dose comes from the single outdoor hour

C = P × R × F; F = 0.5 indoors with closed windows; breathing rate 0.25 m³/h seated, 1.56 m³/h brisk walking (U.S. EPA, 2011).

Moving outdoor activity to late afternoon: ≈ 38% less $PM_{2.5}$ inhaled



Typical-level hourly profile, same activity and duration.

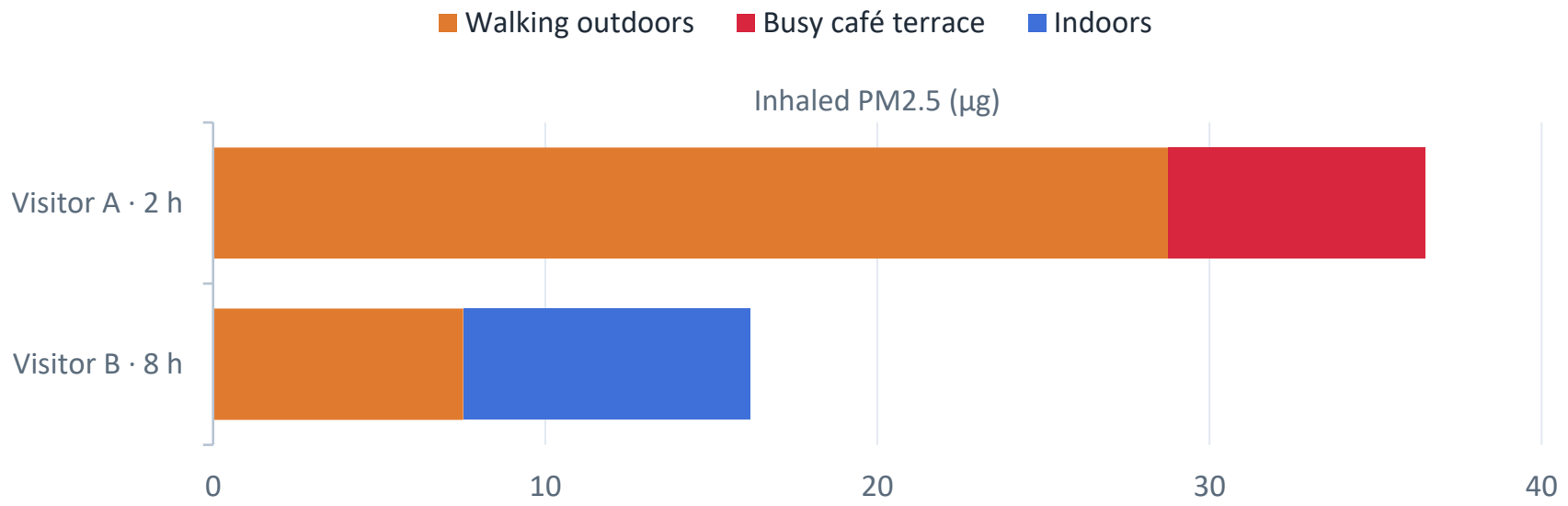
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Two visitors, one campus

MODELLED

2 hours in the wrong places can exceed 8 hours in the right places



36.5 µg

A · 07:00–09:00, roadside walks and a busy café terrace

16.2 µg

B · 10:00–18:00, library, a department building and a late-afternoon walk

Illustrative scenario: modelled dose, not a measured person. Hourly campus profile, May–Oct 2026 (app snapshot, 20 Oct 2026) × building ratios R (building mean / all field measurements, bounded 0.5–2; app exposure model) (campus café 2.0 = model cap, not the café/rooftop ratio of 0.96 on slide 7; Congress and Culture Centre 1.40; Chem. & Env. Eng. 0.92; Library 0.62). A/B = 2.3 in this model; ≈ 1.2–1.5 with the measured personal/rooftop ratios (slide 7).

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Animation · Visitor A: 2 hours, 07:00–09:00

MODELLED



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Animation · Visitor B: 8 hours, 10:00–18:00

