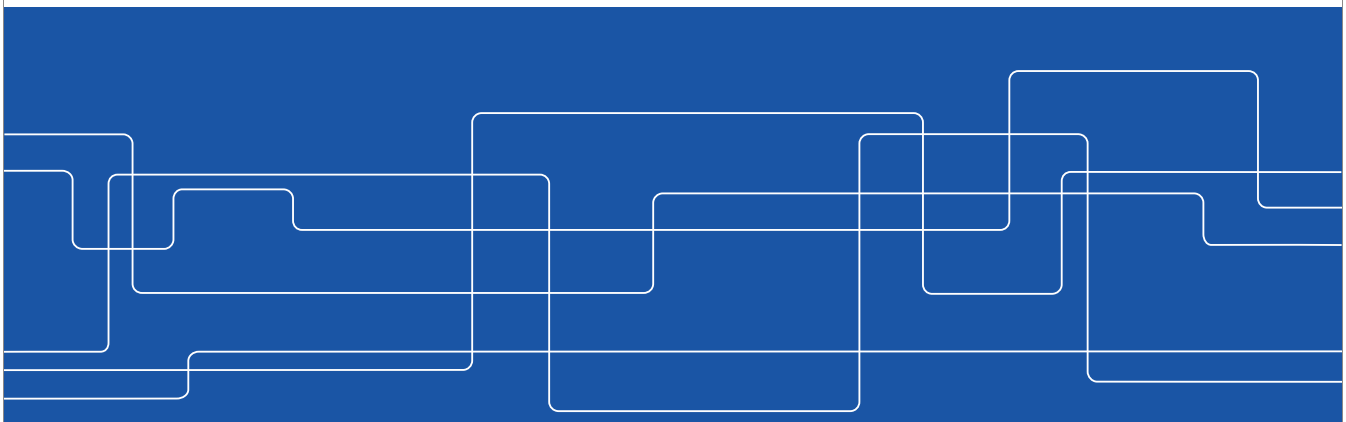
# Energy implication of using gas-phase air cleaners in residential & office buildings

Sasan Sadrizadeh



Nourozi, B., Holmberg, S., Duwig, C., Afshari, A., Wargocki, P., Olesen, B., & Sadrizadeh, S. (2022). Heating energy implications of utilizing gas-phase air cleaners in buildings' centralized air handling units. *Results in Engineering*, *16*, 100619.

## Introduction and background

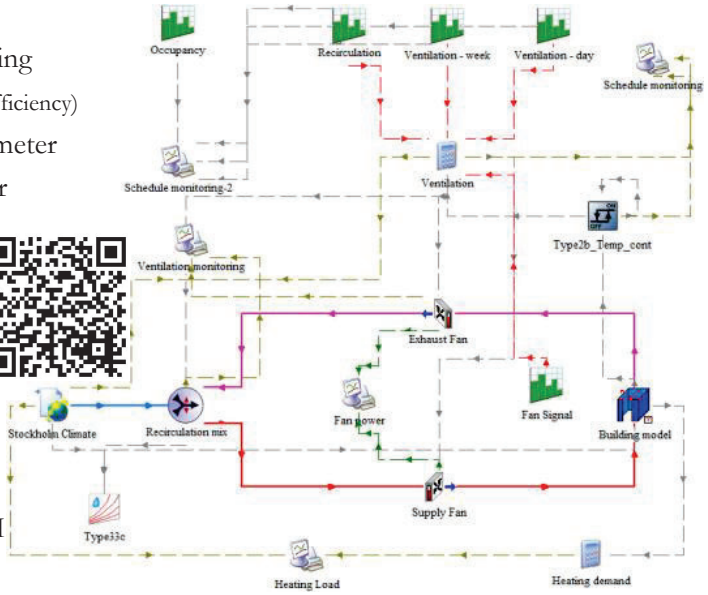
- **Ventilation** systems are important for maintaining a **healthy and comfortable indoor** environment.
- In cold climates, ventilation systems contribute to **approximately 30% of building heat losses**.
- **Indoor emissions** and **outdoor pollutants** affect **indoor air quality** and need to be controlled.
- **Gas-phase air cleaning** as an extension of ventilation can help maintain acceptable indoor air quality while reducing **energy use**.

## Investigated parameters

- **Heating demand** of a ventilated building
- Indoor **TVOC level** (with 60% capturing efficiency)
- Indoor **$CO_2$ level** as a monitoring parameter
- Possibility of **air recirculation** when air cleaner is integrated.

