Attractive, Acceptable and Affordable deep Renovation by a consumer orientated and performance evidence based approach
Contract No.: 784972

Report: D5.1 TripleA-reno Monitoring Protocol
Annex 2: Affordable monitors for TripleA-reno measurements

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Prepared for:

Prepared by:
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1 IEQ monitors

Indoor Environmental Monitoring includes measurements for both comfort factors and environmental pollutants.

Comfort parameters include temperature, CO₂, relative humidity, sound level and illuminance. All these parameters can be measured with portable “real-time” monitors. Buildings that are comfortable, attractive and productive to live and work in and which protect human health relay, among others, on indoor air quality and thermal comfort, defined as that condition of mind which expresses satisfaction with the thermal environment. Dissatisfaction can be caused by warm or cool discomfort of the human body as a whole or by an unwanted cooling (or heating) of one particular part of the human body¹.

For the environmental pollutants, VOCs will be monitored. Although we are not providing quantitative protocol to measure formaldehydes, mould, benzene, particles (PM2, PM5 and PM10), or radon, it would be desirable to get measurements, when possible, and according to the geographic risk.

Internal spaces within a building shall be tested and inspected on-site and upon full occupation of the building after a minimum of one year, by direct sampling of the air in rooms, or indirect sampling of exhaust air, over 1 week or 7 working days, according to Table 1 parameters.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mandatory</th>
<th>Type</th>
<th>Units</th>
<th>Range</th>
<th>Tolerance</th>
<th>Resol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature</td>
<td>Y</td>
<td>Time series</td>
<td>ºC</td>
<td>-20 to 50</td>
<td>+/- 0,5</td>
<td>0,1</td>
</tr>
<tr>
<td>Globe temperature</td>
<td>Y</td>
<td>Time series</td>
<td>ºC</td>
<td>0 to 70</td>
<td>+/- 0,5</td>
<td>0,1</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Y</td>
<td>Time series</td>
<td>%</td>
<td>10 to 90</td>
<td>+/- 4</td>
<td>0,1</td>
</tr>
<tr>
<td>Air Speed</td>
<td>N</td>
<td>Time series</td>
<td>m/s</td>
<td>0 to 5</td>
<td></td>
<td>0,01</td>
</tr>
<tr>
<td>Noise Level</td>
<td>N</td>
<td>Time series</td>
<td>dB(A)</td>
<td>30 to 110</td>
<td>+/- 1</td>
<td>0,1</td>
</tr>
<tr>
<td>Illuminance level</td>
<td>N</td>
<td>Time series</td>
<td>lux</td>
<td>50 to 30,000</td>
<td>3 to 7,5%</td>
<td>1</td>
</tr>
<tr>
<td>CO₂</td>
<td>Y</td>
<td>Time series</td>
<td>ppm</td>
<td>0 to 10,000</td>
<td>+/- 75</td>
<td>1</td>
</tr>
<tr>
<td>TVOCs</td>
<td>Y</td>
<td>Cum/ spotty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>N</td>
<td>Cum/ spotty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>formaldehyde</td>
<td>N</td>
<td>Cum/ spotty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: IEQ Measurements characteristics

These data should be downloaded or extracted for analysis and comparison on ‘standard’ formats, such as CSV, XLS or XML.

¹ EN ISO 7730
1.1 Direct access to raw data

A data logger is an electronic device that records data over time or in relation to location either with a built-in instrument or sensor or via external instruments and sensors. Thus, raw data as measured by the sensors can be downloaded for transformation or further analysis.

Raw data can be stored on a physical device connected to the recipient computer through a cable, by Bluetooth or Wi-Fi; or can be stored on a cloud server, connected to the recipient computer through the internet.

**BAPPU EVO**

*By ELK*


---

**Figure 1_ BAPPU EVO**

**Specifications:**

<table>
<thead>
<tr>
<th>Position in the office building</th>
<th>Type of measurement</th>
<th>Units</th>
<th>Equipment - Company</th>
<th>Technical Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside</td>
<td>Time series</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside</td>
<td>Time series</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside</td>
<td>Time series</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside</td>
<td>Time series</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**BAPPU EVO - ELK**

