

**INSTALLATION OF CO₂ SENSORS
FOR SCHOOL SERVICE CENTRES
AND SCHOOL BOARDS**

INTRODUCTORY REMARKS

To ensure that air quality is monitored in all schools in Québec, the Ministère de l'Éducation has asked that educational organizations install approximately 90 000 carbon dioxide (CO₂) sensors in every classroom used for preschool, elementary and secondary school and for vocational training and adult education.

Contracts have been signed with the firms Honeywell, Nova Biomatique, Assek Technologie and Airthings, which will provide the carbon dioxide (CO₂) sensors. The call for tenders ended on August 20. This initiative sets Québec apart as the first Canadian province to install such devices, which will help ensure good air quality in all classrooms in the school network by assisting with the evaluation of certain air quality indicators, and optimizing them, if necessary.

Although we remain on target to meet our objectives, the pandemic has affected our installation plan, which explains certain delays. We have been informed by our suppliers of transport and supply issues beyond their control, including the closure of an overseas factory due to the COVID-19 pandemic. Suppliers are also facing a global shortage of electronic components as another consequence of the pandemic. The Ministère is working closely with all of the suppliers to implement solutions and reach the objectives that have been set.

We would also like to note that the process for selecting suppliers, which was managed by the Centre d'acquisitions gouvernementales in collaboration with the Ministère and its partners, was carried out efficiently and in a thorough manner. Great care was taken to select firms that met all the initial requirements set for comfort parameter sensors.

General considerations

1) What is meant by "indoor air quality" (IAQ)?

It is important to ensure that Québec students and school staff are provided with the best possible learning and working conditions in classrooms. This includes having adequate IAQ.

IAQ is determined by several factors, including CO₂ concentration, temperature, level of relative humidity, air changes per hour, quality of outdoor air and the presence of contaminants such as mould, particles in the air, asbestos, volatile organic compounds (VOCs), radon and carbon monoxide (CO).

For the moment, the intention is for educational organizations to add the CO₂ concentration to the air quality indicators that are monitored. The CO₂ concentration will be monitored on an ongoing basis to allow for better management of ventilation in classrooms, which will contribute to improved air quality and the comfort of the occupants.

The temperature and the relative humidity are also provided for reference purposes, as these factors may contribute to maintaining good IAQ and comfort for occupants.

It is important to note that thermal comfort (appropriate temperature and relative humidity) and sufficient ventilation (acceptable CO₂ concentration) are always desirable, but are sometimes difficult to obtain, especially in winter with the heating on, in summer during heat waves and in buildings without mechanical ventilation. For more information, see the [Document de référence sur la qualité de l'air dans les établissements scolaires](#) (available in French only).

2) What targets must be met to ensure good IAQ and adequate comfort?

- A daily average CO₂ concentration of less than 1500 ppm may be used as an indicator of good ventilation. However, the optimal target for newer buildings (constructed after 2014) is a daily average CO₂ concentration of less than 1000 ppm. This target will serve as the benchmark for work undertaken in the coming years to improve air quality in school buildings.
- The level of relative humidity should be between 30% and 50%, depending on the type of ventilation and the season.
- The ambient temperature should be between 20°C and 26°C, depending on the type of ventilation and the season.

3) Why install CO₂ readers in educational institutions?

The health and safety of students and staff members are a key concern.

Using the data collected by the CO₂ sensors, it will be possible to optimize learning and working environments for students and staff. Note that CO₂ is a natural component of air, and its presence indoors at the levels encountered in school environments does not have negative effects on the health of occupants. CO₂ still serves as an indicator of ventilation quality and a comfort parameter in the same way that temperature and relative humidity do. The installation of sensors will allow the concentration of CO₂ to be monitored in real time in all classrooms in Québec, which means that corrective measures to improve air quality can be taken quickly.

4) Is installing these sensors mandatory?

Yes, sensors must be installed in all classrooms in every public and private educational institution in Québec.

The process

1) What is the role of school service centres, school boards and private educational institutions in the Ministère's action plan?

Educational organizations have been working with the Ministère for several years to ensure good air quality in their facilities. More recently, a new internal action plan for improving indoor air quality was created by the Ministère in collaboration with representatives from the education network. The plan covers the following four areas:

- Air quality management
- Updating norms and standards
- Investment projects and improvements
- Reporting on air quality

Installing CO₂ sensors in schools is part of the first area of the plan.

The installation of sensors was prioritized as follows:

- Priority 1: schools where CO₂ concentrations higher than 2000 ppm were recorded
- Priority 2: schools where CO₂ concentrations higher than 1500 ppm were recorded
- Priority 3: schools with natural ventilation
- Priority 4: schools with mechanical ventilation

Educational organizations are responsible for the ongoing monitoring of all parameters measured, as well as saving the data and storing it for 10 years.

