DO YOU SUFFER FROM CORONA? WEBINAR ON VENTILATION IN BUILDINGS ?

Impact of the Covid-19 pandemic on the missions of an engineering office

10 Février 2020

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Program

1. Sanitary context

November 2019 – start of the pandemic
February 2022 - Photograph of the situation

1.1 Specifications

Start pandemic : Transmission by contact was the preferred transmission factor

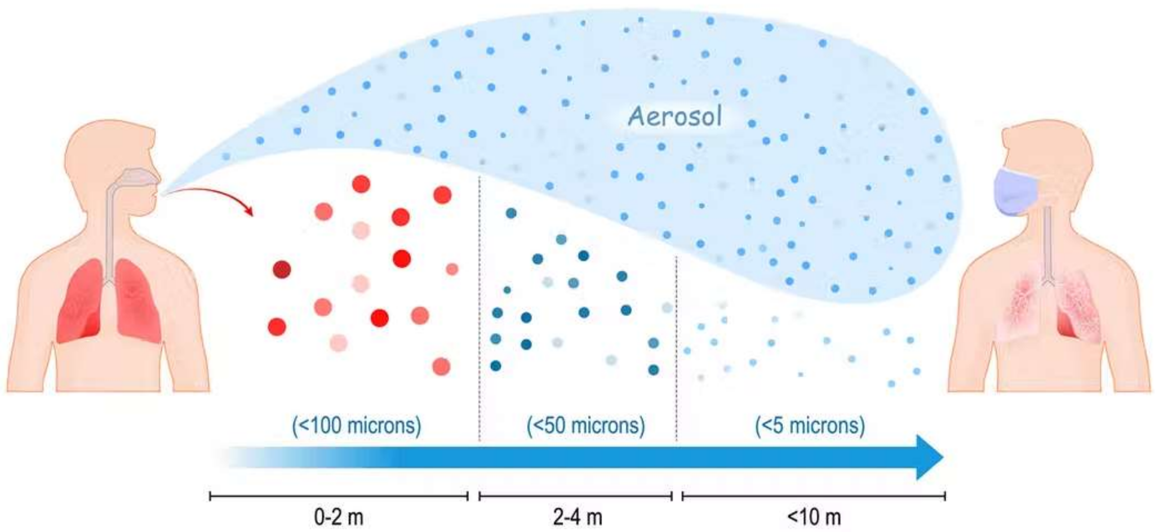
Mi-2020 : WHO recognizes the significant influence of aerosol transmission

1.2 Transmission

Two main ways of transmission :

1. Direct contact with the infected person or a surface they have contaminated ;
2. Aerial (or airborne) of the virus via droplets or aerosol emitted by the infected person ;

→ HVAC can play a complementary role in reducing the potential transmission of SARS-CoV-2 through the air by maintaining a level of air quality.



1. Sanitary context
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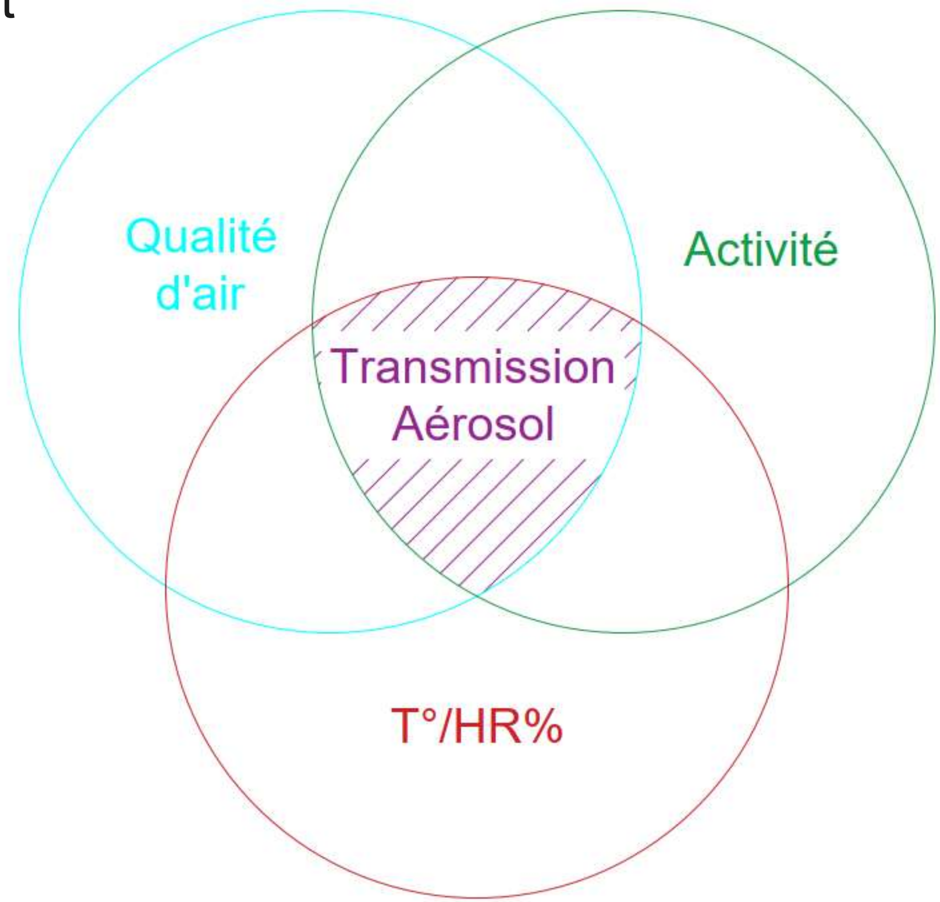
2. Mondial guide-line

Important factors to consider about airborne transmission of the virus:

- Air quality
- Atmospheric conditions (temperature and humidity)
- The activity of people



2.1 Atmospheric conditions

Influence of atmospheric conditions on the spread of coronaviruses :

- **Interior :** HR between 40% and 95% (optimum at 55%)
- **Exterior :** unfavorable winter conditions

2.2 Air quality

World Health Organization

<u>Before</u> covid:

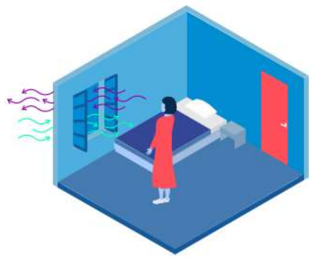
Consortium on the importance of maintaining air quality (< 900 ppm)

Roadmap to improve and ensure good indoor ventilation in the context of COVID-19

<u>After</u> covid:

Viral load of Covid-19 remains unknown

WHO has released a roadmap: maintain a CO_2 concentration < 900 ppm (or 500 ppm above the outdoor concentration).



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2.3 CO_2 Emission

The mondial CO2 concentration outside air : 415 ppm for 2021.

In Belgium : between 400-500 ppm

Why 800-900 ppm ?

- The air exhaled by a person in normal circumstances contains about 4% CO2 (40.000 ppm).
- An increase of 400 ppm from the base rate (500 ppm) indicates that 1% of the air we emitted has already been breathed by someone else in the same space.
- In the context of covid-19, to date, no study has been able to precisely define the infectious dose and therefore the critical concentration value of the virus in the air to limit its spread.

→ **An international understanding tends towards the value of 900 ppm**

3. Belgium prescriptions

European norm NBN EN 13 779 :

- INT 1 (excellent quality) : < 400 ppm
- INT 2 (average quality) : 400 à 600 ppm
- INT 3 (moderate quality) : 600 à 1.000 ppm
- INT 4 (low quality) : > 1.000 ppm

Royal decree 02/05/2019

- CO_2 concentration rate < 900 ppm
- Relative humidity: 40-60%

July 2021: Ventilation plan: **"Recommendations for the implementation and control of ventilation and indoor air quality in the context of the COVID-19 pandemic – version 2.0".→ < 900 ppm**

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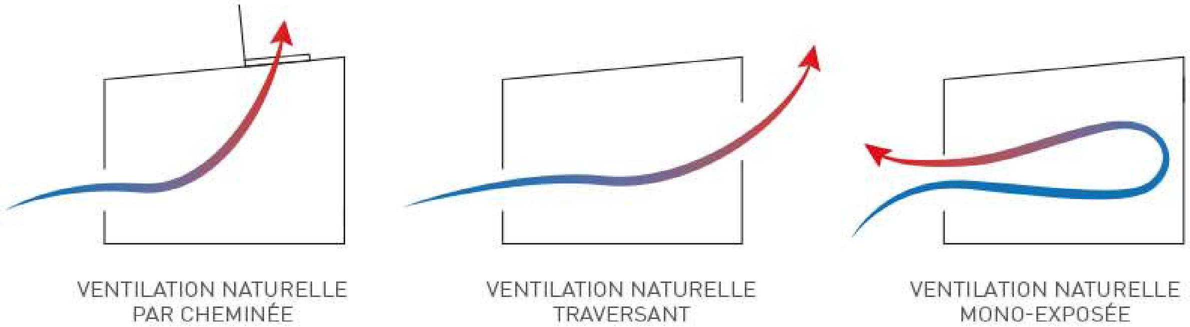
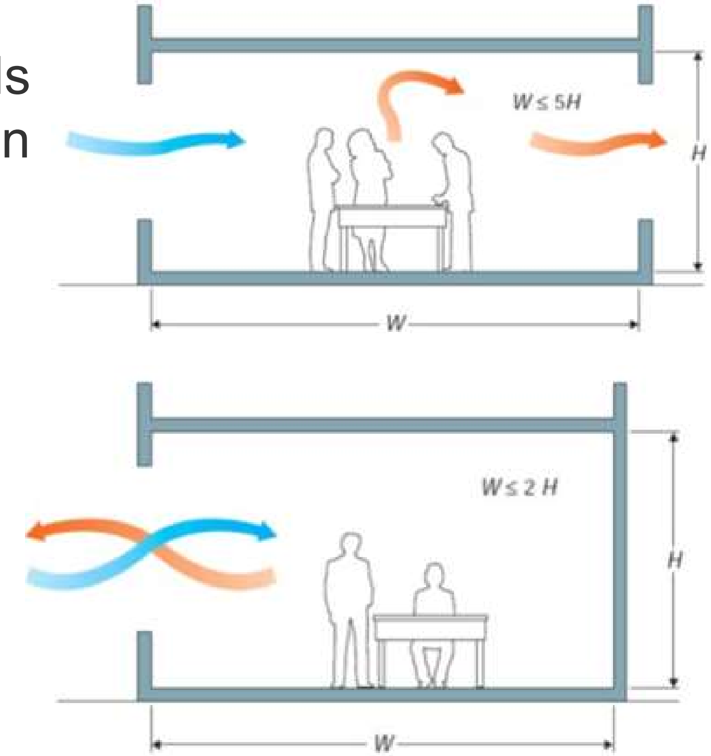
3.1 Natural ventilation

The effectiveness of natural ventilation depends on the configuration of the room and the location of the openings





If the quality level > 900 ppm, you should:

- Reduce the number of occupants;
- Purify the air;
- Install a mechanical ventilation system;

3.2 Mechanical ventilation

Measure the existing air flow

A Ventilation Plan recommends airflows depending on the activity of the people in order to guarantee 900 ppm (See table 2)

