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Demand Controlled Ventilation Systems

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Abstract

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The purpose of the Bachelor's thesis was to compare different approaches to demand-controlled ventilation (DCV) systems which can be applied to school buildings, and to find the most suitable system to satisfy the need for better indoor air quality in classrooms while providing highest potential energy savings.

Literary sources were studied to establish the base approaches to automatically control ventilation systems on the basis of room occupation levels, as well as the usage of these tools in existing products available in the market. Major focus was given to CO_2 control systems since, in theory, they should directly tackle the problems with indoor air quality in classrooms in most cases. The thesis also includes sample calculations of airflow balance for CO_2 based ventilation control systems.

The result showed that DCV systems are an important tool to achieve good indoor air quality and that, in most cases, CO_2-based control systems will provide the best result. In addition, most modern ventilation systems available tend to compile multiple methods in one product, even including specific measurement methods.

Keywords: demand controlled, ventilation, indoor air quality, classrooms

Contents

1 Introduction

The final year project focuses on different types of Demand Control Ventilation (DCV) systems and control tools which could be applied in spaces like classrooms and lecture rooms, since the indoor air quality (IAQ) in school buildings is a major concern in European countries, especially in Northern Europe where ventilation is more often achieved through mechanical ventilation, due to the change of seasons. However, mechanical ventilation systems account for a significant portion of HVAC system energy consumption and total energy consumption. The improvement of both indoor air quality and energy demands are challenges considered in Sustainable Building Engineering studies.

The second chapter of the thesis is dedicated to indoor air quality concerns across Europe and the reasoning behind the integration of mechanical ventilation systems in buildings. The third chapter explains the principles of modern ventilation systems and commonly used design values according to standardization. Further, it describes the relation of CO_2 levels to indoor air quality and student comfort in classrooms.

The fourth chapter of the thesis explains the implementation methods of demand control in ventilation systems, the benefits of each of the methods and a comparison for highest potential energy savings considering the average classroom. The fifth chapter demonstrates the basic methods of utilizing CO_2-based demand-controlled systems and compares the results of case studies where such method is used in refurbished buildings across Europe. Additionally, a part of chapter five is focused on market offered solutions for demand control systems. The sixth chapter gathers the results of the findings and presents conclusions about the viability and potential uses of DVC systems.

2 Indoor Air Quality

According to World Health Organisation data, millions of Europeans spend approximately 90% of their time indoors, whether it is in their homes, workspaces, schools or public spaces [1]. Therefore, good indoor air quality is a top priority to ensure the wellbeing and general comfort of people. Simultaneously, modern building standards enforce low air permeability through building envelopes in order to reduce energy losses related to ventilation. This trend started as early as 1973 due to the energy crisis. [2.] As a side effect to this, building indoors became more enclosed, leading to an accumulation of hazardous substances in the indoor air. The main negative contributors to harmful indoor environments are for example carbon dioxide (CO_2) accumulation, volatile organic compounds (VOCs) from building materials and furniture, as well as high room humidity, which can be cause for mould leading also to possible damage to materials. [3.]

With increased performance requirements, some of the more traditional types of ventilation become inefficient, for instance, passive stack ventilation or relying completely on window ventilation. For this reason, new buildings along with renovated buildings are often equipped with mechanical ventilation systems, especially in Nordic countries with cold seasons. However, to ensure that all the systems work well together and produce the best indoor air quality while maintaining the best energy efficiency is a challenge for HVAC designs.

3 Ventilation System Design Principles

3.1 General Ventilation System Principles

The purpose of ventilation is to deliver fresh outdoor air into the indoor environment to disallow the accumulation of indoor pollutants such as VOCs and CO_2. Additionally, a ventilation system provides control over the indoor temperature and air humidity in an enclosed space, thus becoming the most important tool in HVAC systems to control the indoor air quality. However, it is also the most energy consuming section of HVAC systems in the building. [4, p.4].

When considering mechanical ventilation, the goal is to estimate the maximum required fresh outdoor air supply considering the use of space, size and occupancy. By underestimating the needs, the hazards in indoor air discussed above may be realised, causing poor air quality, which in turn leads to occupants' discomfort. However, in case of mechanical ventilation even if the values are set correctly for maximum fresh air needs, setting and leaving the system at a fixed rate of air intake leads it to cause energy losses if changes in occupancy are not taken into account. [3, p.8].