<table>
<thead>
<tr>
<th>Measure Range</th>
<th>Tolerance</th>
<th>Sensor</th>
<th>Res.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20 - 50 ºC</td>
<td>+/- 0.5 ºC</td>
<td>PT 1000 Sensor</td>
<td>0.1 ºC</td>
</tr>
<tr>
<td>0 - 70 ºC</td>
<td>+/- 0.5 ºC</td>
<td>Integrate temperature semiconductor sensor</td>
<td>0.1 ºC</td>
</tr>
<tr>
<td>-20 - 70 ºC</td>
<td>+/- 2 ºC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 - 90 %</td>
<td>+/- 4% rH</td>
<td>Capacity humidity sensor</td>
<td>0.1 %</td>
</tr>
<tr>
<td>0.0 - 5 m/sec</td>
<td>+/- 10% f. MV +/- 3 digit</td>
<td>Thermo-anemometer</td>
<td>0.01 m/sec</td>
</tr>
<tr>
<td>30 to 110 dB(a)</td>
<td></td>
<td></td>
<td>0.1 dB (A)</td>
</tr>
</tbody>
</table>

---

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Noise level (class 2) | A- evaluation Slow/Fast | Precision electret condenser microphone  
---|---|---  
Inside | 50-30,000lux | 1 lux  
Time series | V-Lambda adjustment 7.5%. Cos-accurate evaluation 4%. Linearity 3% | Non-dispersive infrared  
Illuminance level (class C) | 0-10,000 ppm | 1 ppm  
Inside | 0-10,000 ppm | 1 ppm  
Time series | +/- 75 ppm; +/- 5% f.MV (at 0 to 2000 ppm) |  
CO2 (carbon dioxide) | +/- 1.0 dB(A) (at 1Khz) inherent noise < 25 dB(A) |  

Price: around 3.000 €

**CO2000 Carbon Dioxide CO2 Datalogger & Monitor**

*By Perfect Prime*


**Figure 2**: CO2000 Carbon Dioxide CO2 Datalogger & Monitor

**Specifications:**

- **Carbon Dioxide (CO2),**
  - Range: 0 ~ 9999 ppm
  - Accuracy: ± 70 ppm + 3% reading (0~ 2000)
- **Temperature,**
  - Range: -10 ~ 70°C (14 ~ 158°F)
- **Humidity**
  - Range: 0.1 ~ 99.9%
- **Display**: CO2, Temperature, Humidity, CO2 Warning Alert
• Logs:
  o Real-Time Logs
  o Data Logging: Date, Time for each log
  o Data Logging Memory: 12,700
  o Download Collected Data Through PC’s USB Interface
• Software Version for: Window 98/2000/XP/7/8/Vista/Win10
• Analysis Software Used from the Recorded Data

Price: $110.99

Indoor Air Quality Monitor & Datalogger - 800049

By Sper Scientific Direct


![Figure 3: Indoor Air Quality Monitor & Datalogger - 800049](https://www.sperdirect.com/indoor-air-quality-monitor-datalogger-970-prd1.htm)

**Specifications**

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Resolution</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>-10 to 50°C (-14 to 122°F)</td>
<td>0.1°C &amp; F</td>
<td>±0.6°C (-10 to 50°C) otherwise ±1.2°C, ±2.5°F</td>
</tr>
<tr>
<td>RH</td>
<td>10% to 90%</td>
<td>0.1%</td>
<td>±5% (@25°C &amp; 10 to 99% RH) otherwise ±7%</td>
</tr>
<tr>
<td>CO2</td>
<td>0 to 9999 ppm</td>
<td>1 ppm</td>
<td>±75 ppm +5% of rdg (0 to 2000 ppm)</td>
</tr>
</tbody>
</table>

Price: 800049 Datalogging Indoor Air Quality Monitor: $273.00
Datalogging Indoor Air Quality Meter – 800050

By Sper Scientific Direct


![Datalogging Indoor Air Quality Meter – 800050](image1)

Figure 4: Datalogging Indoor Air Quality Meter – 800050

Specifications

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Resolution</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>-10 to 50°C</td>
<td>0.1°C/F</td>
<td>±1°C (±2°F)</td>
</tr>
<tr>
<td>RH</td>
<td>10% to 90%</td>
<td>0.1%</td>
<td>±5% (@25°C)</td>
</tr>
<tr>
<td>CO2</td>
<td>0 to 9999 ppm</td>
<td>1 ppm</td>
<td>±75 ppm +5% of rdg (0 to 5000 ppm)</td>
</tr>
</tbody>
</table>