## Simulation case

- Newly constructed or renovated buildings
- Older buildings without heat recovery ventilation
- Residential and office cases with various ACH



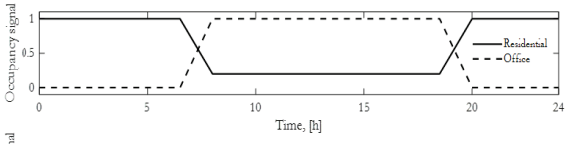

Energy simulation using TRNSYS

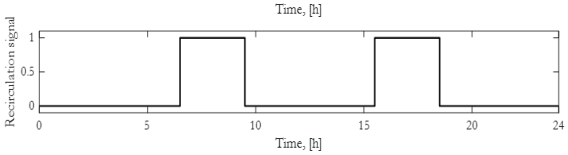


## Simulation cases study in Stockholm climate equipped with centralized air handling unit (2000 $m^2_{vent.\ area}$)

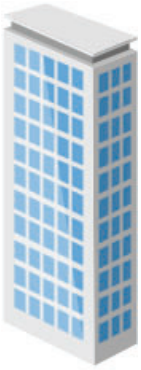
Energy in Buildings and Communities Programme

- **Residential building**
  - 0.45 ACH
  - Occupancy schedule




- **Office building**
  - 2.1 ACH
  - Occupancy schedule
  - Ventilation schedule



| Air pollutant | TVOC | | | $CO_2$ | |
|---|---|---|---|---|---|
| Source | Outdoor | Occupants | Interior furnishing | Outdoor | Occupants |
| Value | $\mu gr.m^{-3}$ | $mgr.h^{-1}.person^{-1}$ | $\mu gr.m^{-3}h^{-1}$ | $mgr.m^{-3}$ | $gr.h^{-1}.person^{-1}$ |
| | 110 | 6.3 | 120 | 720 | 120 |

**Indoor and outdoor emission rates**

| Location | Reference | TVOC concentration $\mu g.m^{-3}$ |
|---|---|---|
| Europe | Report EUR 14449 EN. 1992 | Comfort range < 300<br>Multifactorial exposure range < 3000<br>Discomfort range < 25000<br>Toxic range > 25000 |
| Finland | Finnish Society of IAQ and Climate. 2000 | Individual indoor climate < 200<br>Good indoor climate < 300<br>Satisfactory indoor climate < 600 |
| Germany | Federal Environment Agency of Germany | Hygienically safe < 1000<br>Hygienically noticeable < 3000<br>Hygienically alarming < 10000<br>Hygienically unacceptable > 1000 |
| Germany | Seifert B. | 300 |

**Guideline values for indoor TVOC concentration**



## Residential building (0.45 ACH)

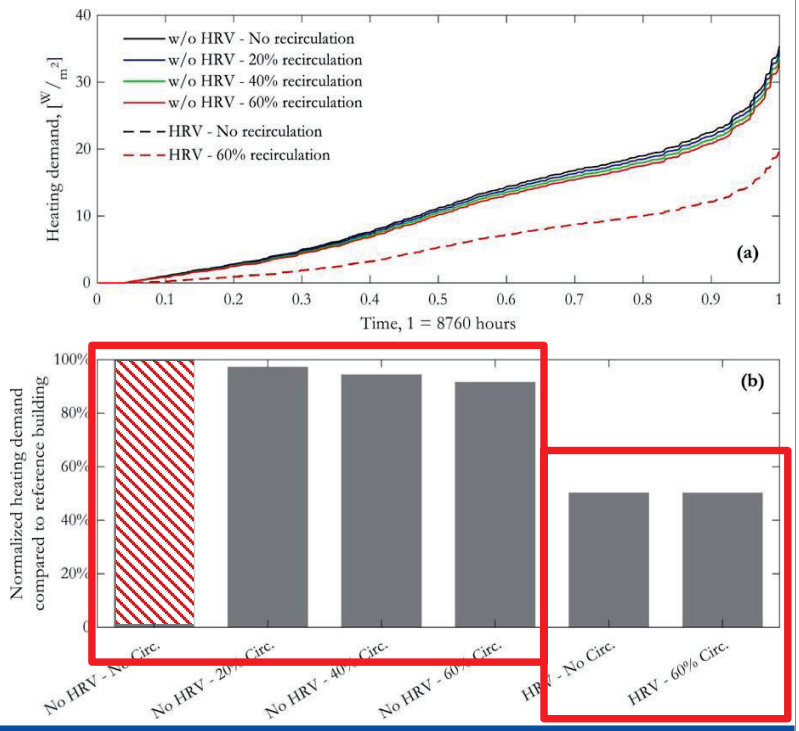
EBC Energy in Buildings and Communities Programme

**Ventilation <u>with</u> heat recovery:**

- **The recirculation** effect on **heating demand** is <u>negligible</u>!
- Air cleaner implementation **might not be** that effective!

