Environmentally Friendly Ventilation Systems: A Comparison Between Two Types of Ventilation Systems

Author: Mitra Mohebi Nouraldin Vand

Introduction

Based on the European Commission, climate change poses a serious threat to all aspects of our lives, it needs urgent actions. The construction industry, with a high emission, plays a critical role in this effort. This study compares the energy efficiency and global warming potential (GWP) of two ventilation systems, Variable Air Volume (VAV) and Active Chilled Beams (ACB), across their entire life cycles.

Overview

VAV System:

The Variable Air Volume (VAV) system provides conditioned air through an air handling unit (AHU) via fans and ducts. The airflow rate changes during operation, based on the number of occupants and temperature in the rooms, this changing airflow is controlled by device name VAV box in each zone, to adjust airflow based on cooling demand.

ACB System:

Active Chilled Beams (ACB) are air-water convection units integrated with a constant air volume (CAV) air handing unit. They provide cooling through chilled water pipes and maintain air quality with fresh air. Since a part of cooling demand of rooms provides by chilled water, therefore, the need for airflow rate is minimum, and accordingly the air volume is less than air volume in VAV system. So, by having a lower airflow the size of duct and air handling units can be smaller compared to VAV system.

Life Cycle Assessment (LCA) Criteria:

Each product has different life cycle stages from when it is produced till it will be deconstructed. These life cycle stages include construction (A), use (B), and end-of-life (C) stages. You might don't know what these stages include, so let see what are they?

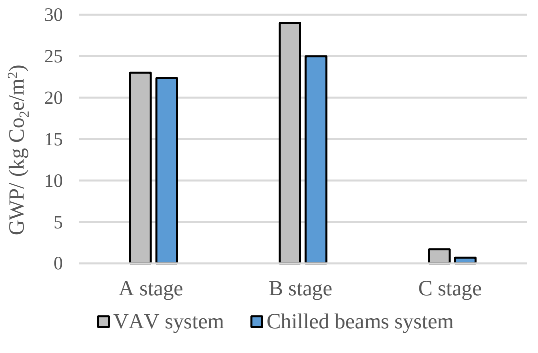
A stage includes the steps from producing, transporting it to the user site and finally installing it for usage proposes. In B stage, there are stages about using a product, and all the aspects that will occur during usage time, like replacement, maintenance, any energy use, etc. In C stage, the lifespan of the product is over, and it needed to be removed and throw away or even reuse or recycled. So, in all these stages, some harmful impacts might be occurred to our environment. Therefore, the amount of these harmful emissions is calculated in each stage and sum up together to see if the product is a environmental friendly option or not. In this study only global warming potential impact is calculated through all these stages. This means that two system were compared in their entire life cycle stages to see which one resulted in a lower global warming potential.

This is important to know that in B stage, there is a module named operational energy use, which shows the amount of global warming potential while using any kinds of energy sources for operating the product in its use stage. This module can be sensitive and might be results in different outcomes by changing the geographical location of the usage, changing the time from now to the fossil free future, or even changing the operation time of the product. Therefore, this operational energy use which is also called B6 is studied during different scenarios to see if the results can be reliable.

Results

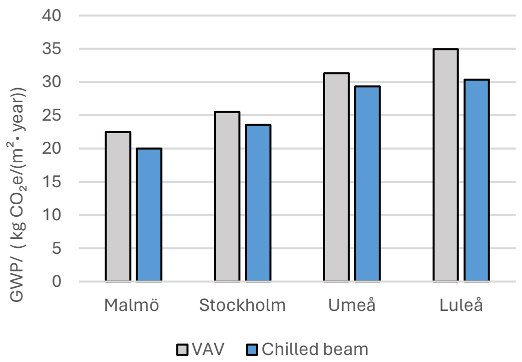
GWP Fossil Emissions:

ACB systems show lower total GWP $_{fossil}$ emissions across their entire life cycle. The reduced primary supply air results in less weight and material use in AHU and duct systems, leading to lower embodied emissions. Additionally, lower operational energy use further reduces GWP emissions for ACB compared to VAV.



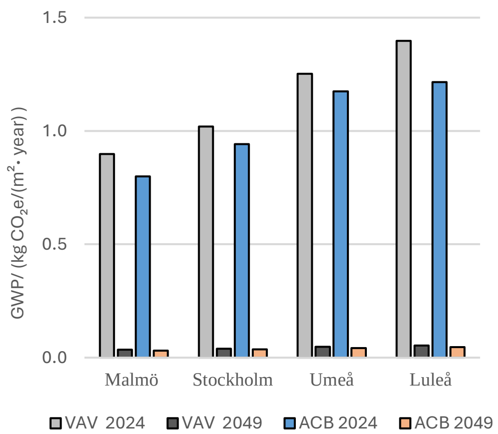
Geographical Impact:

In Sweden's different climates, operational GWP $_{fossil}$ emissions increase in colder regions due to the higher need for heating. However, ACB systems consistently show lower emissions than VAV systems across all locations.



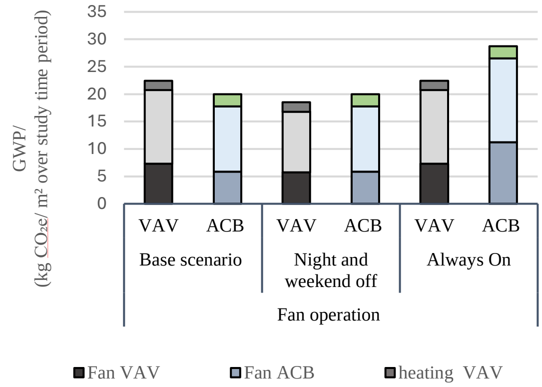
Future Energy Scenarios:

Transitioning to fossil-free energy sources significantly reduces operational GWP emissions for both systems. By 2049, both systems achieve low emissions, with ACB maintaining a slight advantage.

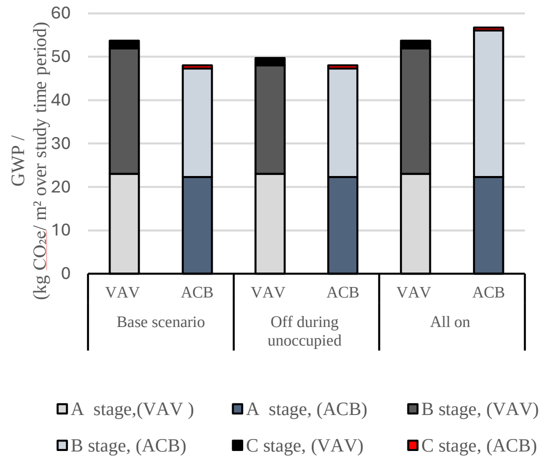


Operational Schedules:

Different fan operation schedules show that ACB systems' efficiency can vary. Continuous fan operation without off times diminishes ACB's advantages, highlighting the need for optimized operational strategies to maximize efficiency.



But what if we consider entire life cycle for this scenario? In this case, VAV presents lower global warming potential when both systems always operate without any turning off.



Conclusion:

ACB systems demonstrate superior energy efficiency and lower GWP fossil emissions compared to VAV systems, making them a preferable choice for environmentally friendly ventilation. However, operational strategies and geographical factors must be carefully considered to fully realize these benefits.