Price: $241.00

Environmental Quality SD Card Logger – 850071

By Sper Scientific Direct


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Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Range</th>
<th>Resolution</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature</td>
<td>32 to 122°F</td>
<td>0.1</td>
<td>±1.5°F</td>
</tr>
<tr>
<td></td>
<td>0 to 50°C</td>
<td></td>
<td>±0.8°C</td>
</tr>
<tr>
<td>Type K Temperature</td>
<td>-58 to 2372°F</td>
<td></td>
<td>±(0.4% + 1.8°F)</td>
</tr>
<tr>
<td></td>
<td>-50 to 1300°C</td>
<td></td>
<td>±(0.4% + 1°C)</td>
</tr>
<tr>
<td>Type J Temperature</td>
<td>-58 to 2192°F</td>
<td></td>
<td>±(0.4% + 1.8°F)</td>
</tr>
<tr>
<td></td>
<td>-50 to 1200°C</td>
<td></td>
<td>±(0.4% + 1°C)</td>
</tr>
<tr>
<td>RH</td>
<td>0 to 95%</td>
<td></td>
<td>±(3% reading + 1% RH)</td>
</tr>
<tr>
<td>Airspeed m/s</td>
<td>0.4 to 25.0</td>
<td>0.1</td>
<td>±(0.2% + 0.2 m/s)</td>
</tr>
<tr>
<td>Airspeed km/h</td>
<td>1.4 to 90.0</td>
<td>0.4</td>
<td>±(0.2% + 0.8 km/h)</td>
</tr>
<tr>
<td>Airspeed mile/h</td>
<td>0.9 to 55.9</td>
<td>0.1</td>
<td>±(0.2% + 0.4 mph)</td>
</tr>
<tr>
<td>Airspeed knots</td>
<td>0.8 to 48.0</td>
<td>0.1</td>
<td>±(0.2% + 0.4 knots)</td>
</tr>
<tr>
<td>Airspeed ft/min</td>
<td>80 to 4930</td>
<td>1</td>
<td>±(2% + 40 ft/min)</td>
</tr>
<tr>
<td>Lux</td>
<td>0 to 20,000</td>
<td>1</td>
<td>±5% rdg + 8 d</td>
</tr>
<tr>
<td>Foot Candle</td>
<td>0 to 1860</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Price: With Certification: $310.00

Exttech C0210

By BSRIA

https://www.bsria.co.uk/instrument/sales/product/extech-co200-and-c0210/
Specifications:

- **CO2**
  - range 0 to 9999 ppm
  - resolution 1 ppm
  - accuracy ±(5%rdg +50 ppm)
  - CO2 sensor type NDIR (non-dispersive infrared) technology

- **Temperature**
  - range -10 to 60°C
  - resolution 0.1°C
  - accuracy ±0.6°C
  - Air temperature type Thermistor

- **Humidity**
  - range 0.1 to 99.9%
  - resolution 0.1%
  - accuracy ±3%(10 to 90%), ±5%(< 10% or > 90%)
  - Humidity sensor type Capacitance

- **Display**
  - LCD

- **Datalogging**
  - Up to 5333 data points
  - Sample rate 1 second to 4 hours-59 minutes-59 seconds

- **Dimensions / weight**
  - 117x102x102mm / 204g

Price: £223.17
CO22 Carbon Dioxide / Temperature/ Humidity Indoor Air Quality Monitor Meter

By Gain express

https://www.gainexpress.com/products/co22

![CO22 Carbon Dioxide / Temperature/ Humidity Indoor Air Quality Monitor Meter](image)

**Figure 7: CO22 Carbon Dioxide / Temperature/ Humidity Indoor Air Quality Monitor Meter**

Specifications:

- **Carbon Dioxide (CO2)**
  - Range: 0 ~ 2000 ppm 2001 ~ 9999 (out of scale)
  - Accuracy: ± 50 ppm ± 5% rdg (0 ~ 2000)
  - Resolution: 1 ppm

- **Pressure Dependence:** + 1.6% reading per kPa deviation from normal pressure, 100kPa

- **Temperature**
  - Range: -10.0 ~ 60.0 °C (14 ~ 140 °F)
  - Resolution: 0.1 °C / °F
  - Accuracy: ± 0.6 °C / ± 0.9 °F

- **Humidity**
  - Range: 0.0 ~ 99.9%
  - Resolution: 0.1%
  - Accuracy: ± 3% (10 ~ 90%) ** ± 5% (others)