**Ventilation <u>without</u> heat recovery:**

- **The recirculation** effect on **heating demand** is <u>small</u>!
- Air cleaner implementation **might reduce** building heating demand!



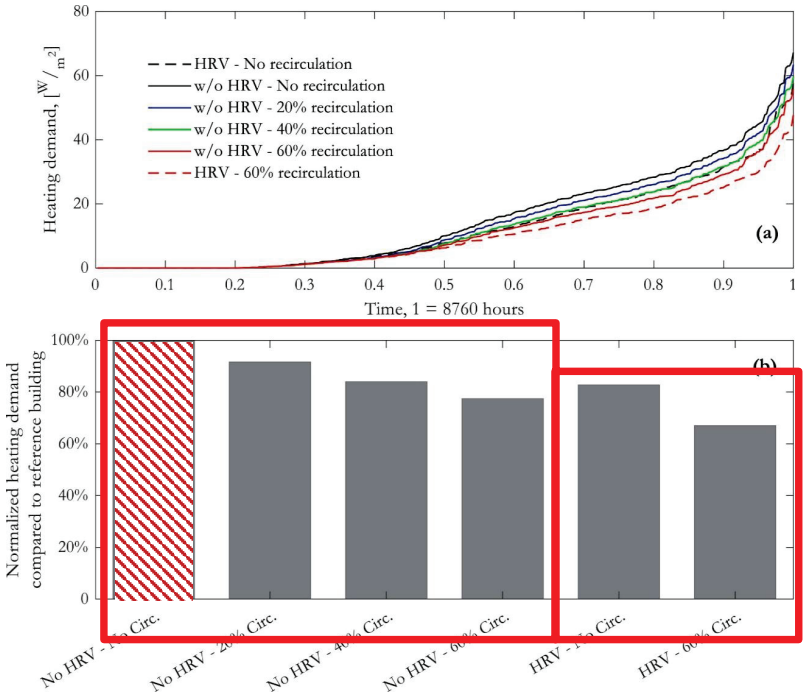

HRV: Heat Recovery Ventilation

## Office building (2.1 ACH)

**Ventilation <u>with</u> heat recovery:**

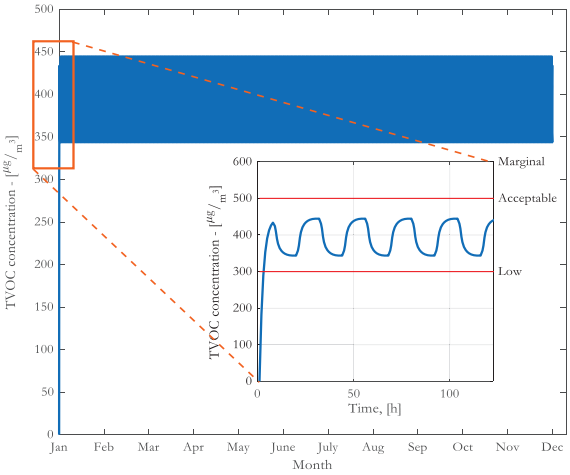
- **The recirculation** effect on **heating demand** is **<u>notable</u>** compared to the residential buildings!
- This is the case for both **<u>with and without</u>** heat recovery!
- Air cleaner implementation **<u>is effective</u>**!