MODELLED

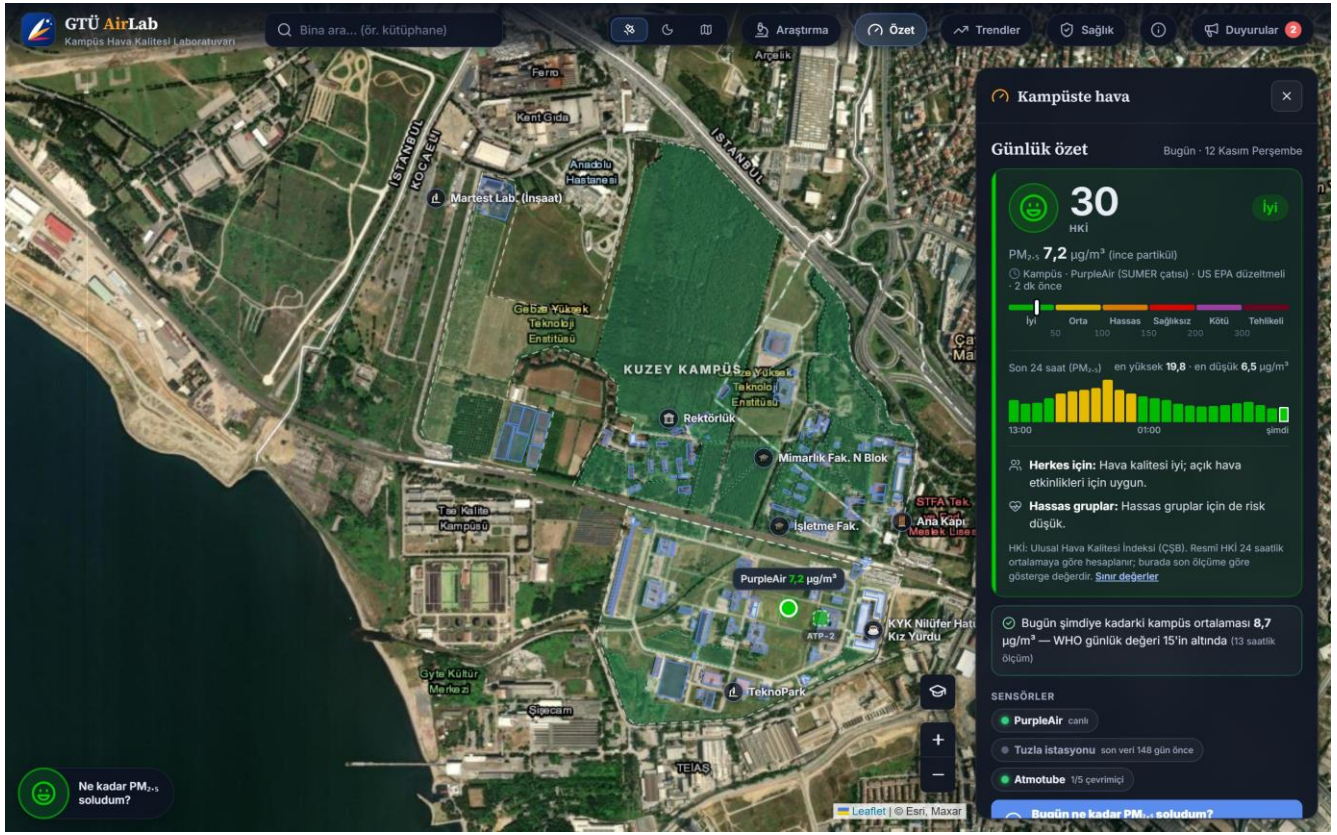


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From data to decisions: the public GTU AirLab app

IN OPERATION



Live interface (in Turkish), 12 November 2026 · imagery: Esri, Vantor, Earthstar Geographics, GIS User Community

- ✓ Live campus map on satellite imagery, updated every 2 minutes
- ✓ Indicative AQI classes (Türkiye's HKİ scale) with plain-language health advice
- ✓ Push alerts for poor air and an 08:00 morning summary; daily and monthly trends
- ✓ Personal exposure assistant: estimate today's inhaled $PM_{2.5}$
- ✓ Privacy by design: no analytics, cookies or tracking; inputs stay on the device

Scan: app, poster & contact
gtuairlab.github.io
free · no sign-in

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Alignment with the COP31 agenda

COP31 AGENDA

1

Climate-resilient cities

Hyper-local evidence on when and where people breathe polluted air, for healthier built environments.

2

Resilient health systems

Exposure-based, plain-language advice for sensitive groups; health co-benefits of climate action.

3

Youth and education

The campus as a living laboratory: students measure, analyse and act on their own data.

4

From pledges to implementation

From measurement to decision with low-cost tools that institutions and municipalities can pilot now.

Transfer pathway

GTU campus → Kocaeli–Gebze industrial region (municipalities, organized industrial zones; green industrialization) → open protocol and guidance for national and international use.

SDG 3 | SDG 4 | SDG 11 | SDG 13

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Limitations and next steps

Current limitations

- One outdoor rooftop low-cost sensor analysed; indoor lecture-hall sensor added on 20 Oct 2026
- Field data from four spring days; 87.8% of points inside one building
- Wearable–rooftop co-location not yet completed; wearable values used as relative
- Modelled doses rely on assumed indoor factors and breathing rates

Next 12 months

PLANNED

- Co-location of wearables with the rooftop sensor; device-specific correction
- Seasonal field campaigns across more buildings and commuting routes
- Machine-learning exposure forecast with reported performance
- Decision-support scenarios and guidance for campus management
- Open data protocol for transfer to schools, hospitals and municipalities

Traceability: measured numbers come from a reproducible analysis report (v1.2, 13 Oct 2026) with source queries; the visitor scenario from the app's exposure model (hourly profile May–Oct 2026, app snapshot of 20 Oct 2026).

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THANK YOU

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