Price: $133.90 USD
Figure 8: CO98 CO2 Data Logger Temperature Humidity Monitor 9999ppm

Specifications:

- **Measuring Range**
  - CO2: 0~2000ppm  2001~9999 (out of scale)
  - Air Temperature: -10 ~ 60°C (14 ~ 140°F)
  - Air Relative Humidity: 0.1 ~ 99.9%RH

- **Resolution**
  - CO2: 1ppm
  - Air Temperature: 0.1°C / 0.1°F
  - Air RH: 0.1%RH

- **Accuracy**
  - CO2: ±50ppm ±5% of reading (0~2000ppm) other ranges accuracy are not specified
  - Air Temperature: ±0.6°C, ±0.9°F
  - Air Relative Humidity: ±3%RH (at 25°C, 10~90% RH) ±5%RH (at 25°C, <10% & >90% RH)

- **Response**
  - CO2: <2 mins (90% step change)
  - Air Temperature: <2 mins (90% step change)
  - Air Relative Humidity: <10 mins (90% step change)

- **Air Quality Level (CO2 Concentration):**
  - Good: <700ppm (programmable by user)
  - Normal: 700 ~ 1000ppm (programmable by user)
  - Poor: >"Normal"
TROTEC PC 220 handheld measurement and datalogger (5000 points):


Figure 9: TROTEC PC 220 handheld measurement and datalogger (5000 points)

Specifications:

- **Particle concentration**
  - Number of channels: 6
  - Duct sizes: 0.3 µm, 0.5 µm, 1.0 µm, 2.5 µm, 5.0 µm, 10.0 µm
  - Counting modes: Concentration, cumulative, differential
  - Counting efficiency: 50 % at 0.3 µm, 100 % for particles > 0.45 µm
  - Flow rate: 2.83 l/min (0.1 ft³/min), controlled by internal pump
  - Zero count: < 1 particle / 5 min
  - Coincidence loss: .5 %, 2 million particles per ft³ (28.3 litres)
  - Detector type: Scattered light measurement
  - Sample inlet: Isokinetic probe

- **Particle mass conversion**
  - Particle mass conversion: 2.5 µm, 10 µm
  - Min. measuring range [µg/m³]: 0
  - Max. measuring range [µg/m³]: 2,000
  - Resolution [µg/m³]: 1

- **HCHO Formaldehyde**
  - Min. measuring range [ppm]: 0.01
  - Max. measuring range [ppm]: 5
  - Genauigkeit ± [%]: 5
  - Resolution [ppm]: 1

- **Carbon monoxide**
  - Min. measuring range [ppm]: 10
- Max. measuring range [ppm]: 1,000
- Accuracy ± [%]: 5
- Resolution [ppm]: 1

- Air temperature
  - Min. measuring range [°C]: 0
  - Max. measuring range [°C]: 50
  - Accuracy ± 10 °C - 40 °C [°C]: 0.5
  - Temperature below 10 °C - Temperature above 40 °C [°C]: 1

- Relative humidity
  - Min. measuring range [%]: 0
  - Max. measuring range [%]: 100
  - Accuracy 40 % - 60 % [%]: 3
  - Accuracy 20 % - 40 % [%]: 3.5
  - Accuracy 60 % - 80 % [%]: 3.5
  - Accuracy 0 % - 20 % [%]: 5
  - Accuracy 80 % - 100 % [%]: 5

- Dew point temperature
  - Min. measuring range [°C]: 0
  - Max. measuring range [°C]: 50
  - Accuracy ± 10 °C - 40 °C [°C]: 0.5
  - Accuracy ± 10 °C - 40 °C [°C]: 1

- Wet-bulb temperature
  - Min. measuring range [°C]: 0
  - Max. measuring range [°C]: 80
  - Accuracy ± [°C]: 1

Price: 735 - EUR

TROTEC BQ16 handheld measurement

Figure 10: TROTEC BQ16 handheld measurement

Specifications:

- **HCHO Formaldehyde**
  - Min. measuring range [ppm]: 0
  - Max. measuring range [ppm]: 5
  - Resolution Formaldehyde [ppm]: 0.01
  - Measuring range min. [mg/m³]: 0
  - Measuring range max. [mg/m³]: 5
  - Resolution [mg/m³]: 0.01
  - Genauigkeit ± [% FS (full scale)]: 5

