Report Hungary

In the framework of iSERV Intelligent Energy for Europe project a compact Indoor Air Quality system was developed and placed in buildings with HVAC systems larger than 12kW in different European metropolitan cities in order to investigate the relationship of IAQ and energy consumption. The sensor was capable of measuring temperature, relative humidity, CO2 and level of VOC'Ss while energy monitoring systems were also engaged to provide information on the building and HVAC system energy consumptions. The data was recorded locally and downloaded on a regular basis by NKUA.

SUMMARY

The measurements taken for the air quality in the buildings can be considered satisfactory. The air quality in all offices can be considered as good, as all of them had a majority of values below 600 ppm, but 4 offices only recorded a significant percentage of CO_2 values over 1000 ppm. CO_2 concentrations in buildings below do not exceed the limit of 1000 ppm, indicating that ventilation is adequate and occurs in higher concentrations during the operation of the offices. Moreover, with refer to VOCs, in offices the air quality could not lead to any irritation or discomfort. VOCs concentrations in offices below could cause no irritation or discomfort in the 1st building or at least possible irritation or discomfort depending on the interaction with other factors in 2nd building, while Tair maintained at higher levels during the operation hours. Last but not least RH was at higher levels during the non – operation hours of the day or at the same levels the whole day. Finally, the frequency distributions showed that in this office the ventilation is adequate and the air quality leads to no irritation or discomfort.

1 DESCRIPTION OF THE BUILDINGS

The systems IAQ 39 and IAQ 42 are located in offices in Budapest, Hungary from February 2014 to April 2014. Also, the 1st building has been constructed in 1/6/2010 and has an air conditioned area of 17203 m^2, while the 2nd one has been constructed in 1/6/2008 and has an air conditioned area of 20095 m^2.

2 RESULTS

2.1 Carbon dioxide measurements (CO_2)

CO_2 is produced by human expiration and is often observed in increased quantities in places with many people without adequate ventilation. It is not toxic, but it can cause suffocation in high concentrations. Initially there was an attempt to select limits of CO_2 and Volatile Organic Compounds (VOC'S). Guided by CO_2 limits by ASHRAE it was made an adaptation to the limits to the buildings and it was used as limits the values 800 ± 2 standard deviation and 1000 ± 2 standard deviation, 800 ± 1 standard deviation and 1000 ± 1 standard deviation which led to a large overlap between categories. For this reason a frequency distribution took place, based on classes by CIBSE guide and the classes of buildings relative to carbon dioxide resulted as follows:

Indoor Air Quality	*CO_2 Concentration*

	[ppm]
Good	< 600
Acceptable	600 – 1.000
Bad	>1.000

To reduce carbon dioxide indoors it would be necessary not only to eliminate the emission but also to ventilate often the room.

The need for selecting the most appropriate limits of carbon dioxide led to frequency distribution and found that both offices recorded the majority of values 0 - 600 ppm thus they can be classified in the category of good air quality, suggesting that the ventilation of the buildings is adequate. Below are given the total chart of CO2 frequency distribution and an indicative diagram of one office:

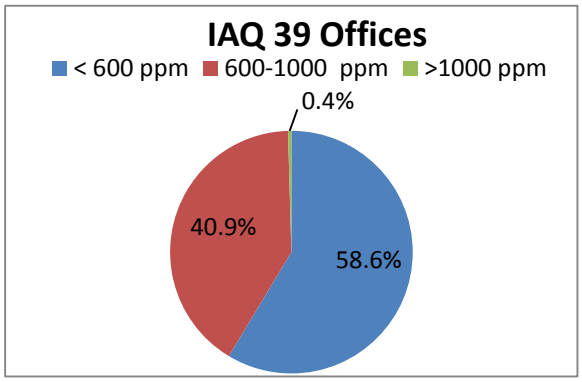
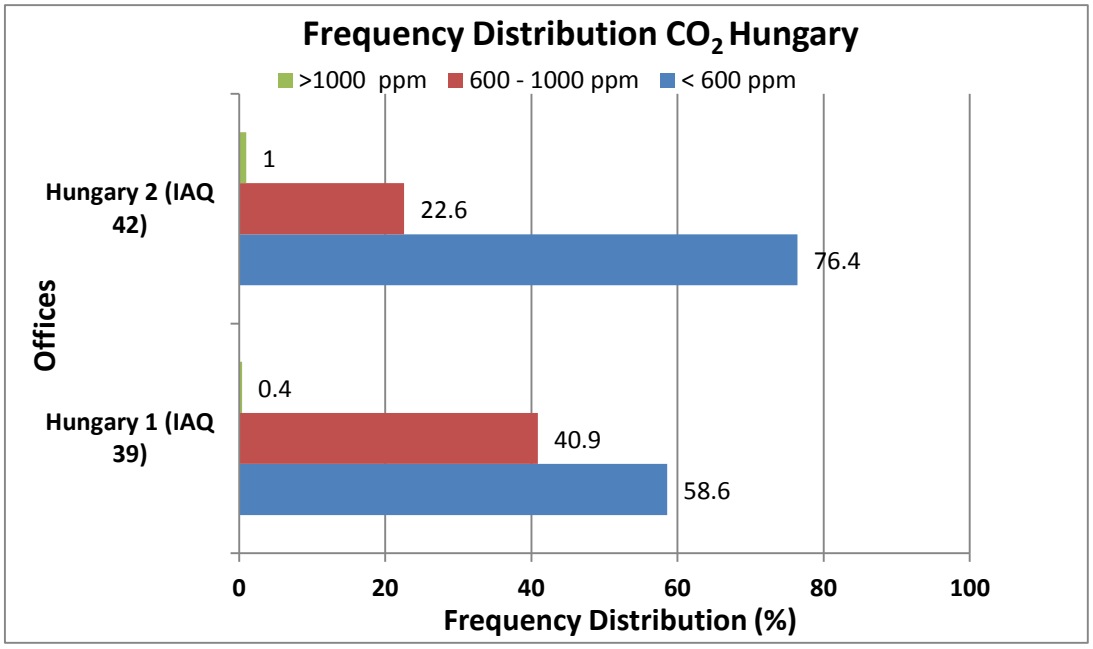