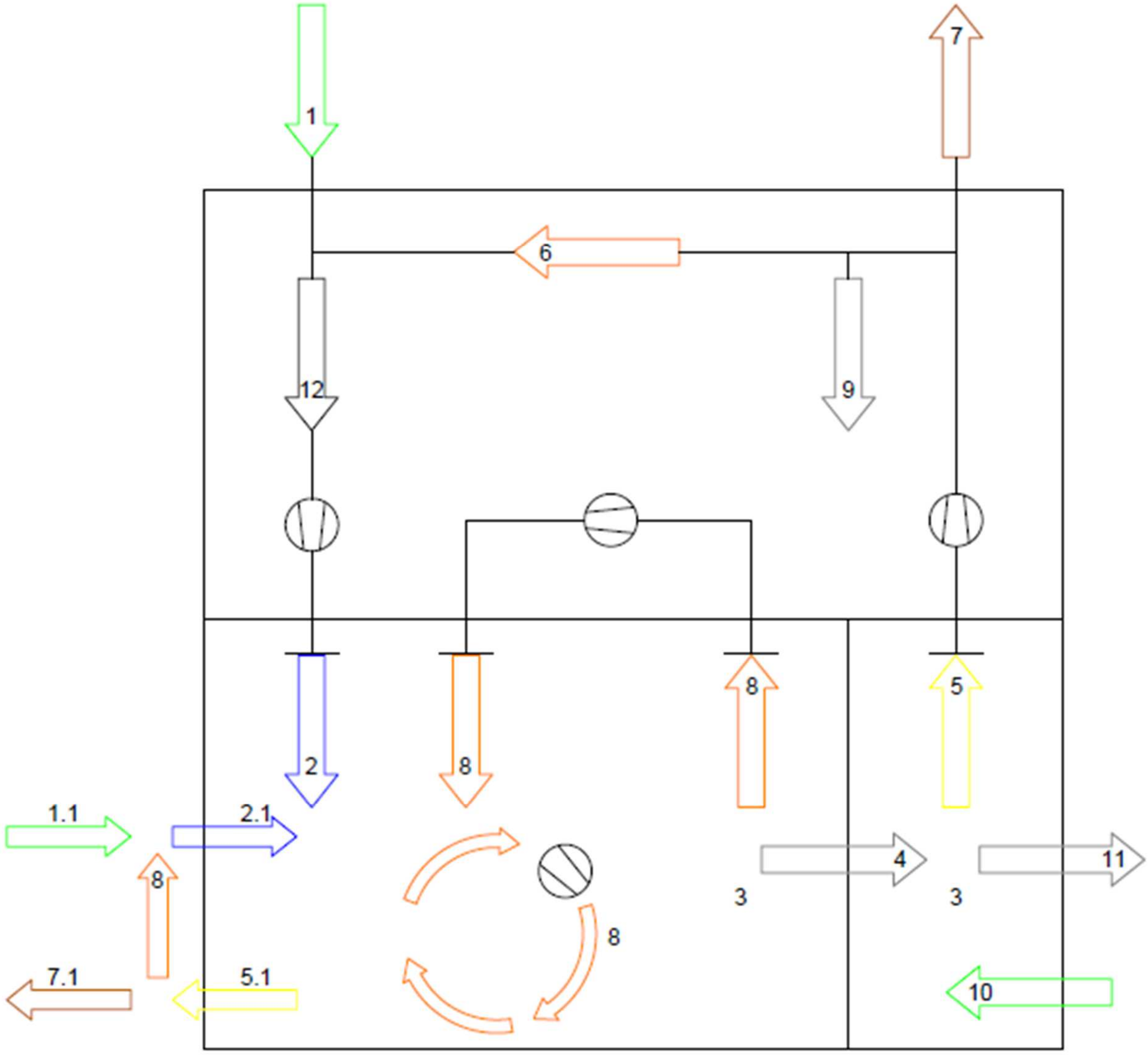

Figure 1. – An illustration of types of airflows in building ventilation system.

Figure 1 represents the general airflows in a ventilation system regardless of building type. The standardizations give base design values for supply air, number 2 in the drawing, in different types of buildings to maintain acceptable IAQ. Using these values, the designers have to determine the required total supply of air to the building. The appropriate descriptions of air flows can be found in appendix 4 [5].

The schools, classrooms and lecture halls are examples where ventilation systems need to work close to the maximum requirement for portions of the day or just facilitate the minimum required air flow depending on classroom occupancy. During the heavy loads, good IAQ is important to ensure that the working ability of both students and teachers are not hindered by bad air quality. Yet, outside of the working hours the ventilation system is not required to work at maximum performance, as it would lead to waste of energy [4, p.8].

3.2 Design Values in Schools

Most of the indoor ventilation standardizations provide a set of suggested design values for space ventilation, which are used to design maximum required airflow according to the type of building. Specifically, general standardization, as well as the Finnish regulations and guidelines for indoor climate and ventilation in buildings suggest a design value for classrooms of 6 l/s per person as a starting point for ventilation design needs. This value is meant to represent the optimal air supply for a classroom occupant while avoiding too high velocities in systems that would cause other indoor environment hazards, such as air drafts in classrooms and too high noise in ventilation systems or even provide uncomfortable temperature in a set space [6].

However, research [6] indicates that required ventilation rates for school classrooms in Finland can differ from case to case being lower than the predetermined 6 l/s or going as high as 10 l/s per person. While on one hand, it is understandable that having a higher supply airflow rate will help to prevent issues with high CO_2 and accumulation of moisture in air, on the other hand, if the ventilation system is not exactly suited for its task, it causes the discomforts with noise and air drafts. Furthermore, without additional control mechanisms, a set state mechanical ventilation will prove to be expensive [4].

When designing ventilation systems, it is also important to consider the type of construction. It is probably easier to implement systems with more suitable airflow rates in new projects, and, thus, avoid the risks of set indoor environment hazards, whereas in renovations there might be additional limitations in terms of space and possibility to integrate advanced HVAC systems in older buildings. Furthermore, buildings under renovation might contain older building materials that over time produce additional VOCs which have to be removed from the indoor air in order to maintain good air quality. Therefore, renovation projects might create a need for systems with higher capabilities in order to maintain efficiency.

In response to the points discussed above, also current guidelines are getting updated, and they already encourage the usage of ventilation rates based on the demand during the use of room. Regardless, it is still a requirement to estimate the maximum required ventilation rate according to a school building's needs, as well as set a baseline ventilation rate to remove background contamination caused by building materials [3, p.46].

3.2.1 CO_2 Levels in Classrooms

One of the main indicators for good IAQ in general is the CO_2 levels in the room during the occupancy periods. Other important measurements for HVAC systems are room air temperature and air humidity levels. However, increases or decreases of CO_2 levels relate directly to the usage of the room [5].

Studies that focus on students' performance in classrooms have identified that high levels of CO_2 contribute highly to the general discomfort during and after the time spent in the classroom. Naturally, it also decreases the students' productivity and hinders the learning process. If the fresh air exchange is insufficient, CO_2 can accumulate rapidly in a classroom with many students [3, p.15]. Therefore, limiting the CO_2 content should be an important target when designing ventilation systems for classrooms.

Table 1. Summary of carbon dioxide concentration – Comfort levels [7].

CO_2 concentration description	CO_2 Level (ppm)
Normal outdoor level	350 – 450
Good levels	450 – 1000
Possible drowsiness (Acceptable levels)	1000 – 2500
Maximum allowed concentration within an 8-hour working period	5000
Dangerous level to health	>30000

For CO_2 concentration in classrooms, the ASHRAE standard 62.1 provides guidelines, with recommended levels at less than 1000 ppm. Most often the increase in CO_2 levels in the classroom during the active hours is caused by human metabolism and the rate per person can be predicted. The approach of using CO_2 concentration readings in rooms is acknowledged as a method to design fresh air flow demand, since CO_2 levels also provide information on how populated the room is at a given time of the day [3, p. 25].