3.3 Air purification

May 2020 and February 2021: publication of recommendations from the Superior Health Council

2 types of air purification:

- **Capture :** captures particles potentially containing the virus (HEPA filter, system based on electrostatic precipitation - ESP)
- **Inactivation :** damage microorganisms in an air stream, so that they can no longer multiply or spread (UV-C)

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3.3.1 Filter

- HEPA (99%) or F7 (60%)
- incompatible with Pressure Drops / ERP 2018;
- Complicated installation
- Additional filter box dimensions;
- Complicated maintenance

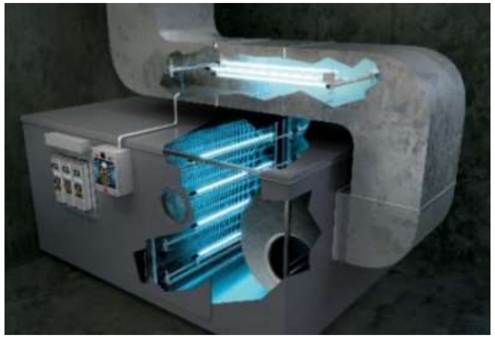
→ this solution is difficult to apply except in special cases (hospital environment)

3.3.2 ESP (electrostatic precipitation)

- Complicated to integrate into existing installation
- Complicated maintenance
- Investment cost

→ this solution is difficult to apply except in special cases (hospital/industrial environment)

3.3.3 UV-C



- If wavelength > 220 nm → potentially dangerous for humans (cancer)
- UVGI : for large rooms and can be integrated into ventilation ducts (hospital application)
- Complicated installation and maintenance
- Airspeed < 2 m/s → ↗ ductsize

→ this solution is difficult to apply except in special cases (hospital environment)

3.3.4 Ozon

Effectiveness thresholds are incompatible with human presence

3.4 CO_2 Detector

Easy installation with a guide line from April 2021 :

« Choice and use of CO2 sensors in the context of Covid-19»

4. Impact on the construction

4.1 Calculation and test case

Classe	MET	Production CO_2 (*) (l/h)	V_{900} (m³/h)	V_{1200} (m³/h)	Exemples
Calme assis	1.5	18	37	23	Assis à regarder ou à écouter un film, de la musique ou du théâtre, spectateur dans une salle de sport, salle de classe (**), assister assis à un service religieux
Standard	1.63	20	40	25	Norme minimale pour les locaux de travail (Codex), travail de secrétariat et de bureau
Léger	1.8	22	44	28	Artisanat léger assis, manger ou boire, salon de coiffure ou de beauté, se promener dans un musée
Moyen	3.0	37	74	46	Travail physique régulier debout, shopping, bowling intérieur
Lourd	4.1	50	101	63	Travail physique intense avec mobilisation du tronc
Très lourd	5.2	64	128	80	Travail très intense et rapide, sports tels que le badminton, la gymnastique, la natation, la salle d'escalade
Intensif	7.3	90	180	112	Patinage sur glace, boxe, discodance, fitness, cyclisme sur piste, squash, tennis

Table 2 of the ventilation plan:

Flow recommendation per person depending on the activity

The CESI recommends 800 ppm with a flow rate of 50 m³/h.pers and tending towards 80 m³/h.pers !!!

→ These values seem to be largely oversized

4.1.1 Calculation assumptions

- **Met :** 58,2 W/m² (Firlag & Murray, 2013)
- **CO_2 :** 17 L CO_2 /h (average between Firlag & Murray et Ventilatie, achtergrond van de eisen)
- **average build :** according to the National League against Obesity and INSEE
- **Body surface :** according to Dubois & Dubois formula
- **Activité :** according to following table
- **CO_2 level ext :** 400-450 ppm
- **Infiltration :**

  Renovation : n50 = 6 (25%)

  Construction : n50 = NC
- **T° ext = 10°C**
- **T° int = 21°C**

Tableau 2-13 : Taux représentatifs auxquels la chaleur et l'humidité sont émises par les êtres humains dans différents états d'activité (ASHRAE, 2009; CIBSE, 2006; ISO7730, 2005; Liébard and De Herde, 2005; NBN-EN-13779, 2007)

Degré d'activité		Métabolisme énergétique (met)	Chaleur totale (W)[e]		Chaleur sensible (W)[e]	Chaleur latente (W)[e]	% chaleur sensible rayonnée		Apport en eau (g/h)
			Homme adulte	Adaptée, H/F[a]			Faible[b]	Elevée[b]	
Repos, couché		0,8	80		55				
Assis au théâtre / assis au repos	Théâtre, en matinée	1,0	100*-114-115	95	65-70	30			37
Assis au théâtre, la nuit	Théâtre, la nuit		115	105	70	35	60	27	
Assis, travail très léger	Bureaux, hôtels, appartement, école*	1,2	125-130	115	70-75	45			
Debout au repos			128						46
Travail de bureau modérément actif	Bureaux, hôtels, appartement		140-145**	130	75	55			61
Debout, travail léger ; marche	Magasin, industrie légère, laboratoire	1,6	160-170*-174**	130	75-85	55	58	38	99
Marche, debout	Drugstore, banque		160	145	75	70			
Travail sédentaire	Restaurant c		145	160	80	80			
Travail modéré	Vendeur, travail ménager, travail sur machine	2,0	197**-210		105				116
Travail de laboratoire léger / travail actif	Usine		232-235	220	80	140	49	35	141
Danse modérée	Salle de danse		265	250	90	160			
Marche à plat à du 2 km/h		1,9							
Marche à plat à du 3 km/h		2,4							
Marche à plat à du 4 km/h		2,8							
Marche à 4,8-5* km/h ; travail léger sur machine / travail intense	Usine	3,4	290**-295-360	295	110-120	185			213
Bowling[d]	Allée de bowling		440	425	170	255			
Travail lourd / travail pénible	Usine		406-440	425	170	255			319
Travail lourd sur machine, levage	Usine		470	470	185	285	54	19	
Athlétisme	Gymnase		585	525	210	315			