Diagram 1: Frequency distribution CO_2 (indicative)

Diagram 2: CO_2 Frequency distribution



2.2 Volatile Organic Compounds measurements (TVOC's)

According to the European Directive 2004/42/CE as Volatile Organic Compounds, TVOC'S, defined as all organic compounds having an initial boiling point less than or equal to 250°C, measured at atmospheric pressure 101.3 kPa. According to EPA, the class of volatile organic compounds composed of all carbon compounds, which are involved in atmospheric photochemical reactions, except for carbon monoxide, carbon dioxide and carbonic acid.

The concentration of volatile organic compounds in the interior of buildings is derived from two species of sources (Wiglusz et al., 2002):

- The background emissions, such as chemical compounds derived mainly from construction materials and building equipment (furniture, etc). The background emission is continuous and has nearly constant transmission rate.

- Periodic emissions resulting from human activities such as smoking, cooking, cleaning etc.

The final concentration of volatile organic compounds in the interior of buildings depends on the transmission rate, the concentration in the external environment and the level of ventilation in the building.

Emissions of volatile organic compounds from the materials inside the building are an extremely complex phenomenon. These emissions are classified into two major categories (Wolkoff 1999, Zabiegala et al, 1999).

According to studies[1],, the concentrations of TVOC'S can be classified into four categories, depending on the effects that can cause in health. Furthermore, based on accredited institutions of the University of Athens the kits were calibrated, from which emerged the following correlation between price VOC'S output of the instrument and the scales by Molhave, as shown in the following table:

Table 1: Scale of exposure to concentrations of volatile organic compounds (TVOC's)

Total concentration	Sensor output (o/u)	Discomfort and Irritation Show	Exhibition scale
Less than 0.2 mg/m³ (Less than 0.05 ppm)	**Up to 10**	**No irritation or discomfort**	**Comfort Scale**
From 0.2 mg/m³ to 3.0 mg/m³ (from 0.05 to 0.80 ppm)	**From 10 to 20**	**Possible irritation or discomfort depending on the interaction with the other factors**	**Scale Exposure to multiple factors**
From 3.0 mg/m³ to 25 mg/m³ (From 0.80 to 6.64 ppm)	**From 20 to 30**	**Symptoms - Possible headaches depending on other factors**	**Discomfort Scale**
Over 25 mg/m³ (Over 6.64 ppm)	**Over 30**	**Additional neurotoxic effects may occur, apart from the headache**	**Toxic Exposure Scale**

[1] A. Molhave L., Human reactions to controlled exposures to VOC'S's and the "total VOC'S" concept. In: H, Knoppel and P. Wolkoff (eds.), Chemical, Microbiological, Health and Comfort Aspects of Indoor Air Quality - State of the art in SBS, Netherlands 1992, pp 247-261,

B. Molhave L., Volatile Organic Compounds, Indoor Air Quality and Health. In: Walkinshaw (ed.), Proceedings of Indoor Air 90, Toronto 1990, Vol.5, pp 15-33