4 Demand Controlled Ventilation (DCV)

As discussed above in chapter 3.2, revisions of ventilation standardization and indoor climate encourage building owners to use demand-controlled ventilation (DCV) systems, especially for buildings with varying occupancy during the day or from day to day. Usually, the buildings do not require the maximum possible amount of fresh air during the whole day, only during specific working hours. Variable fresh airflow can be introduced as “on demand”, based on real time readings from sensors, or through the means of automatic controls based on predetermined occupancy patterns. This approach would lead to a more efficient use of energy required for ventilation of rooms. In addition, the bigger the fresh air requirement for building is, the bigger are the profits of a DCV system. As one of the reference points, buildings with airflow rate requirements over 2000 m^3/h should consider the usage of DCV. Especially, school buildings would be considered under these criteria for the implementation of “on demand” ventilation systems. [3, p. 25.]

Most mechanical ventilation systems can be improved to serve as a DCV system; however, it would require several additions to the system to work properly. Firstly, the system needs a means of controlling the airflow itself. This can be achieved with fans with variable fan power, and mechanical dampers. Secondly, the system needs some type of input from the occupied space. This can be achieved by the use of a certain type or combination of sensors or time, in case of scheduled tasks. Most common output methods are temperature and moisture readings or CO_2 readings from an occupied space within the building [4, p. 5].

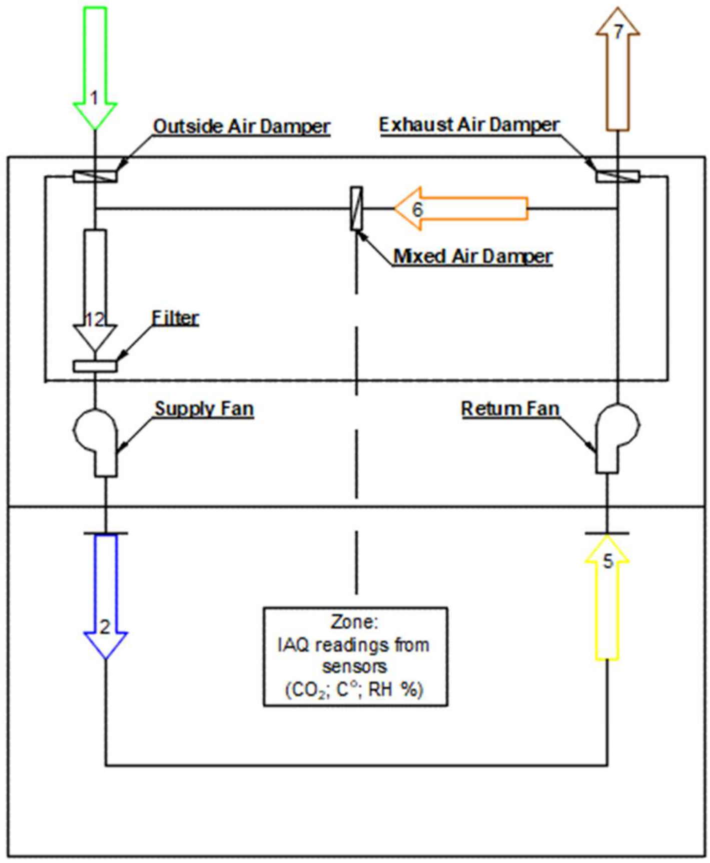

Figure 2. – Ventilation control system scheme with return air.

Figure 2 shows a schematic ventilation control system with additions to the general air loop in the building, which can be used to improve the fixed rate mechanical ventilation system as discussed in chapter 3.1.

When implementing a DCV system, it is important to remember that maximum and minimum requirement calculations are still required to ensure that the system will work properly, since the purpose of DCV is only to monitor and adjust ventilation real time. Maximum ventilation capacity design is required to assure that the system will perform at maximum occupation capacity without issues. Nonetheless, a minimum base ventilation rate is required to remove background pollutants from building materials and furniture fabrics regardless of the occupancy. This is especially important when renovating older buildings, since some older building materials are considered harmful if building occupants are exposed to the contaminants [5].