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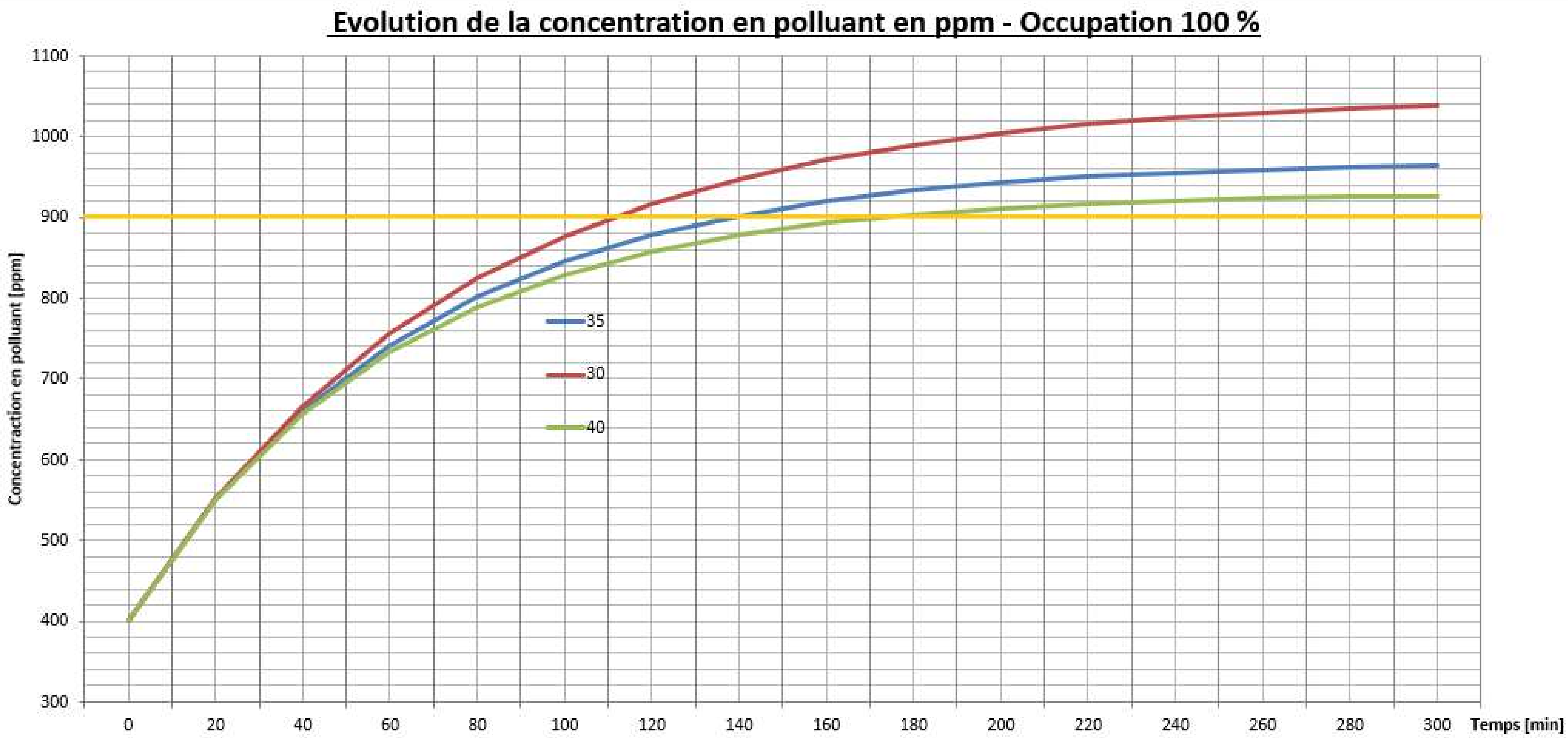
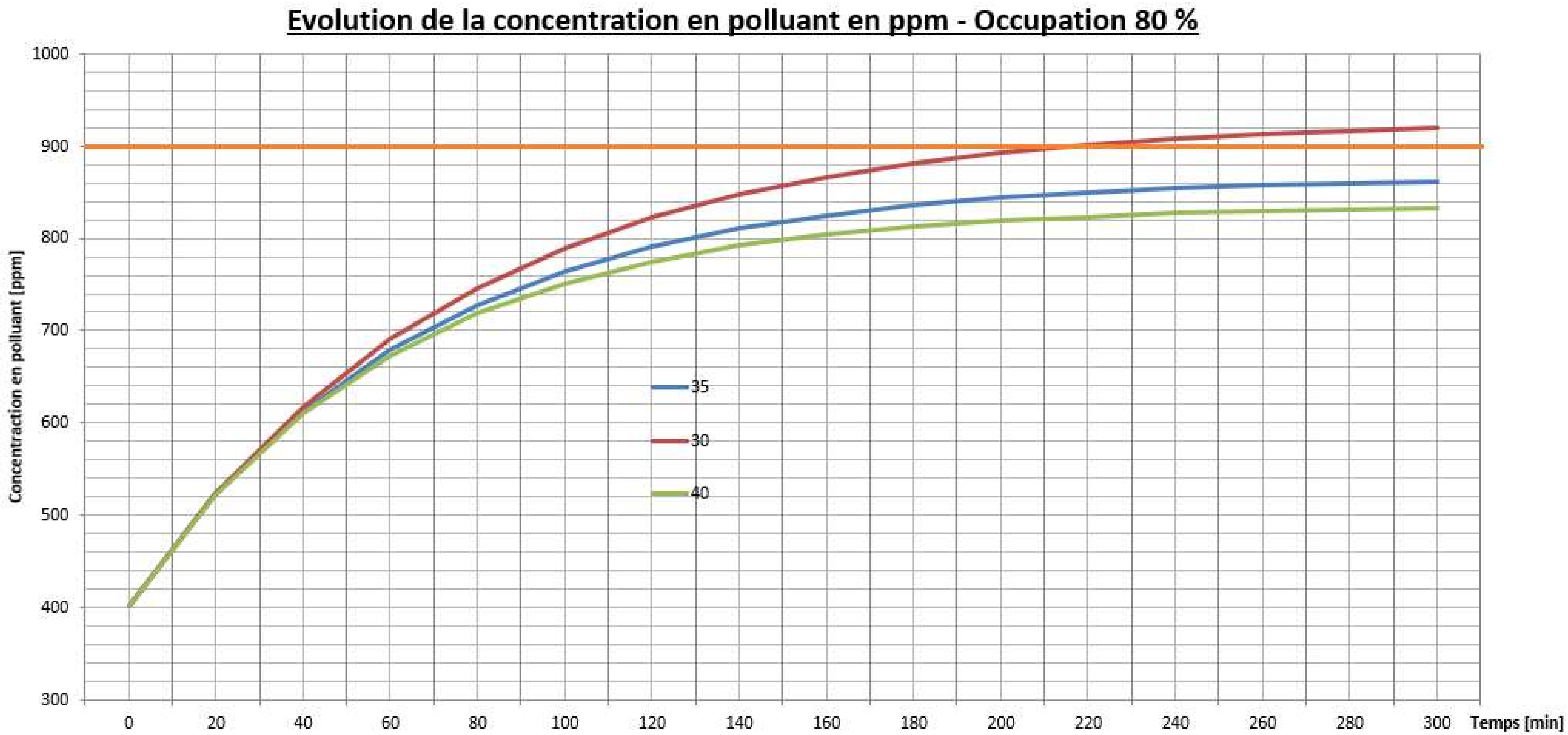
4.1.1 Test case