C. Molhave L., Evaluations of VOC'S emissions from materials and products: solid flooring materials. In: Maroni M. (ed.), Proceedings of Healthy Buildings, '95, Milano 1995, Vol. 1, pp 145-162

Similar to carbon dioxide, it was made a frequency distribution for VOC's and found that the air quality could to lead to no irritation or discomfort, as the majority of hourly rates ranging from 0 – 10 o/u at both buildings. . Below are given the total chart of VOCs frequency distribution and an indicative diagram of one office:

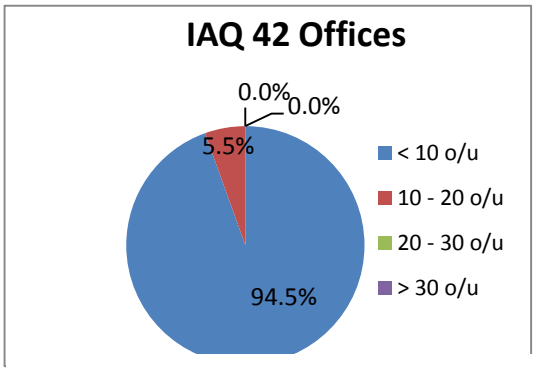


Diagram 3: Frequency distribution VOC'S (indicative)

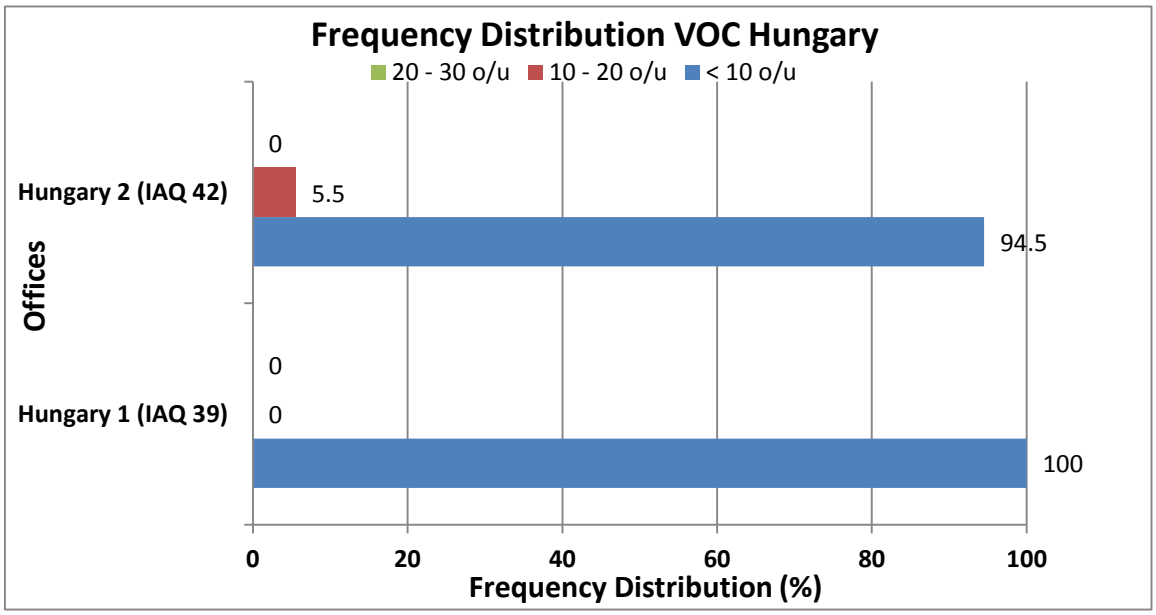


Diagram 4: VOCs Frequency distribution

3 MONTHLY VARIATIONS

At the following diagrams, the monthly morning and the daily values are illustrated. That means that the daily variation only in operation hours of each building for each month is depicted. The operation hours of office buildings are 8:00 – 18:00.

3.1 CO_2

There is a steady trend at the monthly CO_2 measurements for the systems IAQ 39 and IAQ 42 with the maximum of these exceeding the limit of 1000 ppm.