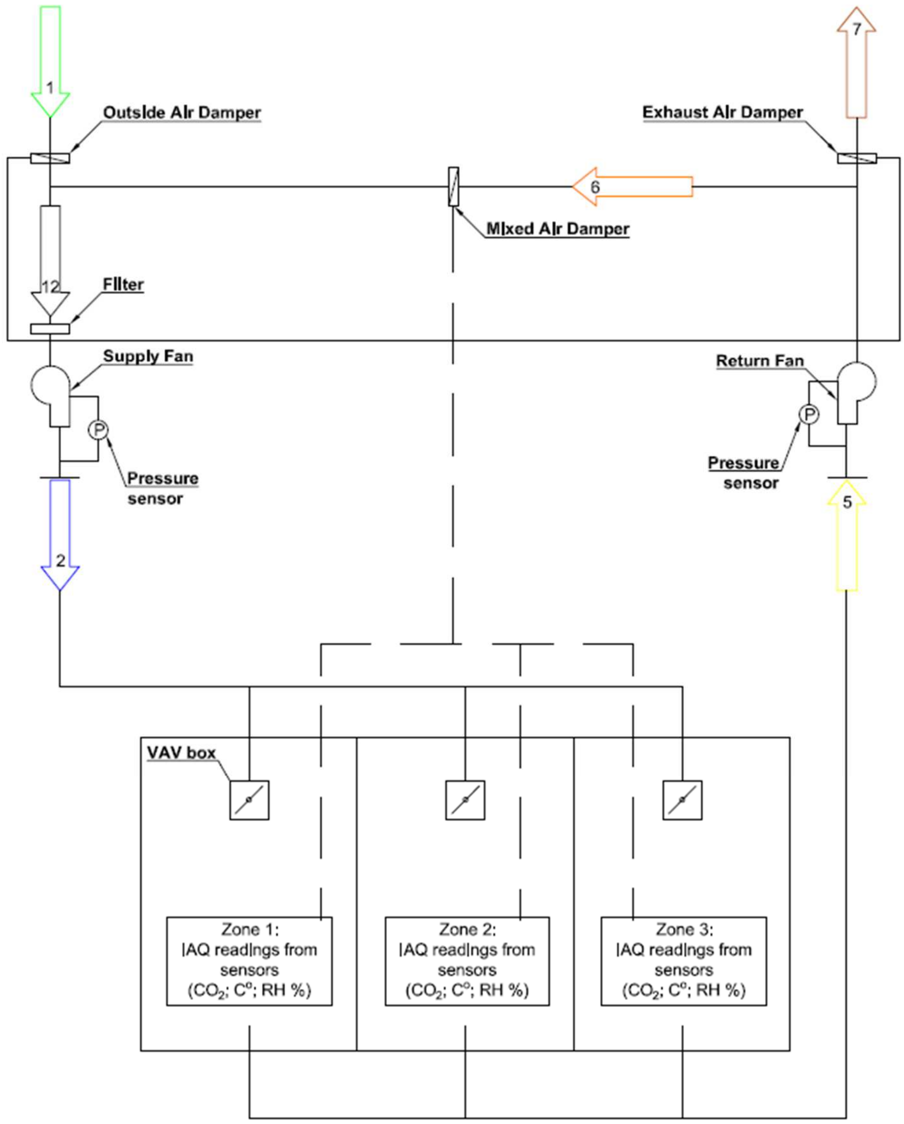

Figure 3. Ventilation system with several demand-controlled spaces.

Figure 3 shows a schematic for the ventilation system when it covers multiple spaces. The controls of the outdoor damper are similar to those in the system presented in figure 2 above. However, when considering multiple zones, the position of the Variable Air Volume (VAV) box damper is more complex. At this point, the building automation system has to determine the critical zone and adjust all connected VAV boxes to fulfil the requirement for the critical zone [4, p. 32].

4.1 DCV Implementation Strategies

When considering the addition of DCV to a building, there are multiple implementation strategies to maintain good indoor quality and reduce energy consumption by ventilation. The most noticeable are

- Occupancy schedule
- Presence control
- Air quality – based system [4].

Methods like occupancy schedule could be considered as predictive as they use a previously estimated value, whilst the other alternatives operate by reacting to the changes in room occupancy. Additionally, many modern products offer a mix of these tools to ensure the best possible outcome [5].

4.1.1 Occupancy Schedule

The first DCV strategy type to discuss is the occupancy schedule. This can be applied by installing a timer to the ventilation system with a predetermined schedule of the room’s occupancy. At a set time, the ventilation system will turn on or increase the airflow rate to classrooms. Even though it is possible to predict working hours for an individual classroom in a school, as well as to design maximum required flow rate for classrooms, this strategy relies on prediction of occupancy and is susceptible to changes in actual use times of the classrooms. However, a simple improvement can be achieved through the addition of timers to an already existing constant air volume ventilation system which otherwise operates continuously or must be adjusted manually [3].

4.1.2 Presence Control

The second DCV strategy listed above utilizes a presence sensor to monitor the occupation of a space to control the required rate of ventilation. Often, the information to the system is delivered by passive infrared sensors (PIR). These devices work by measuring changes in infrared radiation within their range. More commonly, PIR devices are used in light switches and on motion sensors for alarm systems. However, they can also be used to monitor occupancy rate in a room [4].

When focusing on DVC systems used in classrooms specifically, movement sensor-based control system is least useful, since classroom work does not often require a lot of movement. Therefore, methods that can produce data for steady state calculations are more useful. It is worth mentioning nonetheless, since presence control can be utilized in school buildings in areas that are not classrooms and where measurements like CO_2 level monitoring is not feasible, for example, in locker rooms and sports halls [5].

4.1.3 Air Quality-based System

The final DCV strategy listed in above is the control strategy based on air quality detection, also referred to as CO_2 based DCV system. Additionally, the use of humidity or VOC sensors can be considered in this category.

The location of a CO_2 sensor is important, since their measures can be altered by the interference of the surroundings. It is not recommended to place CO_2 sensors near doors, lamps, heaters, in direct sunlight or behind curtains or coat-stands, since all these locations can alter the readings of the control devices [3, p. 22].

One possible location for a sensor is directly in an exhaust duct. However, this does not work accurately if there are multiple spaces connected to the same exhaust duct. Other acceptable locations for sensors can be on the wall in areas which require monitoring, for example in a classroom. Even here the location must be chosen carefully to avoid a direct contact with a student, and the measurements can be altered if the device is located too close to doors or openable windows [3 p. 22].

The air-quality based systems benefit from being able to directly monitor the causes of hazards to the indoor air quality and automatically adjust ventilations systems accordingly to improve indoor air quality. However, it requires use of the right type of sensor or combination of different types, in case there is potential for multiple hazards within the room.

4.2 Energy Saving Potential

Alongside the established benefits in terms of improved IAQ and building user satisfaction, also estimations of the energy saving potential of DCV should be discussed. The ventilation systems require a significant portion of HVAC system total energy consumption in buildings and more often ventilation is directly tied to heating with heat recovery systems or cooling systems, depending on the climate where the building is located. The addition of the DCV to the HVAC system also requires more complex designs and larger initial investment from the building owners, therefore its actual efficiency and possible payback time is a major consideration.

As shown in studies, depending on the used strategy, the relative energy requirement can be reduced quite significantly, providing significant energy cost savings [8].

Table 2. Relative effect of various ventilation strategies on the energy requirement for schools with 200m^3 classroom with 30 pupils, 10 l/p*s, basic flow 0.5h^{-t} [8].

No.	Strategy	Relative energy requirement
1	Full flow, 24h	1.00
2	Full flow 10h during the day, basic flow 14h	0.47
3	Presence-related control	0.36
4	As for case 2, but with 50% heat recovery	0.24
5	As for case 3, but with 50% heat recovery	0.18

The table 2 shows total energy requirement and potential energy saving of displacement ventilation compared to a basic mechanical ventilation system without any additional control system. The displacement ventilation results in a 20% reduction of the user-related requirement. The example assumes the general case of a school's classroom with 30 pupils. The factors that should be considered when applying any DCV strategy for a space are:

- The air flow rates
- The length of operating hours
- The energy prices
- The general climate at the building location.
- Pressure drops in system
- Good heat recovery system
- The efficiency level of system
- The initial costs of system/ payback time. [3.]