- **TVOC (Total Volatile Organic Compound)**
  - Measuring range min. [ppm]: 0
  - Measuring range max. [ppm]: 9.99
  - Resolution [ppm]: 0.01
  - Measuring range min. [mg/m³]: 0
  - Measuring range max. [mg/m³]: 9.99
  - Resolution [mg/m³]: 0.01
  - Accuracy ± [% FS (full scale)]: 10

Price: 125 - EUR
Summary

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mandatory</th>
<th>Type</th>
<th>Units</th>
<th>Range</th>
<th>Tolerance</th>
<th>Resol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature</td>
<td>Y</td>
<td>Time series</td>
<td>ºC</td>
<td>-10 to 50</td>
<td>+/- 1</td>
<td>0,1</td>
</tr>
<tr>
<td>Globe temperature</td>
<td>Y</td>
<td>Time series</td>
<td>ºC</td>
<td>0 to 50</td>
<td>+/- 1</td>
<td>0,1</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Y</td>
<td>Time series</td>
<td>%</td>
<td>10 to 90</td>
<td>+/- 5</td>
<td>0,1</td>
</tr>
<tr>
<td>Air Speed</td>
<td>N</td>
<td>Time series</td>
<td>m/s</td>
<td>0.4 to 5</td>
<td>+/- 0.2</td>
<td>0,1</td>
</tr>
<tr>
<td>Noise Level</td>
<td>N</td>
<td>Time series</td>
<td>dB(A)</td>
<td>30 to 110</td>
<td>+/- 1</td>
<td>0,1</td>
</tr>
<tr>
<td>Illuminance level</td>
<td>N</td>
<td>Time series</td>
<td>lux</td>
<td>50 to 30,000</td>
<td>3 to 7,5%</td>
<td>1</td>
</tr>
<tr>
<td>CO2</td>
<td>Y</td>
<td>Time series</td>
<td>ppm</td>
<td>0 to 9,999</td>
<td>+/- 0.75</td>
<td>1</td>
</tr>
<tr>
<td>VOCs</td>
<td>Y</td>
<td>Cum/ spotty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>N</td>
<td>Cum/ spotty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>formaldehyde</td>
<td>N</td>
<td>Cum/ spotty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Measurements characteristics for low cost devices with data loggers
1.2 Indirect access to raw data

Domestic low-cost devices, designed for homes, with user friendly interfaces, aiming for user awareness of their environmental quality and thus, their behavioural impact on it, provide understandable feedback, in the form of colour lights codes, advices or tips. This allows them for more penetration in homes and occupants acceptance, but often, raw data is not available.

Nevertheless, the rising of the IoT paradigm and the social media connected world, induce these devices to comply with connecting protocols like ifTTT, where you can implement different kinds of orders, allowing for raw data access; or connecting schemes like APIs, where you can retrieve data from central repositories programmatically, thus, at some point, allowing for raw data access; or intermediary software with exporting/downloading data web services.

“If This Then That (ifTTT) is the free way to get all your apps and devices talking to each other. Not everything on the internet plays nice, so we’re on a mission to build a more connected world.”

https://ifttt.com/

The Google Sheets IFTTT action provides the ability to add a row to a spreadsheet, and this works the same way regardless of what you’re sending to it — you’ll need to specify a name and Drive folder for the Google Sheet (both of which will be created if they don’t already exist), and then fill in a formatted row of data that will be appended to the bottom of the spreadsheet.

It will depend on the kind of ifTTT trigger actions included on each device that we can keep a regular log, or just a record on i.e. time periods when values were above or below thresholds that we specified.

On the other hand, web APIs are the defined interfaces through which interactions happen between an enterprise and applications that use its assets. An API approach is an architectural approach that revolves around providing a program interface to a set of services to different applications serving different types of consumers. Thus, asking the server for a dataset, for being consumed by an application, which can format and offer it for download, or for being formatted and stored on another server.