2) Why weren't the sensors installed over the summer?

We were waiting to acquire the devices.

The Ministère had to complete several steps before launching the call for tenders last July to find the most appropriate solutions. Installing more than 90 000 sensors for measuring CO₂ concentration, temperature and relative humidity in every school throughout Québec is a major undertaking involving the creation of intervention protocols and directives and requiring input from experts in various fields (e.g. public health, occupational health and safety, engineering). The Ministère also deemed it advisable to conduct two technical demonstrations to better understand needs in the field before starting the call for tenders process. These preparatory steps were necessary.

3) Which stakeholders were consulted?

The Ministère drew on resources in the field, on interdisciplinary expertise, on the knowledge of scientists, various experts and its own specialists (MSSS, INSPQ, CNESST, IRSST, AQCS, FCSSQ, ADGCSSQ) and on experts from the school network specialized in material resources and engineering.

In addition, the Ministère called on Ali Bahloul, a researcher in the field of industrial ventilation and indoor air quality at the Institut de recherche Robert-Sauvé en santé et en sécurité du travail. Mr. Bahloul will assist the Ministère throughout this major undertaking and in the development of the protocols required for the smooth implementation of this program.

The Ministère has implemented the following governance structure to manage this initiative:

- A **strategy committee** to determine the orientations, made up of representatives from the Ministère, the IRSST, the AQCS, the FCSSQ and the ADGCSSQ. This committee will consult on pilot projects.
- A **technical committee** to analyze the issues at the local level and make recommendations, made up of representatives from the Ministère, school service centres, school boards and the IRSST. This committee will provide the Ministère with expert advice on implementation in the network.
- A **three-party committee** to contribute to the process, made up of representatives from the Ministère, the MSSS-INSPQ and the CNESST-IRSST. This committee provides a high-level perspective on health and safety in learning and working environments. It was formed with the goal of supporting, guiding and advising the Ministère on requests from the school network concerning ventilation. Another part of this committee's mandate is to ensure better harmonization of the actions taken by the Ministère regarding indoor air quality.

4) Did the INSPQ validate the Ministère's documents?

In order to create the new CO₂ measurement protocol, the team from the Ministère worked in close collaboration with the IRSST, specifically with Ali Bahloul, an expert in industrial ventilation and indoor air quality. Experts from the CNESST and the INSPQ supported the Ministère in this process by providing advice and commentary on all the documents produced.

The Ministère has adhered to a rigorous process and delivered high-quality work as quickly as possible.

5) When will the sensors be delivered and installed?

Although we remain on target to meet our objectives, the pandemic has affected our installation plan, which explains certain delays. We have been informed by our suppliers of transport and supply issues beyond their control, including the closure of an overseas factory due to the COVID-19 pandemic. Suppliers are also facing a global shortage of electronic components as another consequence of the pandemic. The Ministère is working closely with all of the suppliers to implement solutions and reach the objectives that have been set.

The CO₂ sensors will be distributed fairly between all school service centres and school boards to encourage rapid installation. Directions were sent to school service centres and school boards to determine installation priority in buildings:

- Priority 1: schools where CO₂ concentrations higher than 2000 ppm were recorded
- Priority 2: schools where CO₂ concentrations higher than 1500 ppm were recorded
- Priority 3: schools with natural ventilation
- Priority 4: schools with mechanical ventilation

A list of schools classified as priority 1 and 2 has been sent to the school service centres and school boards. Suppliers have also been informed of these priorities.

6) Where did the technical demonstrations take place?

The CSS du Val-des-Cerfs and the CSS des Chênes agreed to participate. For more details, please contact the Ministère.

7) How much will this project cost and who is going to pay for it?

The Québec government will cover the cost of purchasing equipment for both public and private schools. Total funding of approximately \$76 million will be dedicated to the purchase and operation of sensors over the next 10 years.

For accounting purposes, the value of acquired equipment distributed to each school service centre or school board will be sent to the Financial Services department of each school service centre or school board.

The Ministère de l'Éducation previously announced an investment of \$40 million for building maintenance, especially ventilation systems, as well as a new budget envelope of \$10 million per year over three years to improve indoor air quality. The Minister also distributed several hundred air exchangers in the network.

8) What is the current air quality in schools?

The Ministère de l'Éducation recently published a report on air quality in schools (available in French only):

<http://www.education.gouv.qc.ca/references/tx-solrtyperecherchepublicationtx-solrpublicationnouveaute/resultats-de-la-recherche/detail/article/la-qualite-de-lair-dans-les-etablissements-scolaires/>

9) Why stop at simply installing CO₂ sensors?