Specifically, when designing the system for school buildings, the possibility of openable windows should also be considered as they can be used as a supplement to the ventilation system if the outside climate is favourable. In general, if the factors listed above are taken into consideration when considering the implementation of a DCV system, school classrooms have a great potential for energy savings alongside with IAQ improvements.

5 Real Life Applications

5.1 CO_2 Differential and Ventilation Rates

To better understand how the CO_2 sensors would work to control the ventilation rates in a classroom, a steady-state mass balance calculation can be used. For the calculations, values form the CEN report on Ventilation for buildings – Design criteria for the indoor environment (CR 1752) and Finnish Meteorological Institute data on Greenhouse gases concentrations are used [9; 10].

First, the relation between ventilation rates and CO_2 concentration in air is calculated with the equation:

$$Vo = \frac{N}{(\mathrm{Cs} - \mathrm{Co})}$$

Where:
V_o = outdoor airflow rate, L/s/person
C_s = CO_2 concentration in the space, ppm
C_o = CO_2 concentration in the outdoor air, ppm
N = CO_2 generation rate, L/s/person

Additionally, when carrying out the example calculation for school in Helsinki, the CO_2 load caused by the occupants needs to be taken into consideration. According to the CR 1752 report, the pollution load of CO_2 caused by children in school age “N” is 18 l/(h*occupant), which is equivalent to 0.005 l/s/person. For the calculation, the CO_2 concentration in the space is 1000 ppm which is defined as a good level in the discussion in chapter 3.2.1. The initial CO_2 concentration in the outdoor air used in the calculation is taken from Greenhouse gases concentrations table 3 below for the school classroom usage during the relevant seasons from September till June [10].

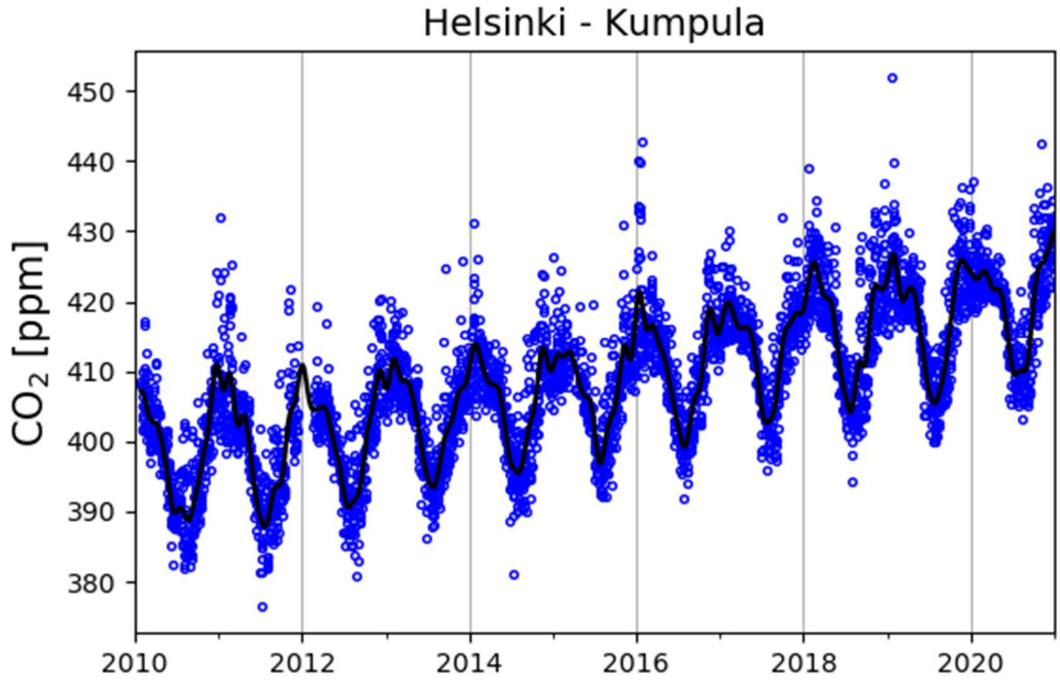

Figure 3. Greenhouse gases concentrations Helsinki – Kumpula [10].

The first example looked at in the thesis is a classroom in Helsinki. For the classroom, the outdoor CO_2 concentration levels are assumed as they were detected in Helsinki in the spring and autumn of the year 2020 as shown in figure 3.

Table 3. Ventilation rate based on CO_2 steady – state mass balance equation – Example 1.

Input data				**Results**	
C_o (ppm)	C_s (ppm)	N (l/s/person)		V_o (m^3/h/person)	V_o (l/s/person)
410	1000	0.005		30.51	8.47

As shown in table 3, the CO_2 concentration in the classroom under the given conditions will not exceed 1000 ppm as long as the outdoor airflow with a rate of 8.47 l/s/person is constantly supplied to the classroom. With this airflow, the difference between the inside and the outside CO_2 level is 590 ppm. If the inside/outside differential increases, the required outdoor airflow rate decreases [3].

To show changes that depend on the change in the impact of the CO_2 differential on outdoor airflow rate, a second example is carried out with outdoor CO_2 concentration value for the same place in Helsinki with data from the year 2011. The lower outside CO_2 concentration value refers to less CO_2 polluted area, such can be also areas further away from city centres, or in areas with generally better outdoor air quality.

Table 4. Ventilation rate based on CO_2 steady – state mass balance equation – Example 2.

Input data				Results	
C_o (ppm)	C_s (ppm)	N (l/s/person)		V_o (m^3/h/person)	V_o (l/s/person)
395	1000	0.005		29.75	8.26

As expected, table 4 shows that an increase in the set differential value from 590 ppm to 605 ppm, the required ventilation rate to reach set equilibrium state will decrease.

Example 3 is the theoretical maximum indoor/ outdoor differential when the outdoor CO_2 concentration is equivalent to 350 ppm and the indoor set state is 1000 ppm. This is sometimes used to describe set design values to reach good IAQ [4, p. 9].

Table 5. Ventilation rate based on CO_2 steady – state mass balance equation – Example 3.