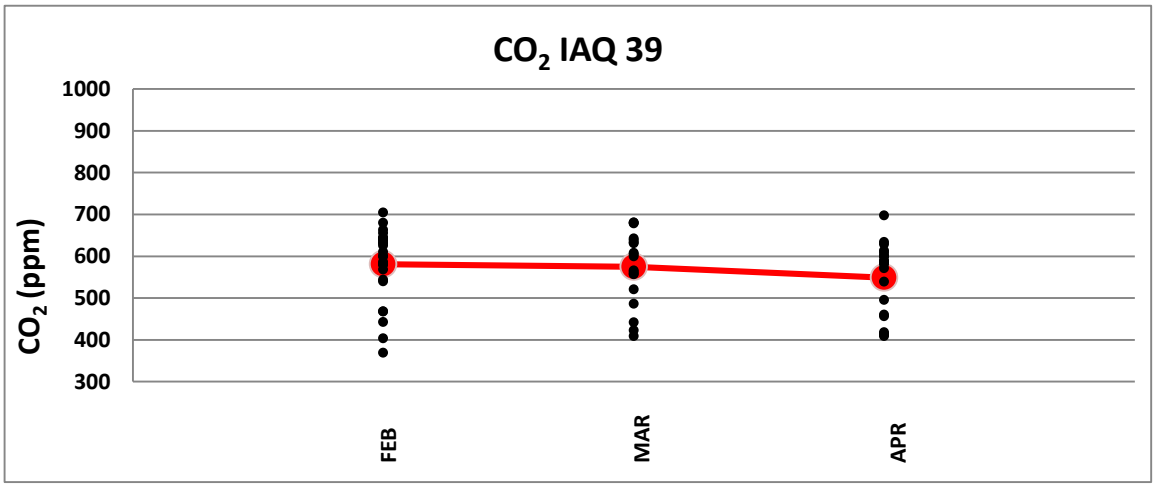


Diagram 5: Monthly CO2 measurements

3.2 VOC's

There is a downward trend at the monthly VOC'S rates for the systems IAQ 39 and IAQ 42 and the indoor air quality could lead to no irritation or discomfort, while some days the limit of 10 o/u was overcome in the 2nd building.

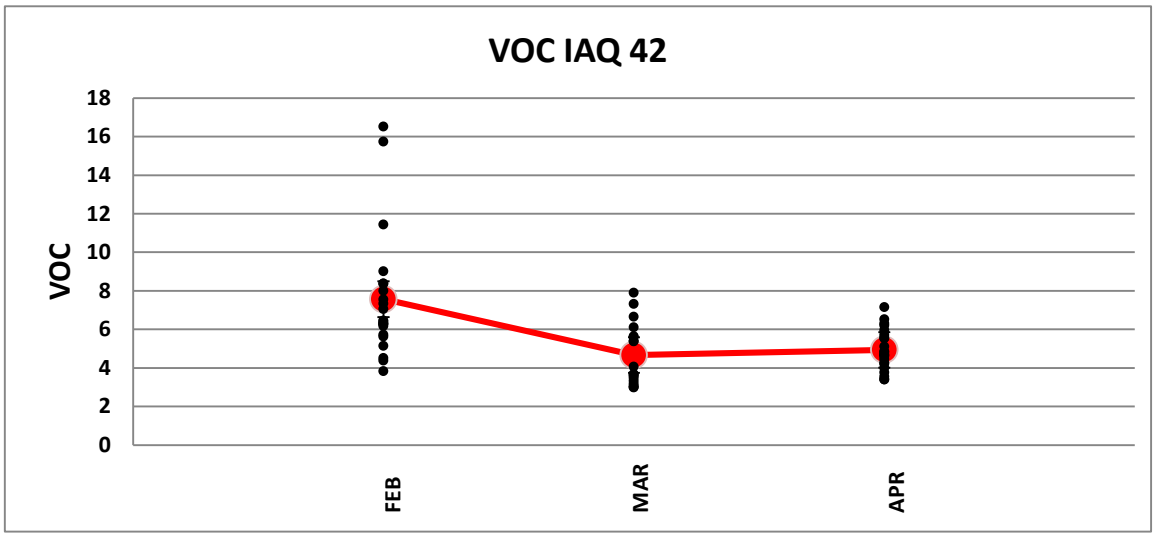


Diagram 6: Monthly VOC measurements

4 CONCLUSIONS

In conclusion, the building's air quality is considered to be good, since the recorded CO_2 values were 0 - 600 ppm. Moreover, both buildings recorded the majority of the hourly VOC's measurements between 0 – 10 o/u (0 - 0,05 of the Molhave scale), so they might be able to cause no irritation or discomfort. The percentages and the diagrams of values for CO_2 and VOC's from Frequency distributions for each building are given below:

CO_2 (%)					
IAQ No	Building Type	< 600 ppm	600 - 1000 ppm	>1000 ppm	Category
39	Office	58.6	40.9	0.4	Good
42	Office	76.4	22.6	1	Good
VOC's (%)					
IAQ No	Building Type	*< 10 o/u*	*10 - 20 o/u*	*20 - 30 o/u*	Category
39	Office	100	0	0	No irritation or discomfort
42	Office	94.5	5.5	0	No irritation or discomfort

Table 3: Percentages of values for CO_2 and VOC's from Frequency distributions for each building