The plan goes beyond the installation of CO₂ sensors. The sensors come with procedures to optimize and improve the existing ventilation systems. Staff working in schools can act in real time to improve air quality in their classrooms (e.g. by opening the windows and door) in order to maintain a learning environment that encourages educational success. Note that this is a 10-year plan and is designed to maintain proper ventilation in school facilities well beyond the end of the COVID-19 pandemic.

Health of students and staff

1) Is CO₂ dangerous to health?

The concentrations present inside our buildings are not dangerous to the health of occupants.

However, it is true that too high a concentration of CO₂ in an enclosed space may be problematic. Educational organizations can aim to prevent discomfort by taking certain measures, such as providing adequate ventilation.

It is important to differentiate between carbon dioxide (CO₂, breathed out by humans) and carbon monoxide (CO, produced by harmful combustion).

- A low level of CO₂ is targeted for comfort, educational success and the dilution of certain contaminants that may be present in indoor air, through ventilation.
- The presence of CO is an immediate and serious danger (evacuation of the school).

Note that poorly maintained oil or gas heating systems that lack an alarm system may lead to dangerous increases in CO in various environments, including schools.

2) What are the management criteria for CO₂?

Health Canada recommends an average concentration over 24 hours of lower than 1000 ppm in proposed guidelines published in 2019.

ASHRAE recommends that the exposure limit for CO₂ be set at 700 ppm greater than the CO₂ level measured outdoors.

The standard set in the *Regulation respecting occupational health and safety* is less than 5000 ppm (upper limit of average exposure, concentrations higher than this may lead to health problems).

3) What are the CO₂ thresholds recommended by the Ministère?

Mechanically ventilated buildings:

- In a reference document on indoor air quality in Québec schools (*Document de référence sur la QAI dans les établissements scolaires du Québec*, available in French only), the Ministère sets the concentration of CO₂ at 700 ppm higher than the concentration in the outdoor air. Assuming an outdoor concentration of 350 to 450 ppm, or even 500 ppm, this means an average daily indoor concentration ranging from 1050 to 1200 ppm.
- The Ministère's optimal target for new buildings is a daily average CO₂ concentration of less than 1000 ppm.

Naturally ventilated buildings:

The Ministère is targeting a daily average CO₂ concentration of less than 1000 ppm, but considers a daily average CO₂ concentration of less than 1500 ppm an indication of adequate ventilation.

All buildings, for level of relative humidity and temperature:

- A level of relative humidity between 30% and 50%, depending on the type of ventilation and the season
- An ambient temperature between 20°C and 26°C, depending on the type of ventilation and the season

Note that these comfort parameters must be respected as they may have an impact on the educational success of students.

5) What will be done with the readings taken using the devices?

Real-time readings allow changes to be made directly in the buildings by adjusting the inflow of outdoor air, for example, or completely airing out a room during a break.

Data on daily averages can be used to identify trends and target buildings that may require broader intervention plans and/or more extensive repairs or corrective measures.

For more information, please contact the Ministère.

6) What does the Ministère plan to do when results exceed the limits set, especially in rooms without windows or ventilation?

Ideally, these rooms would not be used as classrooms, but if this cannot be avoided, educational organizations must ensure that fresh air inflow is possible in these rooms. The Ministère will make air exchange systems available to school service centres and school boards with rooms of this type. This equipment allows fresh air to be brought in from outside.

It is the responsibility of educational organizations to request these systems and install them as soon as possible. Under the law, school organizations are responsible for maintaining the buildings they use and ensuring the safety of occupants.

7) What types of ventilation are used in school service centres or school board buildings?

There are three types of ventilation in buildings:

- Mechanical ventilation: the building is equipped with a mechanical ventilation system for heating and/or cooling and drawing fresh outdoor air into rooms. These buildings may also have windows that open, increasing the amount of fresh air that can be brought in.
- Natural ventilation: the building does not have a mechanical ventilation system and it is necessary to open the doors and windows to ensure an inflow of fresh outdoor air.
- Hybrid ventilation: a mix of the first two types. This is often the case with buildings that have been extended. The old sections are ventilated naturally, and the new sections are ventilated mechanically.

Each school service centre and school board must have the required information to complete the answer.

8) Last year, teachers said that when it was cold outdoors, it was nearly impossible to open the windows to let fresh air in. Has the Ministère come up with a solution to ensure good air quality in these conditions?

Comfort related to air quality involves several parameters, including temperature, relative humidity and CO₂ concentrations. In classrooms, it is important to maintain comfortable levels of all three, without disturbing the balance. Once sensors are installed in classrooms, it will be easier to evaluate the need to open windows in cold weather.