Input data				Results	
C_o (ppm)	C_s (ppm)	N (l/s/person)		V_o (m^3/h/person)	V_o (l/s/person)
350	1000	0.005		27.69	7.69

As the example in table 5 shows, it is possible to design specific required outdoor airflow rate values that are based on indoor space needs at a given location. It is also shown that outdoor air conditions are very important for CO_2 based DCV systems, since fluctuations in outdoor CO_2 levels can impact the required ventilation rates, and it is important to take this into consideration during the systems design. It also means that if a DVC system is implemented with an existing mechanical ventilation system, an additional monitoring system for outdoor air might be required to ensure the precision of the DVC system and, ultimately, to reduce the possibility of excessive over-ventilation of the space, creating additional costs instead of expected savings.

However, the values in the examples should not be considered as final values for the system, but, instead, initial design values. As the ventilation system receives more additions, such as an air treatment system in the form of filters, and a possible air recovery system, the final values can change positively.

Moreover, the CO_2 value in the indoor space used in example calculations (1000 ppm) does not represent an absolute requirement for IAQ since there is no strict standardization for CO_2 concentrations indoors. As shown in chapter 3.2.1, the CO_2 levels indoors can go as high as 2500 ppm and not cause long-lasting effects on room occupants in most cases. However, higher values might bring more consequences [6]. Thus, by increasing the maximum allowed indoor CO_2 levels, less powerful DVC systems can be used. This might be a suitable choice if a project has restrictions, or the existing mechanical ventilation systems cannot be updated to reach the required levels.

5.2 Existing Products

Since improved HVAC systems and increasing requirements for better indoor air quality have been discussed for a while now, the market has also responded with new and innovative products to help the situation. Modern ventilation components of HVAC systems offer multiple monitoring options for improved IAQ. For example, one of the options could be the VMX system of AERECO, which is designed with CO_2 detectors as well as additional presence and movement detectors, proving that modern systems incorporate systems to maintain good levels of IAQ. [11.]

Another product, WISE Parasol EX demand-controlled comfort module by Swegon, has already integrated almost all the common DCV monitoring types with temperature sensors, VOC measurements, Relative Humidity sensors and even presence sensors. This product has a built-in heating and cooling system that takes classroom needs into consideration, making it a rather complicated system, although it is compact and can be used as a separate system dedicated for one classroom. The range of products shows a large variety of solutions with multiple degrees of complexity. [12.]

5.3 Case Studies

Case studies about the addition of DCV in renovation projects show the difference between having constant rate ventilation or just natural ventilation, as well as the benefits of demand-controlled ventilation. Renovated buildings usually gain improvements in multiple areas which contribute to energy efficiency and savings, for instance, thermal performance for walls and roofs, and improved lightning systems. Yet, there are takeaways in all the cases when HVAC and, specifically, ventilation systems are improved. When mechanical ventilation replaces natural ventilation, there is no comparison in energy consumption directly, however, it greatly improves the indoor air quality to the point where the majority people in spaces assess indoor quality as acceptable for work or studies. [13.]

Furthermore, when DCV with presence control strategy is implemented, as for example in the Egedal school in Copenhagen, Denmark, or the Angela school in Osnabrück, Germany, the ventilation energy consumption alone is lowered by 30% - 40% compared to previous full flow ventilation. [13.]

It is worth pointing out that not all schools use maximum designed required air flow rate at all, since there just might not be the maximum number of occupants as designed in the same room ever, or this occurs very rarely [3]. This would be another point in favour of presence-controlled ventilation system implementation in a school building.

6 Conclusion

This thesis has discussed demand-controlled ventilation system appliances to improve general indoor air quality focusing on school buildings and indoor air quality in classrooms. It has been proven that while looking for improvements and energy savings in buildings, general IAQ in classrooms has suffered causing the indoor environment to be a hindrance to the study process. While building regulations are improving in terms of requirements for IAQ in specific building types, there are still possible improvements in terms of reaching higher energy efficiency while also improving the general quality of indoor environments. Furthermore, the types and principles of DCV systems were discussed which could be implemented in school buildings and classrooms to improve general IAQ and show how CO_2 based systems can provide benefits to the quality of the classroom environment.

As ventilation system designs are improving, the market offers more products specifically designed for ventilation systems with DVC options. Some of these products stand out with high complexity to provide systems with multiple control tools to facilitate best possible results, while also increasing the total costs of the system and opening future topics about the payback time for the use of such complex systems. However, this study focused on core DVC implementation strategies. From the available knowledge about how DVC-type systems can be implemented, it can be concluded that the benefits of DVC can be seen by applying simpler strategies. As stated, in the thesis, every mechanical ventilation system can usually be updated to serve as a DVC-type system, thus giving benefits in energy efficiency. While it is easier to design complex ventilation systems and more in line with other HVAC systems in new projects, the more basic options can still be viable and applicable to increase indoor air quality, system performance and energy savings in some renovation cases, such as refurbished buildings. The case studies discussed in the thesis indicate that when refurbishing buildings with DCV, the energy savings for ventilation can reach up to 40% compared with the previous mechanical ventilation systems without additional control tools.

Lastly, although the DCV system principles have been around for a while now, not all the implementations have been successful. There is space for more research focused on details of fully automated ventilation system implementation and for improved guides based on successful cases. As some available systems can be rather complex, it is important to consider space limitations, minimum and maximum design values, and specifics of the control tools implemented in classrooms, to reach the best possible results in indoor air quality levels and energy savings.