4.1.1.1 Open plan office (20 people) mechanically ventilated



With 80% occupancy



→ **The airflows depend on the configuration of each room.**

Starting with a flow rate of 35 m³/h.pers, we can maintain the recommended air quality < 900 ppm VS Table 2 : 40 m³/h.pers

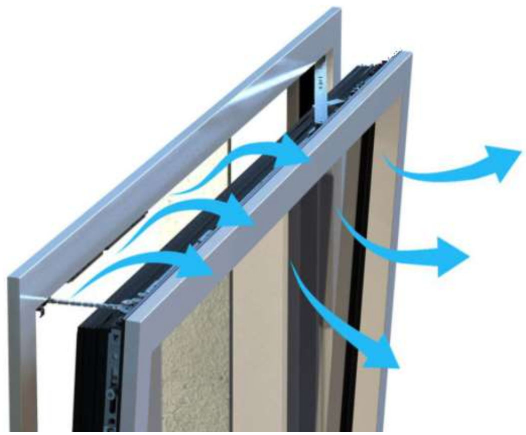
4.1.1.2 office (4 people) naturally ventilated

- Without ventilation (100% occupancy): > 900 ppm after ± 30 min
- Without ventilation (50% occupancy): > 900 ppm after ± 60 min

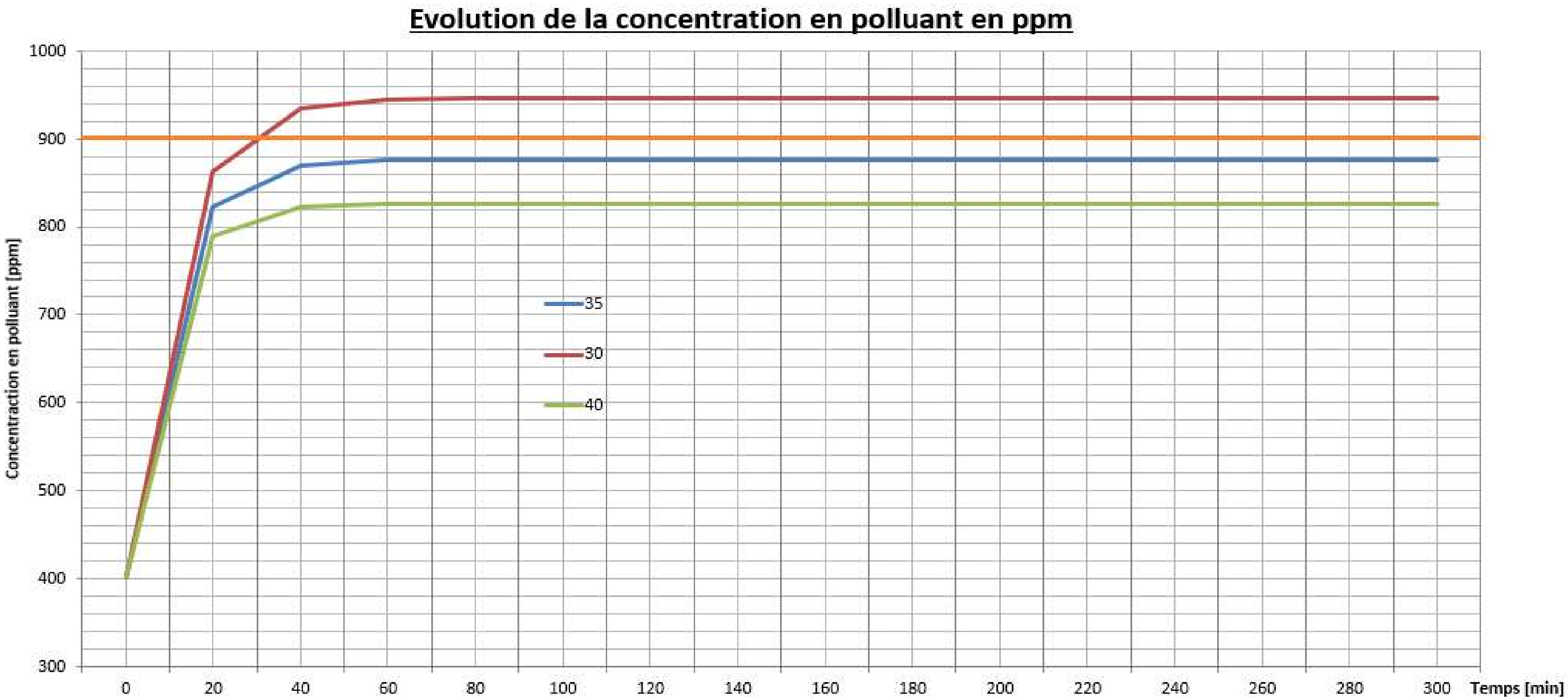
Natural ventilation via windows:

- Occupation 100% : opening in tilt ± 0.4 m² permanently for < 900 ppm
- Occupation 50% :
  - ***tilt and turn :*** permanent opening ± 0.2 m².
  - ***tilt and turn :*** alternating Open 30 min and close every 20 min to vary between 750 and 900 ppm
  - **In swing :** let rise to 900 ppm then alternate opening 5 min / closing 20 min

→ **The ventilation solution can be implemented but this can be restrictive in terms of occupant comfort depending on the configuration of the premises and the atmospheric conditions.**



4.1.1.3 Class (24 children / 1 teacher) mechanically ventilated



→ The airflows depend on the configuration of each room. Starting with a flow rate of 35 m³/h.pers, we can maintain the recommended air quality < 900 ppm

4.1.1.4 Class (24 children / 1 teacher) naturally ventilated

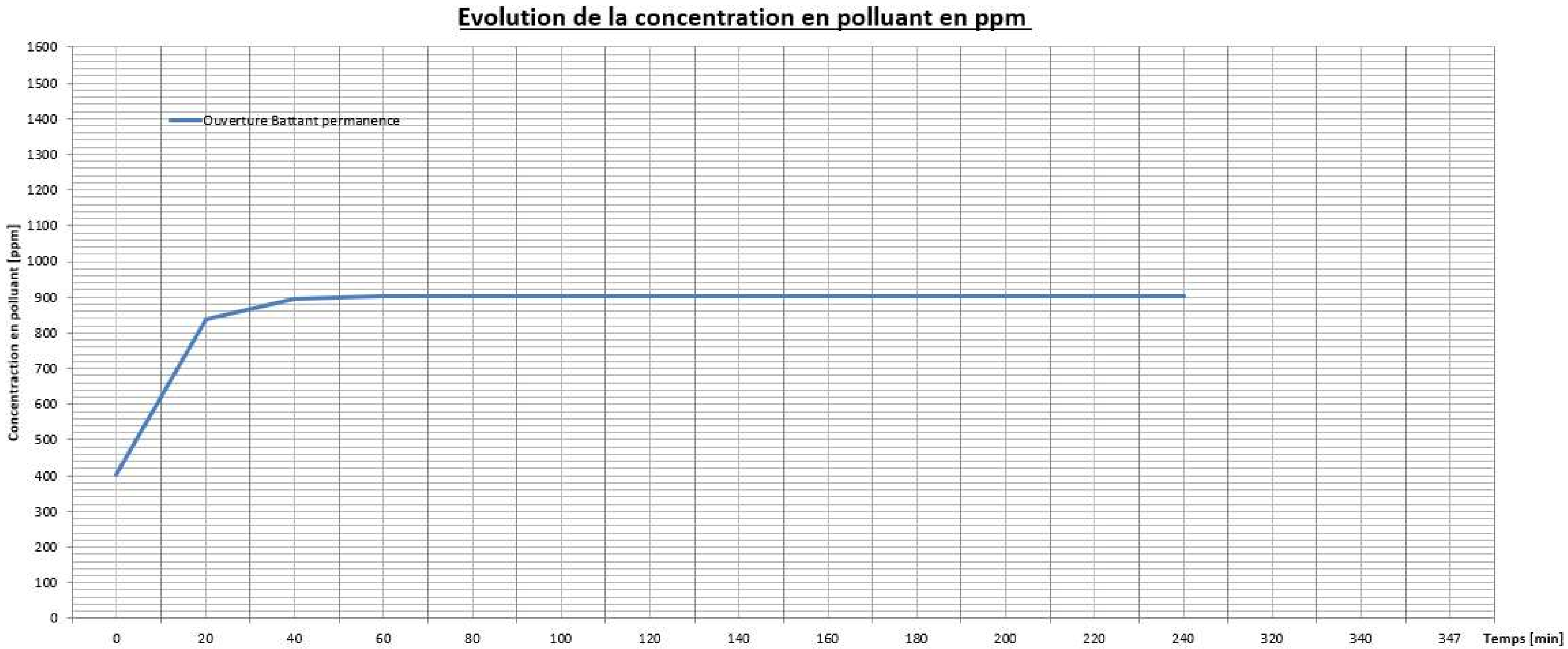
- 100% occupancy required
- Without ventilation: > 900 ppm after ± 10 min !!