Following the installation of the sensors, data will be analyzed to allow educational institutions to identify classrooms in which it is difficult to maintain a comfortable balance. Investment projects can then be undertaken to achieve a balance of the three comfort parameters and thus improve air quality.

9) How often should air be exchanged?

Mechanically ventilated buildings:

- The requirements set by the Ministère call for six air changes per hour (ACH) for a ventilation system that recirculates some air in the distribution system.
- For a ventilation system with 100% exterior air, four ACH are acceptable.

Naturally ventilated buildings:

- In general, the requirements set by the Ministère call for a number of ACH that complies with the *Regulation respecting occupational health and safety*.
- Although the number of ACH is random in naturally ventilated buildings, opening the windows and doors generally allows this requirement to be met. However, the static air pressure in a building, the wind direction and the temperature may make it difficult to meet this requirement.

Ongoing measurement of CO₂ concentration makes it possible to identify rooms lacking adequate inflow of outdoor air, resulting in a low number of ACH, whether or not the doors and windows are open. In such a case, many solutions are possible, but they must be applied in a progressive

manner, starting with the simplest actions (e.g. opening windows and doors, raising awareness) and moving gradually to more complex actions (e.g. installation of air exchangers or replacement of mechanical ventilation systems).

10) Should we be concerned about a one-time measurement that does not meet the standards?

No, it is important to refer to both the CO₂ concentration and the daily average concentration, and to check for persistent high averages over time. For example, one day with an average higher than 1500 ppm out of an entire month does not warrant the same attention as several days with an average higher than 1500 ppm in the same month. It is also important to consider the outdoor temperature and CO₂ concentration when analyzing the results.

11) What is the protocol if the data shows levels higher than the thresholds established?

The Ministère has provided the school service centres and school boards with a guide that includes the procedures to follow should the data exceed the established thresholds. In general, educational organizations must analyze each situation and make corrections to improve the situation. All of the actions must be taken in a progressive manner, starting with the simplest actions (e.g. opening windows and doors, raising awareness) and moving gradually to more complex actions (e.g. installation of air exchangers or replacement of mechanical ventilation systems).

12) Who is responsible for managing IAQ?

In collaboration with the personnel responsible for material resources in schools, teachers are called upon to take action as part of their responsibility for what goes on in their classrooms. For example, they will have to open the windows when necessary and ensure that there is sufficient inflow of outdoor air when the situation requires it.

13) What simple actions can be taken to improve IAQ?

- If possible, open the windows, vent sashes (small windows located above classroom doors) and doors before the start and after the end of classes.
- Regularly air out rooms that are in use by opening the windows during the school day, ideally when students are not present (at least 10 to 15 minutes, at least twice a day), even in winter.
- Create a routine to ensure that all windows are closed after classrooms have had their daily airing out. This will prevent pipes, window slides and window hardware from freezing.
- Leave classroom doors open as often as possible.
- Use the time between classes to open the doors and windows as wide as possible for five minutes, even in winter.
- Leave vent sashes open as wide as possible, if the room has them.

If problems persist, more serious measures may be considered, such as:

- repairing window mechanisms
- turning up the heat in winter
- installing an air exchanger or an extractor
- installing a central ventilation system in the school

Educational institutions and teachers will of course be reminded of these measures over the next year.

14) How is the information recorded by the sensors communicated?

Connected sensors communicate directly with the digital controllers managing the building. The data is then sent to the information management system to be analyzed.

For **stand-alone sensors**, criteria have been added to the call for tenders to ensure that the proposed solutions are compatible with the Internet networks in school service centres and school boards. There is no provision for the sensors to communicate directly using Wi-Fi, in order to avoid issues with information security. The sensors will communicate using radio waves.

Teachers can read the data from the sensors right in their classroom. School administrations will receive reports generated by the system, which will allow them to identify the classes where the thresholds have been exceeded and intervene directly with teachers. The material resources departments of educational organizations will also receive reports that allow them to identify trends in different schools and plan interventions regarding air quality. It is the responsibility of each school service centre or school board to manage these communications with their educational institutions and personnel.

15) Will the sensors used in classrooms have a display that allows teachers to see the CO₂ level so they can then open the windows if necessary?

Yes, the sensors will have a built-in display that allows teachers to act immediately by opening windows and doors, as is required under the current policy. Adding this equipment will make it easier for them to respond appropriately to the situation.

For any additional questions, please contact us at dgi@education.gouv.qc.ca.

Direction générale des infrastructures
 Ministère de l'Éducation
 1060, rue Louis-Alexandre-Taschereau
 Aile Jacques-Parizeau, 3e étage
 Québec (Québec) G1R 5E6
 Tel.: 418-644-2525