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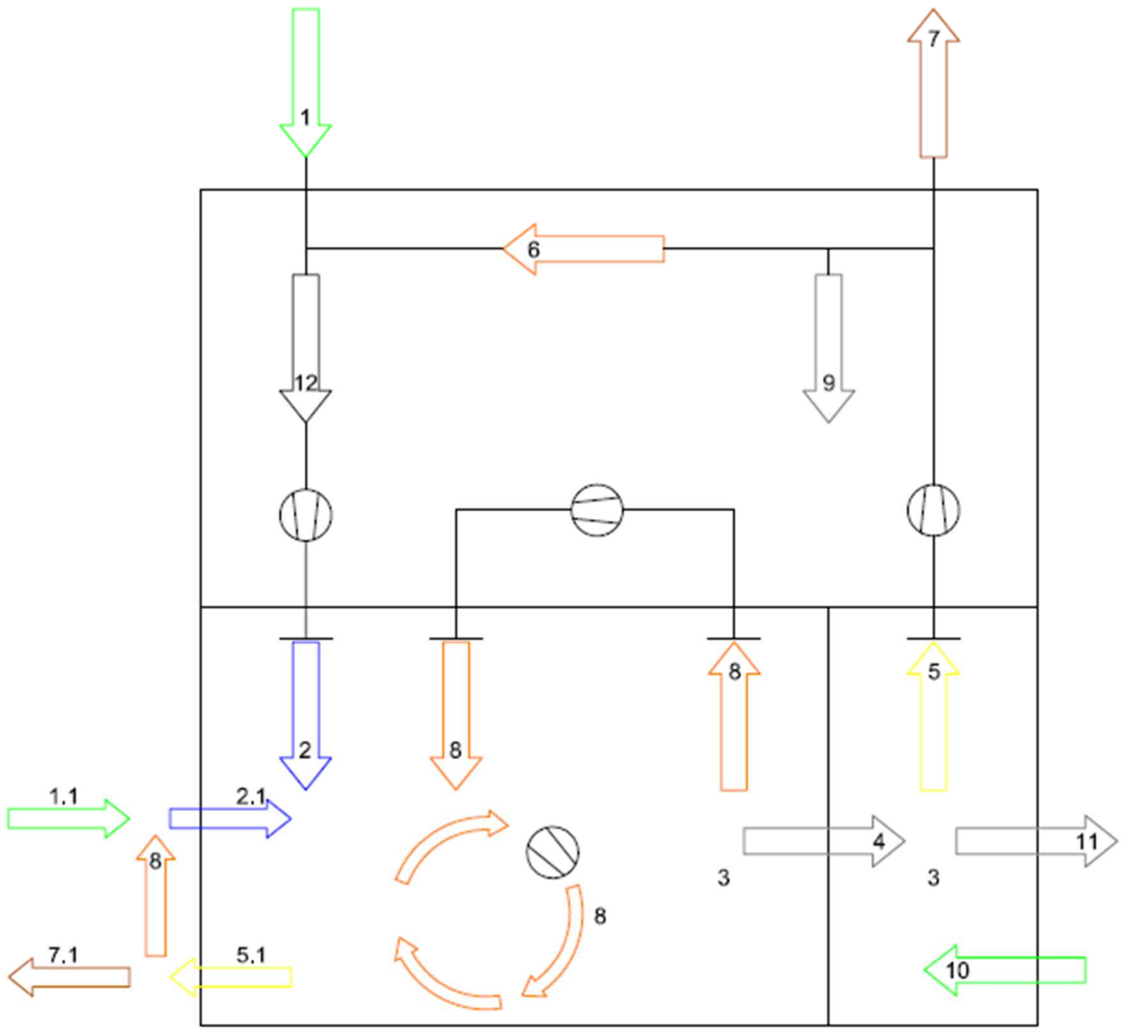
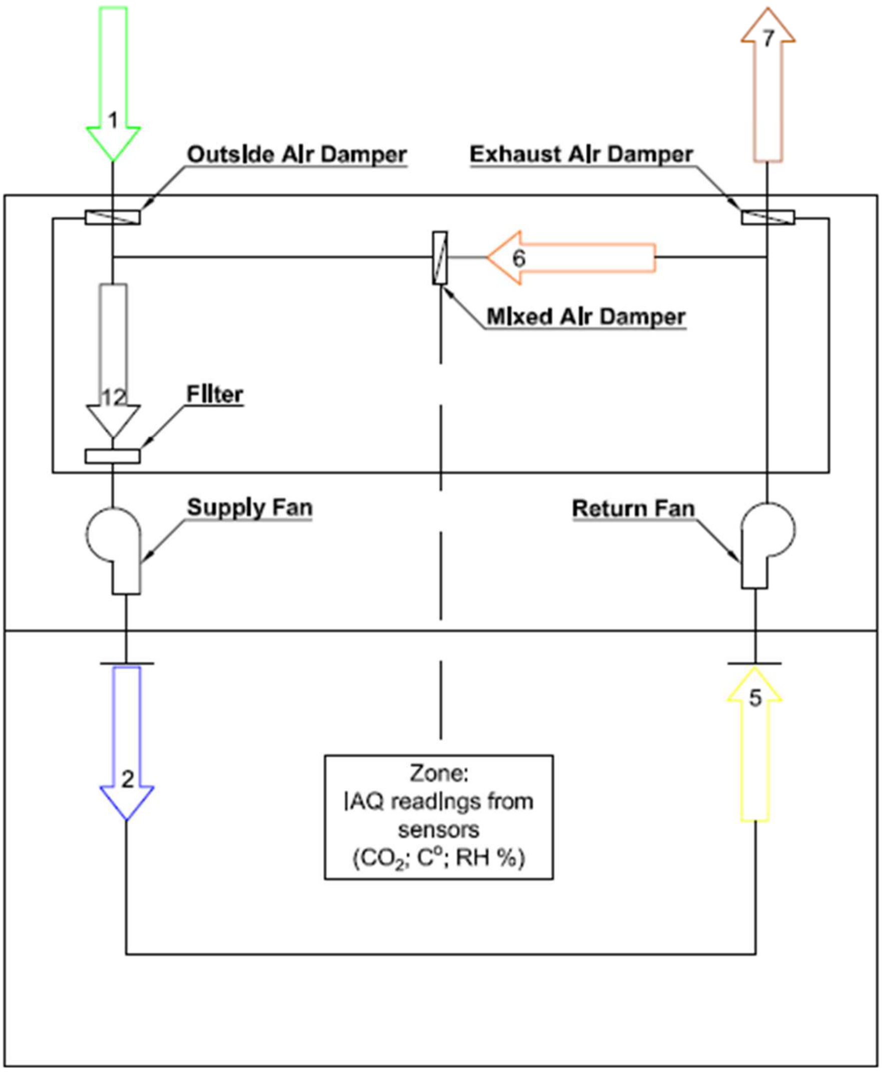
Appendices