Moreover, this kind of attractive devices can be used as rewards for “best” occupants after measurements campaigns are finished.

uHooair

by uhoo

Figure 11: uHooair

Specifications:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>°C / °F</td>
<td>-40 °C / 40 °F to -85 °C / 185 °F</td>
</tr>
<tr>
<td>Humidity</td>
<td>%</td>
<td>0 to 100</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>ppm</td>
<td>400 to 10,000</td>
</tr>
<tr>
<td>VOC</td>
<td>ppb</td>
<td>10 to 1,000</td>
</tr>
<tr>
<td>PM2.5</td>
<td>µg / m³</td>
<td>0 to 200</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>ppm</td>
<td>0 to 1,000</td>
</tr>
<tr>
<td>Ozone</td>
<td>ppb</td>
<td>10 to 1,000</td>
</tr>
<tr>
<td>Air Pressure</td>
<td>mbar</td>
<td>300 to 1,100</td>
</tr>
</tbody>
</table>

Price: €279
Awair 2nd Edition

By getawair

https://getawair.com/

![Awair 2nd Edition](image)

**Figure 12: Awair 2nd Edition**

The specifics of the sensors are as follows, – the *temperature* sensor can read from -40 to +125°C (-40 to +257°F) to within 0.3°C accuracy. It measures *humidity* from 0 to 95% within 3% accuracy. *Carbon Dioxide* is measured from 0 to 4,000 parts per million at 75ppm accuracy while it can measure *dust* volumes from 0 to 500 μg/m³ and detect a range of *VOCs*.

Price: $179.00

Foobot

By foobot

https://foobot.io/

![Foobot](image)

**Figure 13: Foobot**
Specifications:

<table>
<thead>
<tr>
<th>Particulate Matter</th>
<th>Sensing technology: light scattering, lw latency detection Factory Calibration, on the fly signal processing Sensitivity particle size 0.3 μm to 2.5 μm (PM 2.5) Range 0 to 1 300 μg/m³; Precision ±4μg or ±20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total VOC</td>
<td>MOS sensor tech. automotive industry grade High reliability and stability; Precision ±10% Low latency detection Formaldehyde, Iso-Butane, Toluene, Methane, Ammonia, Benzene, etc.</td>
</tr>
<tr>
<td>Temperature</td>
<td>Usage range; Accuracy 15 to 45°C; ±1°C</td>
</tr>
<tr>
<td>Humidity</td>
<td>Usage range; Accuracy 30 to 85% (non condensing); RH ±5%</td>
</tr>
</tbody>
</table>

Price: EUR 199,00

Acer Air Monitor AM110

By Acer

https://home.cloud.acer.com/airmonitor/

Figure 14: Acer Air Monitor

Specifications:

<table>
<thead>
<tr>
<th>Particulate Matter</th>
<th>Detectable Particle size &gt; 0.7 μm m PM2.5 Range: 0 - 500 μg/m³; Resolution: 1.0 μg/m³ PM10 Range: 0-1000 ug/m³; Resolution: 1.0 ug/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>TVOC</td>
<td>Detect Total concentration of Volatile Organic Compounds, including Alcohols, Aldehydes, Range: 125 - 3500 PPB; Resolution: 1.0 PPB</td>
</tr>
</tbody>
</table>
Aliphatic Hydrocarbons, Amines, Aromatic hydrocarbons, CO, CH4, LPG, Ketones, Organic acids, etc.

<table>
<thead>
<tr>
<th>CO2</th>
<th>AM110 Model: CO2. Range: 400 - 10000 ppm, Resolution: 1 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Range: -20°C to 80°C, Resolution: 0.1°C</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Relative Humidity %; Range: 0 - 100%, Resolution: 1.0%</td>
</tr>
<tr>
<td>Ambient Light Sensor</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Price: Currently unavailable

**Medidor de Calidad del Aire Interior Inteligente**

*By netatmo*


*Figure 15: netatmo*

**Specifications:**

- **Frecuencia de grabación:** cada 5 minutos
- **Temperatura:**
  - Intervalos: de 0°C a 50°C
  - Precisión: ± 0,3°C
- **Humedad:**
  - Intervalos: de 0 a 100%
  - Precisión: ± 3%
- **Medidor de CO2:**
  - Intervalos: de 0 a 5 000 ppm
  - Precisión: ± 50 ppm (de 0 a 1 000 ppm) o ± 5% (de 1 000 a 5 000 ppm)
Sonómetro:
  o Intervalos: 35 dB à 120 dB

Price: 99,99 €

(not sure ifTTT compatible)

Air Mentor 2: Indoor Air Quality Detector (8099-AP)

By Air Mentor

https://air-mentor.eu/product/air_mentor_8099ap.html

Figure 16: Air Mentor 2: Indoor Air Quality Detector

Temperature Sensor
  o Range: -20°C ~ 80°C

Humidity Sensor
  o Range: 0 ~ 100%

Particulate Matter Sensor
  o PM2.5 Range: 0 ~ 1000μg/m3
  o PM10 Range: 0 ~ 1000μg/m3