Natural ventilation via windows – Tilt:

➢ Permanently open : the gain has little impact to maintain < 900 ppm

Natural ventilation via windows– Swing :

➢ Permanent opening of ± 1.6 m², we stabilize ~ 900 ppm after 30 min



- Note that these results always depend on the configuration of the room but also on the ΔT between inside and outside plays an important role.
- By way of comparison, with a ΔT = 5.5°K, the necessary surface goes from ± 1.6 m² to ± 2.3 m²; ΔT /2 → Area + 40%

→ Depending on the configuration of each class (number of windows, location, students, location of the class, etc.) and the atmospheric conditions, a uniform solution cannot be envisaged, especially since permanent ventilation would cause significant discomfort for the students. → Case by case

→ **Natural ventilation seems not adequate solution in classrooms in a standard way**

4.2 Renovation and Construction

4.2.1. WITHOUT ventilation

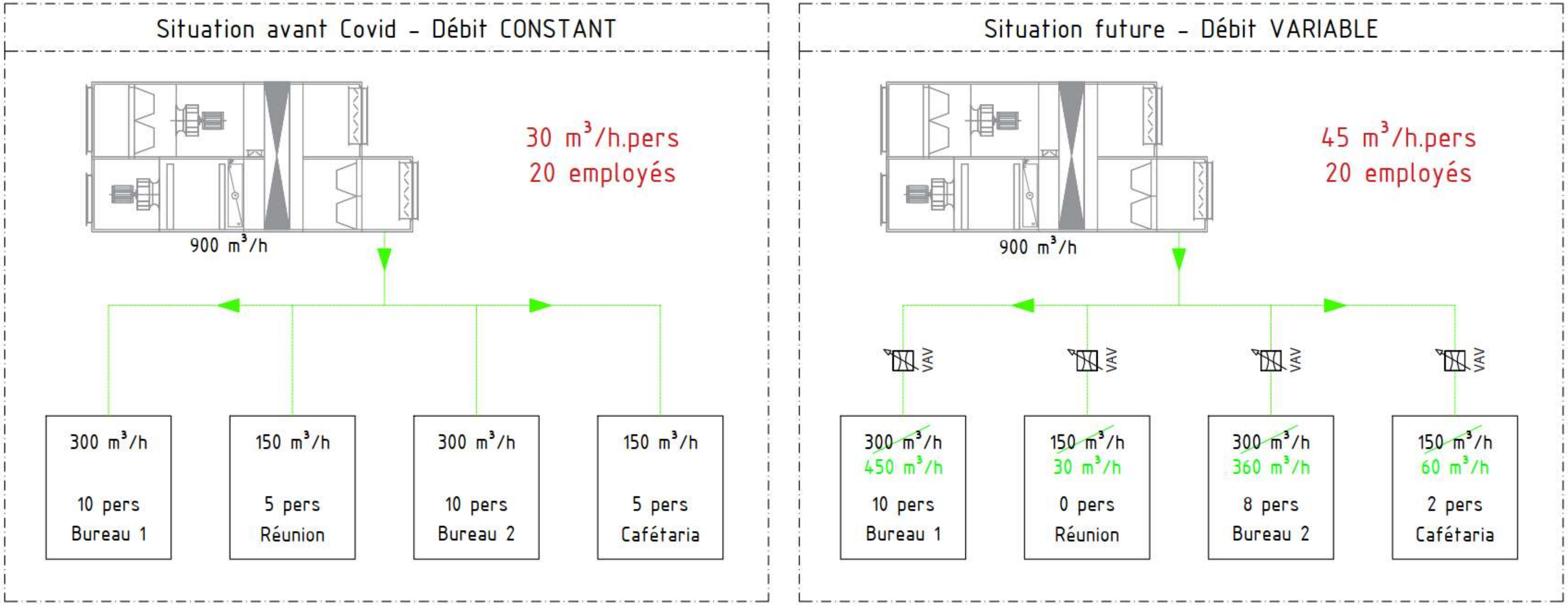
- Reduce the number of occupants; → **Often no option**
- Open doors and windows more often; → **in high occupation not sufficiant**
- Purify the air → **Expensive and difficult to implement** ;
- Indicate that for the moment these are recommendations

→ Establish a measurement campaign and a ventilation plan

4.2.2. WITH ventilation

- Establish a ventilation plan based on occupancy, activity and customer requirements;
- Disable air recirculation if possible ;
- Modification of the regulation : ↗ operating time ;

