Report Slovenia

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 or possible irritation or discomfort depending on the interaction with other factors, while Tair maintained at higher levels during the operation hours. Last but not least RH was at the higher levels during the non – operation hours of the day in first building and during the operation hours in second building. Finally, the frequency distributions showed that the ventilation is adequate and the air quality leads to possible irritation or discomfort depending on the interaction with other factors in 1st building and no irritation or discomfort in 2nd building.

1 DESCRIPTION OF THE BUILDINGS

The system IAQ 32 is located in retail in Slovenia from October 2013 to April 2014. The building has been constructed on 12/12/1994 and it is located in Ljubljana. The system IAQ 36 is located in retail in Slovenia from October 2013 to April 2014. The building has been constructed on 1/10/2011 and it is located in Trbovlje. The 1st building has an air conditioned area of 2604,32 m^2 , while the 2nd one has an air conditioned area of 1798 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 the 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:

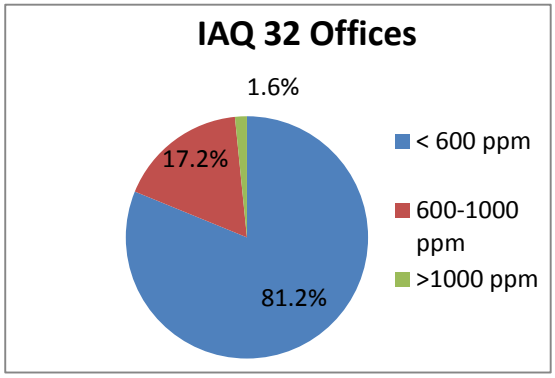


Diagram 1: Frequency distribution CO_2 (indicative)

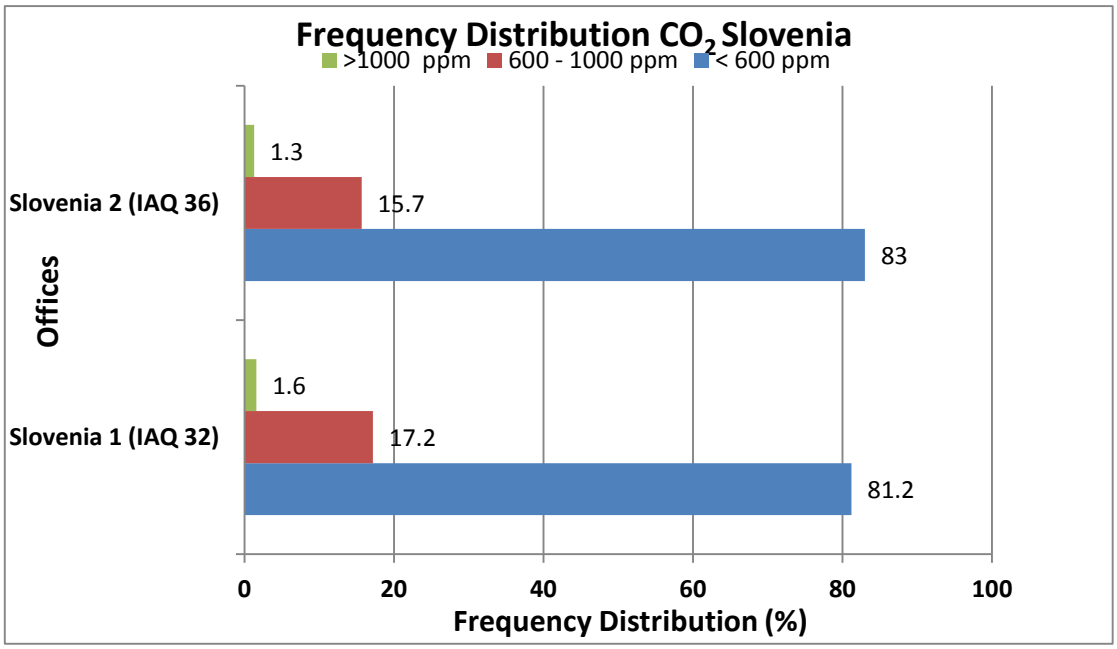


Diagram 2: CO_2 Frequency distribution

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

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:

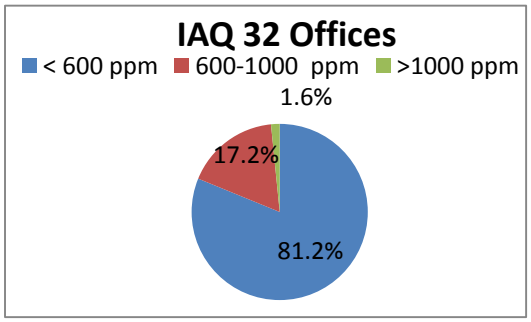
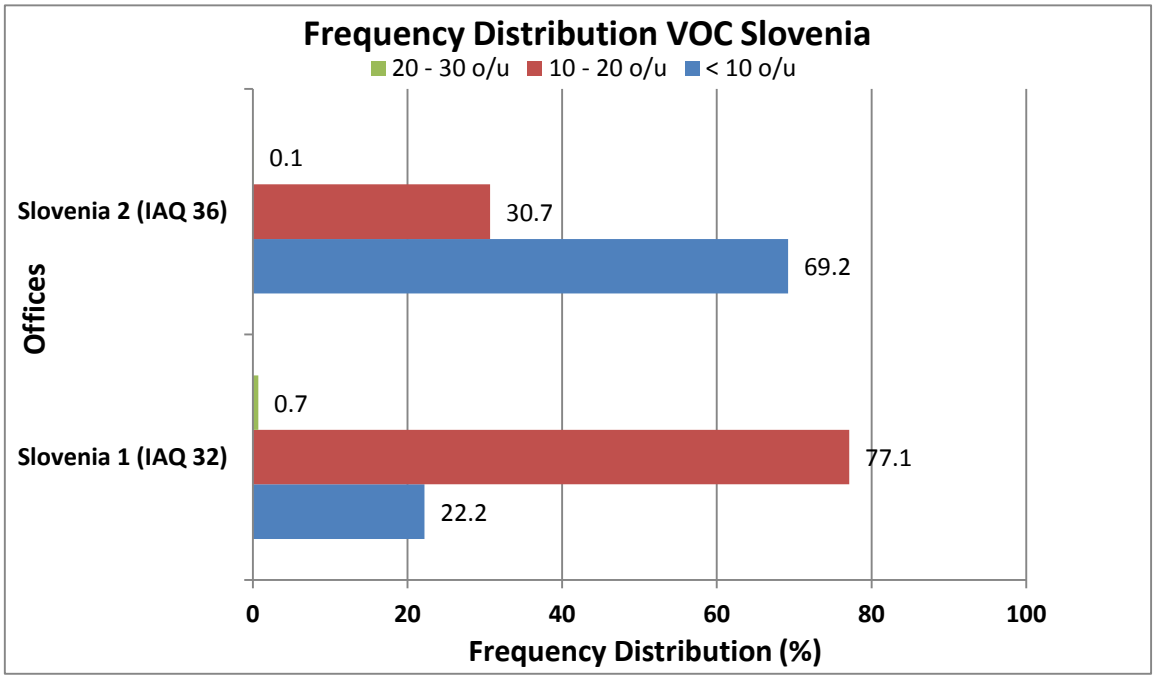


Diagram 3: Frequency distribution VOC'S (indicative)

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 downward trend at the monthly CO_2 measurements for the systems IAQ 32 and IAQ 36 with the maximum of these exceeding the limit of 1000 ppm.