TVOC Gas Pollution Sensor
  o Range: 0.020 ~ 10 PPM

CO2 NDIR Sensor
  o Range: 0 ~ 10000 PPM

Price: € 361,79
Summary

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mandatory</th>
<th>Type</th>
<th>Units</th>
<th>Range</th>
<th>Tolerance</th>
<th>Resol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature</td>
<td>Y</td>
<td>Time series</td>
<td>ºC</td>
<td>15 to 45</td>
<td>+/- 1</td>
<td>0,1</td>
</tr>
<tr>
<td>Globe temperature</td>
<td>Y</td>
<td>Time series</td>
<td>ºC</td>
<td>15 to 45</td>
<td>+/- 1</td>
<td>0,1</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Y</td>
<td>Time series</td>
<td>%</td>
<td>30 to 85</td>
<td>+/- 5</td>
<td>0,1</td>
</tr>
<tr>
<td>Air Speed</td>
<td>N</td>
<td>Time series</td>
<td>m/s</td>
<td>0 to 5</td>
<td></td>
<td>0,01</td>
</tr>
<tr>
<td>Noise Level</td>
<td>N</td>
<td>Time series</td>
<td>dB(A)</td>
<td>35 to 110</td>
<td>+/- 1</td>
<td>0,1</td>
</tr>
<tr>
<td>Illuminance level</td>
<td>N</td>
<td>Time series</td>
<td>lux</td>
<td>50 to 30.000</td>
<td>3 to 7,5%</td>
<td>1</td>
</tr>
<tr>
<td>CO2</td>
<td>Y</td>
<td>Time series</td>
<td>ppm</td>
<td>400 to 5,000</td>
<td>+/- 75</td>
<td>1</td>
</tr>
<tr>
<td>VOCs</td>
<td>Y</td>
<td>Cum/ spotty</td>
<td>ppb</td>
<td>125 to 1000</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>PM</td>
<td>N</td>
<td>Cum/ spotty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>N</td>
<td>Cum/ spotty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Measurement characteristics for domestic devices
2 Energy Consumption Meters

One of the objectives of the project is to decouple human comfort from high energy consumption, so that we can achieve comfortable living spaces which are energy efficient (less CO2 emissions) and liveable. In order to establish this assumption, it is necessary to obtain accurate data about energy consumptions, disaggregated by heating/cooling, ventilation, lighting, DHW and appliances.

Disaggregated energy consumptions can be obtained from energy bills (total real residential unit consumption), using advance modelling techniques in order to estimate disaggregated energy consumption; or through smart metering real-time energy consumption per residential unit disaggregated as much as possible.

Energy Consumption measurements provide users with an understanding of a building's energy demand in the use stage, which is in general responsible for the majority of life cycle energy use in the case of buildings constructed before the turn of the millennium, and up to 30-70% of life cycle energy use, depending on the building type, form and specification, of new buildings.

Delivered energy demand (kWh/m²/yr) is the energy delivered to the building in the form of electricity, heat and fuel. It is the energy per ‘carrier’ supplied to the building, to satisfy uses within the building (heating, cooling, ventilation, domestic hot water, lighting, appliances, etc.). The delivered energy is generally the one metered by the utilities. Reporting is therefore to be disaggregated into the energy used for heating, hot water, cooling, ventilation and lighting, according to Table 4 parameters.

Reporting of other aspects of occupant energy use is also encouraged.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mandatory</th>
<th>Type</th>
<th>Units</th>
<th>Range</th>
<th>Tolerance</th>
<th>Resol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivered energy demand</td>
<td>Y</td>
<td>Time series (recommended each 5 min – as much continue as possible)</td>
<td>Watts/h</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Measurements characteristics

These data should be downloaded or extracted for analysis and comparison on ‘standard’ formats, such as CSV, XLS or XML, in order to obtain, among others, the kWh/m²/yr related to each energy system on each residential unit, that could be presented as CO2eq, saved trees, money saved or any other understandable/friendly unit.
2.1 Direct access to raw data

A data logger is an electronic device that records data over time or in relation to location either with a built-in instrument or sensor or via external instruments and sensors. Thus, raw data as measured by the sensors can be downloaded for transformation or further analysis.