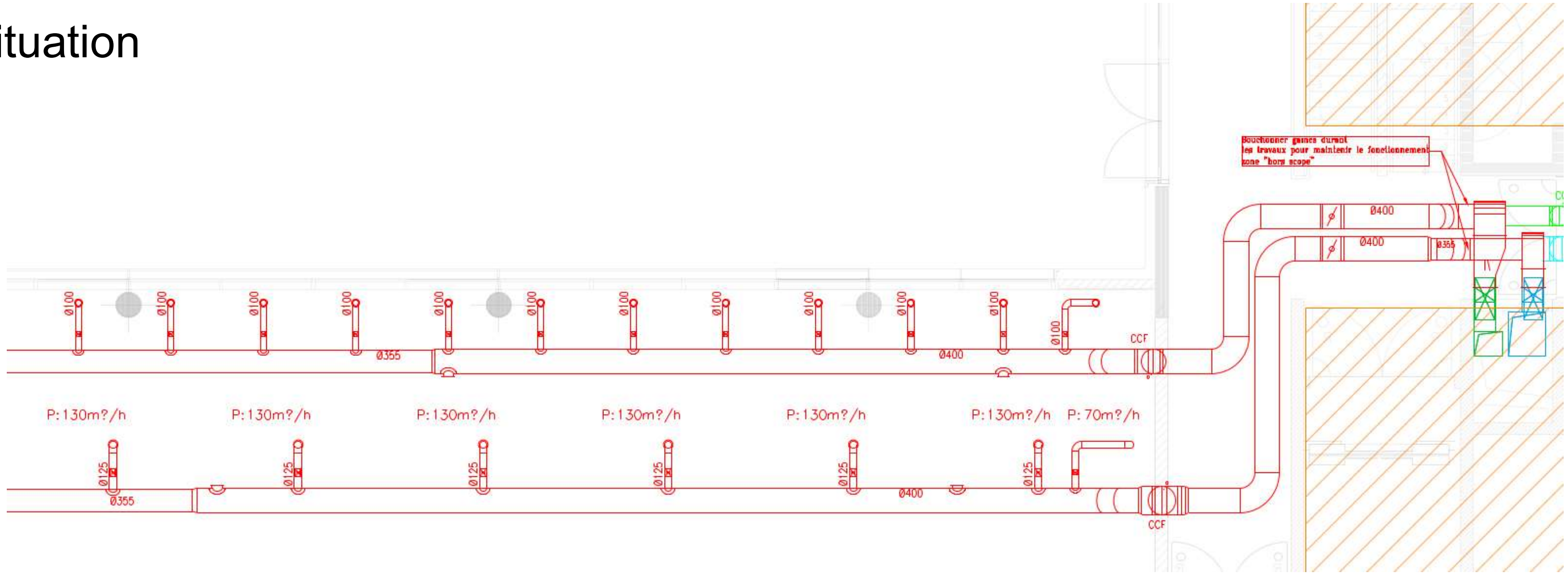
- Constant flow → Variable flow;



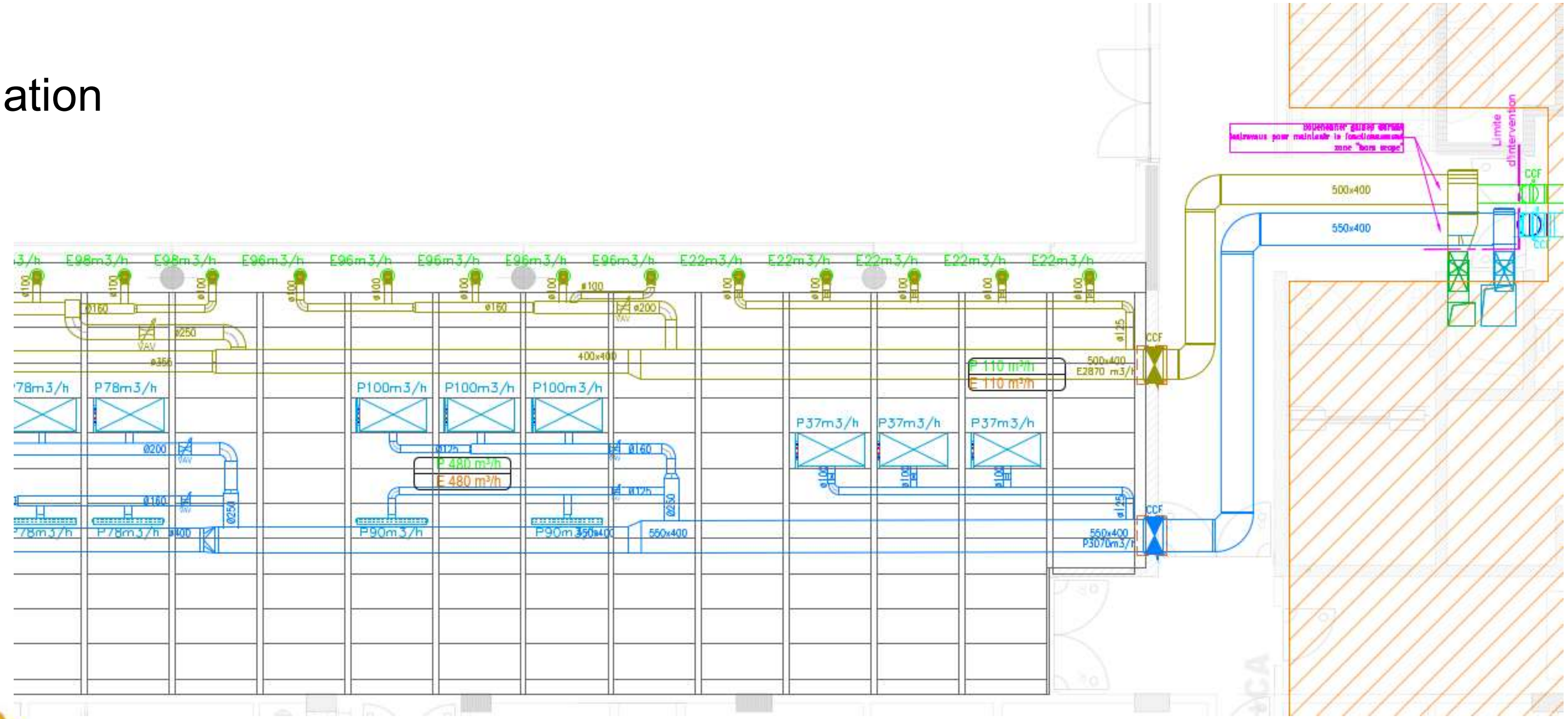
Complicated to adapt existing "constant flow" networks to "variable flow": cost, internal organisation, network architecture, etc…

→ The conditions for adapting existing installations to achieve the recommendations are small. If some are technically acceptable, they often involve non-negligible investments.

Initial situation



Final situation



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5. Conclusion

- **Unrealistic to apply standard solutions**
- **focus more and more on variable airflow operation**
- **Continue to study each building in detail**