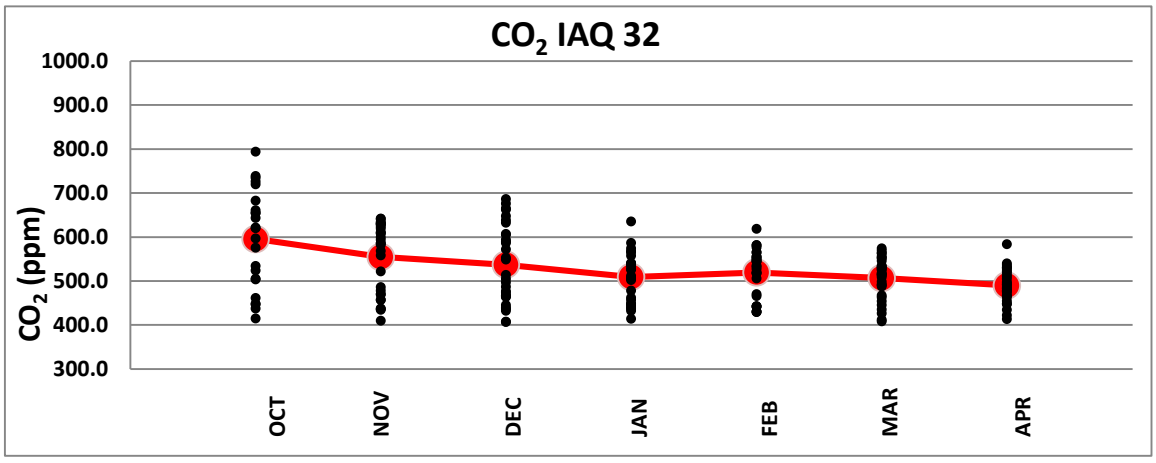


Diagram 5: Monthly CO2 measurements

3.2 VOC's

There is a steady trend at the monthly VOC'S rates for the system IAQ 32 and a downward trend at the system IAQ 36 and the indoor air quality could lead to no irritation or discomfort or possible irritation or discomfort depending on the interaction with other factors.

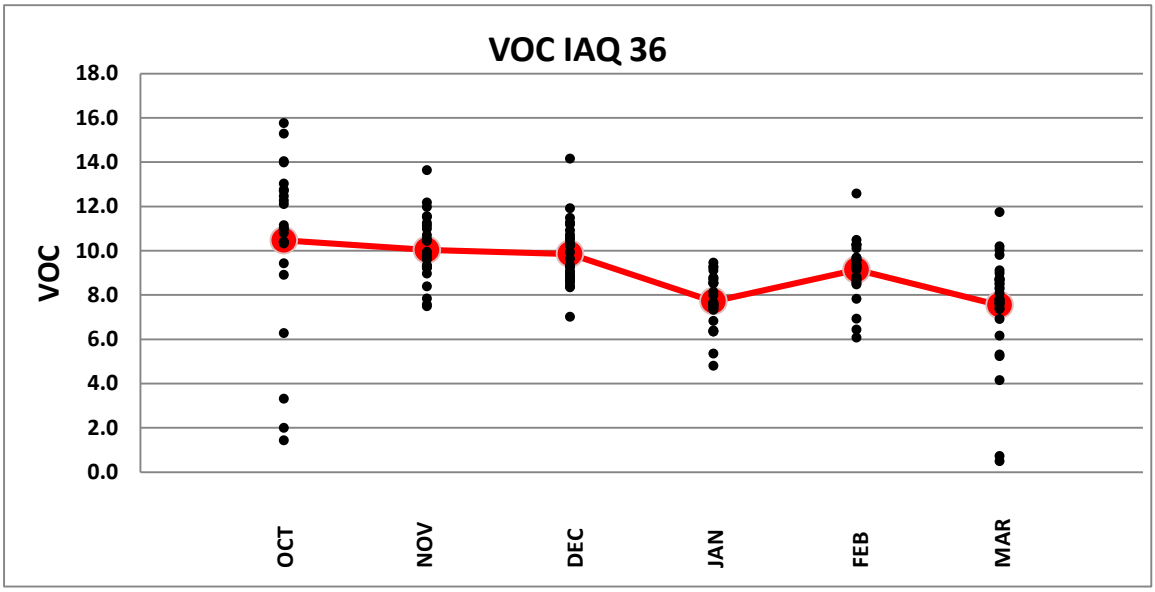


Diagram 6: Monthly VOC measurements

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
32	Office	81.2	17.2	1.6	Good
36	Office	83	15.7	1.3	Good
VOC's (%)					
IAQ No	Building Type	*< 10 o/u*	*10 - 20 o/u*	*20 - 30 o/u*	Category
32	Office	22.2	77.1	0.7	Possible irritation or discomfort depending on the interaction with other factors
36	Office	69.2	30.7	0.1	No irritation or discomfort

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