Raw data can be stored on a physical device connected to the recipient computer through a cable, by Bluetooth or Wi-Fi; or can be stored on a cloud server, connected to the recipient computer through the internet.

E2 Classic with USB

By Efergy

https://efergy.com/electricity-monitors/wireless-energy-monitor-e2-classic/

![Figure 17: E2 Classic](image)

Features:

- Average energy consumption
- Instant power and cost
- Historical data (day, week & month)

Price: 85€
NEURIO SENSOR W1

By neur.io

https://www.neur.io/energy-monitor/

![Neurio Sensor W1](image)

**Figure 18: Neurio Sensor W1**

Features:

- Real-time data
- High resolution data
- Solar monitoring capable
- Sub-metering capable
- Flexible data access: Data access is available through Neurio Software, Neurio Cloud API, or directed to your own Cloud infrastructure.

Price: $219.99

Eco-Eye Smart

By eco-eye

Figure 19: Eco.eye smart

Features:

- Unique traffic light load indicator
- USB interface for real-time feed to PC or network
- Incorporates MMC card reader for up to 10 years of data

Price: £45.60

OWL +USB

By OWL


Product Features:
• Allows monitoring of live consumption for the property.
• Access to historical and average readings for up to 2 years on the monitor via a "History" function.
• Displays greenhouse gas impact, date and time as well as energy usage and cost.
• The last 30 days are able to be downloaded and added to a profile on your PC via our OWL+USB Software - allowing graphical analysis and long-term storage. (Windows only)

Price: £49.95

Not UK:

• http://www.theowl.com/index.php/distributors/international-sales/
• http://www.naotic.com/monitorizacion-energetica.html

IoTaWatt

By IoTaWatt

https://iotawatt.com/

Figure 20: IoTaWatt

Features:

• 14 x single-phase current sense (CT) channels
• 1 x AC VRMS Channel
• Compatible with multiple types of CT sensors and AC-AC voltage sensor adaptor
• Local SD card logging
• WiFi connected to post to Emoncms
• Sample rate: 35-40 channels per second
• Voltage (VRMS), Power (W) and Energy (kWh) logged to local SD card - every 5s
• On-board Real-time-clock (RTC) with battery backup
• 5V Micro USB power supply required

Price: £168.59
2.2 Indirect access to raw data

Domestic devices, designed for homes, with user friendly shapes, textures, colours and interfaces, aiming for user awareness of their energy consumption and thus, their behavioural impact on it, provide understandable feedback, in the form of colour lights codes, or mobile apps with graphs, alarms, advices or tips. This allows them for more penetration in homes and occupants acceptance, but often, raw data is not available.

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Moreover, this kind of attractive devices can be used as rewards for “best” occupants after measurements campaigns are finished.

sense

By Sense

https://sense.com/product.html
Features:

- Track energy use over time
- Set device-level notifications
- Identify sources of energy waste

Price: $255

(not available)
## Summary

| Tool                                      | Air speed | Relative humidity | CO₂ | VOCs | Particles | For mal dehyde | Air temperature | Globe temperature | Illuminance level | Noise level | Energy sub-metering | Direct | Indirect | Fr i endly info | Price | Healthy & comfortable spaces | Requirement represented |
|-------------------------------------------|-----------|-------------------|-----|------|-----------|----------------|-----------------|------------------|------------------|--------------|----------------|---------------------|--------|-----------|----------------|-------|-----------------------------|------------------------|
| BAPPU EVO - ELK 3000                     |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| CO 2000 CO 2 Datalogger & Monitor        |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| IAQ Monitor & Datalogger - 8000          |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| Datalogging IAQ Meter – 800050           |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| EQ SD Card Logger – 850071               |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| Extec h C0210                            |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| CO 22 Indoor Air Quality Monitor Meter   |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| CONRAD ELK 8000                          |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| CONRAD BQ200                              |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| uHooair app                               |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| Awair 2nd Edition                        |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| Foobot                                   |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| Acer Air Monitor AM110                   |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| netatmo                                   |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| Air Mentor 2: Indoor Air Quality Detector|          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| E2 Classic with USB                      |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| NEOIO SENSOR VS                          |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| Eco Eye Smart                            |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| Owls uG8                                  |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| IoTaWatt 200                             |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |
| sense app                                |          |                   |     |      |           |                 |                 |                  |                  |              |                      |         |          |                |       |                            |                        |

Figure 21: Measurements tools assessment

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