**Thus ACH is an important parameter that needs to be considered.**

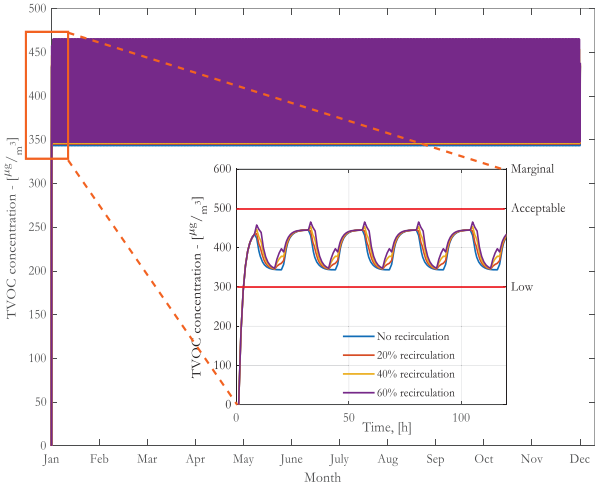





## **Residential building:** Impact of **air recirculation** on TVOC concentration (<500 µg/m³)




Without air recirculation

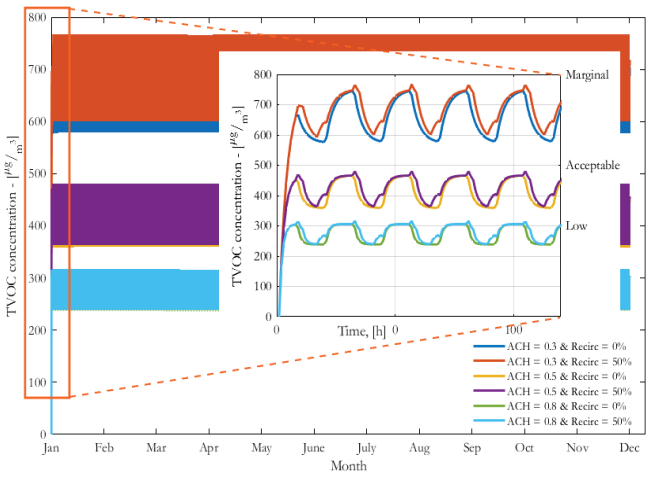



With air recirculation (and air cleaner)

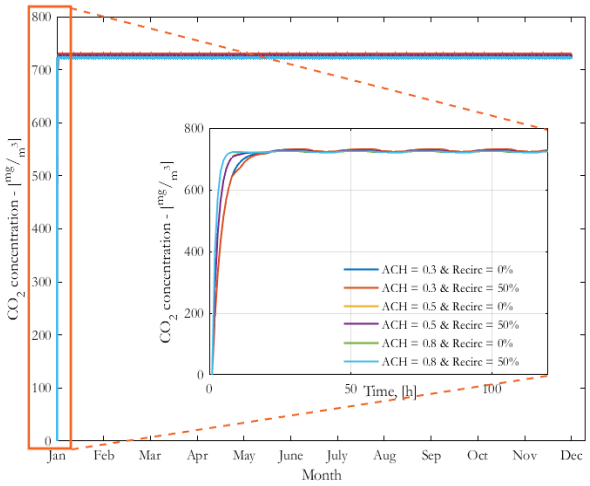
TVOC concentration is within the acceptable range

Recirculation does not result in increased TVOC level

## **Residential building:** Impact of air recirculation and ACH on TVOC & $CO_2$ concentration




TVOC concentration with 0 and 50% air recirculation




$Co_2$ concentration with 0 and 50% air recirculation

- High ACH (>0.5) maintains TVOC concentration within an acceptable range, regardless of recirculation level
- Thus, adding air cleaner and recirculation is beneficial to reduce building heating demand

Recirculation % and ACH do not changes $CO_2$ level since the main $CO_2$ source is the outdoor air.



**Conclusion:**

- This study examines the effect of **gas-phase air cleaners** on **building heating demand**.
- The study also explores indoor **concentrations of TVOC and $CO_2$** when gas-phase air cleaners are used.
- Different parameters were also discussed, such as **ACH**, **air recirculation**, **ventilation**, and **occupancy schedule** on indoor **TVOC** and **$CO_2$** levels.
- Increasing recirculation rate **reduced heating demand** in the office building more than in residential.
- 60% recirculation rate reduced heating demand by **9%** in **residential** and **24%** in the **office building**.
- Integrating gas-phase air cleaner and increasing recirculation rate during rush hours of mornings and evenings kept TVOC and $CO_2$ concentrations acceptable.
- Indoor $CO_2$ concentration value was affected less than TVOC's by increasing the recirculation rate.
- Higher ACH minimizes the impact of recirculation rate on TVOC and $CO_2$ levels.

# Thank you!

Sasan Sadrizadeh
ssad@kth.se