Appendix 1. Illustration of types of airflows in building ventilation system



	"THESIS PROJECT"	F-01	
An illustration of types of airflows in building ventilation system		SCALE	M1:1
		PAPER SIZE	A4
		DATE	15.03.2018
		PREPARED BY	TOMS RIEKSTINS

Appendix 2. Ventilation control system scheme with return air



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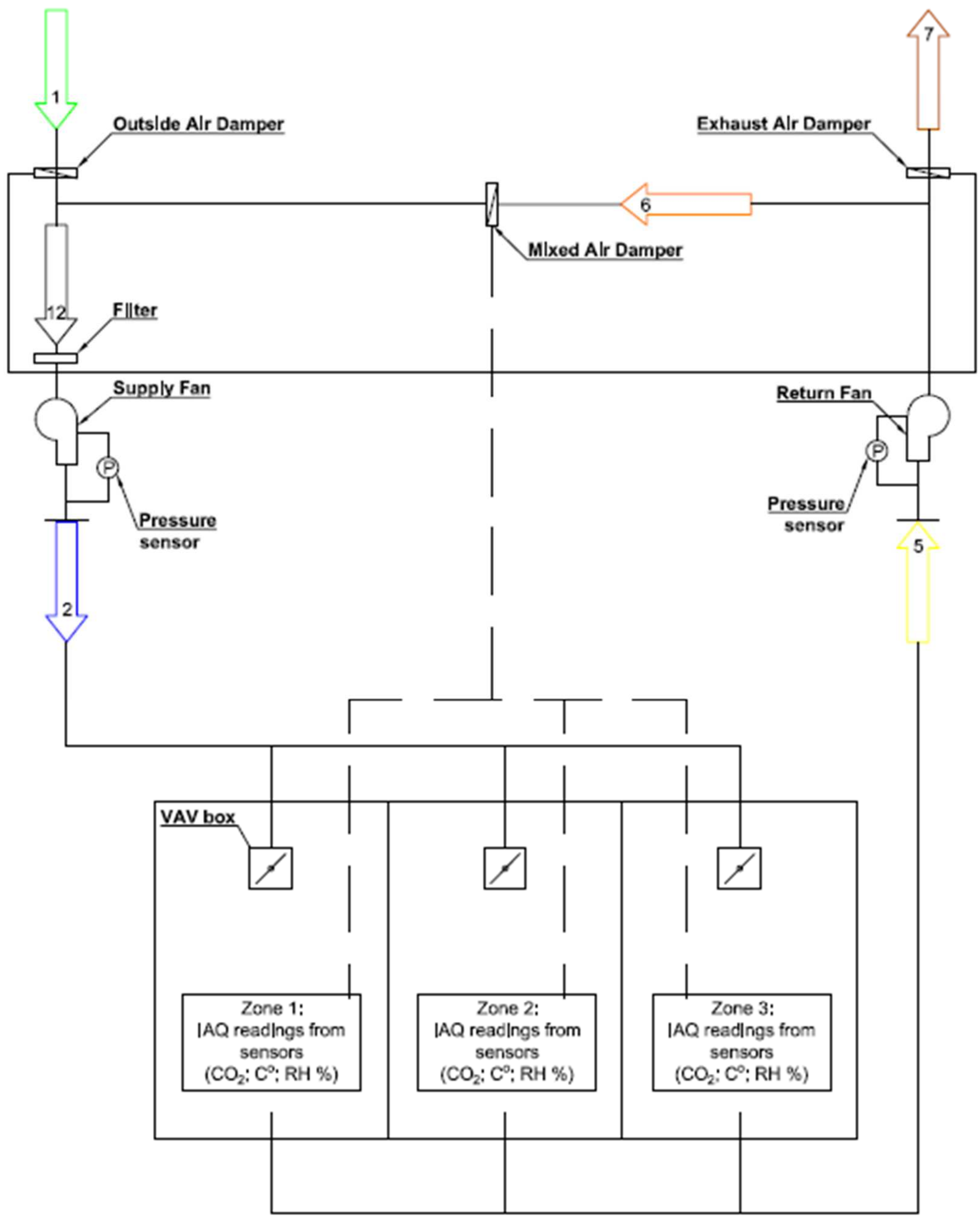
Ventilation control system scheme		SCALE	M1;1
		PAPER SIZE	A4
		DATE	15.03.2018
		PREPARED BY	TOMS RIEKSTINS

Appendix 3. Ventilation system with several demand-controlled spaces



"THESIS PROJECT"	F-03	
Ventilation system with several demand-controlled spaces	SCALE	M1:2
	PAPER SIZE	A4
	DATE	03.05.2021
	PREPARED BY	TOMS RIEKSTINS

Appendix 4. Summary of types of airflows in building [5].

Table 6. Summary of types of airflows in building.

Number Figure 1 (F-01)	Type of air	Abbreviation	Colour	Definition
1	Outdoor air	ODA	Green	Air entering the system or opening from outdoors before any treatment
2	Supply air	SUP	Blue	Airflow entering the treated room, or air entering the system after any treatment
3	Indoor air	IDA	Grey	Air in the treated zone
4	Transferred air	TRA	Grey	Indoor air which passes from the treated room to another treated room
5	Extract air	ETA	Yellow	The airflow leaving threated room
6	Recirculation air	RCA	Orange	Extract air that is returned to the air treatment system and reused as supply air
7	Exhaust air	EHA	Brown	Airflow discharged to the atmosphere
8	Secondary air	SEC	Orange	Airflow taken from a room and returned to the same room after any treatment
9	Leakage	LEA	Grey	Unintended airflow through leakage paths in the system

10	Infiltration	INF	Green	Leakage of air into building trough leakage paths in elements of structure separating it from the outdoor air
11	Exfiltration	EXF	Grey	Leakage of air out of building trough leakage paths in elements of structure separating it from the outdoor air
12	Mixed air	MIA	Black	Air which contains two or more streams of air
1.1	Single room outdoor air	SRO	Green	Air entering single room air handling unit or opening from outdoors before any air treatment
1.2	Single room supply air	SRS	Blue	Airflow entering the treated room
5.1	Single room extract air	SET	Yellow	The airflow leaving the treated room into a single room air handling unit
7.1	Single room exhaust air	SEH	Brown	Airflow discharged to the atmosphere from a single room air handling unit