

Review Article

A Comprehensive Review on Air Ventilation Systems

Neetu Singh¹, VishvendraNath Bartaria²

¹Research scholar, Mechanical Engineering, LNCTU, Bhopal, M.P., India

neetusengar29@gmail.com

²Professor, Mechanical Engineering, LNCTU, Bhopal, M.P., India

yvbartaria@lnct.ac.in

Corresponding Author: neetusengar29@gmail.com

DOI-10.55083/irjeas.2024.v12i01011

© 2024 Neetu Singh, et.al.

This is an article under the CC-BY license. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract: This collection of papers and reviews explores the diverse applications and implications of air ventilation in various settings. It provides a detailed examination of ventilation systems in residential, commercial, industrial, healthcare, educational, agricultural, and transportation settings, highlighting their unique requirements and contributions to maintaining healthy and productive environments. The literature review section critically analyzes research on natural ventilation models, simulation tools, and the effectiveness of different ventilation systems in different contexts.

Furthermore, the papers delve into the intersection of air ventilation with solar panel performance and the effectiveness of solar-powered ventilation systems in parked cars. The studies emphasize the importance of ventilation in enhancing energy efficiency, thermal comfort, and reducing environmental impact. Notably, the future directions section outlines potential advancements in air ventilation technology, including smart and adaptive systems, sustainable energy recovery, integration of natural ventilation strategies, and occupant-centric design, among others.

The research papers collectively contribute valuable insights into advancing the understanding, application, and future directions of air ventilation across diverse environmental settings. The comprehensive exploration of these topics serves as a valuable resource for researchers, practitioners, and policymakers in the field of ventilation and environmental science.

Keywords: air ventilation, building design, car cooling, energy efficiency, indoor air quality, natural ventilation, simulation tools, solar panels, solar-powered ventilation, thermal comfort.

1. INTRODUCTION

The roots of air ventilation trace back centuries, evolving from rudimentary methods such as natural ventilation through openings in structures. Technological progress over time has given rise to sophisticated mechanical ventilation systems that offer precise control over airflow and indoor climate. Diverse ventilation systems cater to various needs. Natural ventilation relies on passive elements like windows and vents, while mechanical ventilation employs fans, ducts, and advanced control mechanisms for targeted and efficient air circulation.[1]

Recent advancements have transformed the field of air ventilation. Intelligent ventilation systems, incorporating sensors and automation, adapt in real-time to environmental conditions, thereby optimizing both energy efficiency and indoor air quality (IAQ). Cutting-edge technologies, such as energy recovery ventilators (ERVs) and heat recovery ventilators (HRVs), demonstrate sophisticated capabilities in exchanging stagnant indoor air with fresh outdoor air while simultaneously recovering energy from the exhaust air.

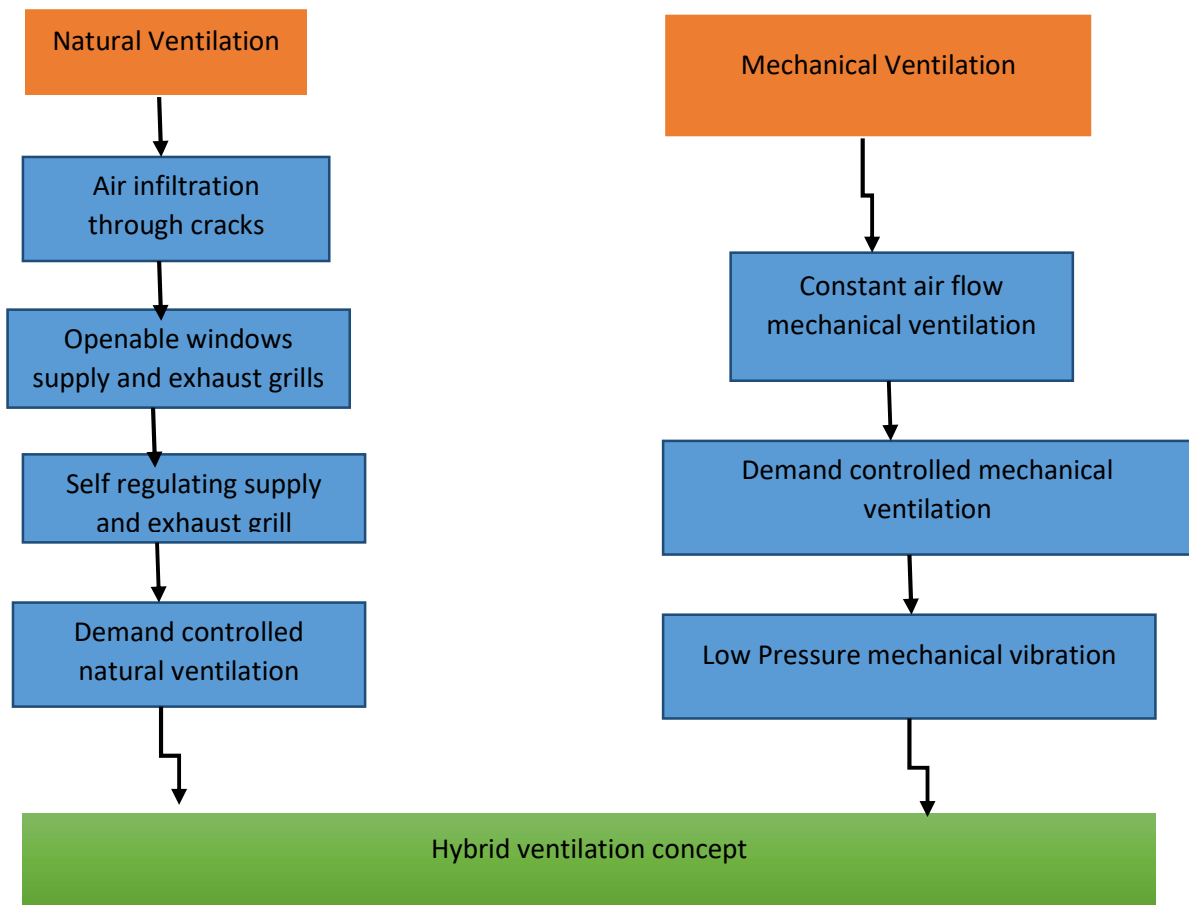
Effective air ventilation holds critical importance across residential, commercial, industrial, and institutional settings. In homes, it prevents the accumulation of indoor pollutants and mold growth.

In workplaces, ventilation systems contribute to sustaining a comfortable and productive atmosphere. In industrial settings, they are indispensable for removing airborne contaminants that may pose health risks.[2][3]

Scientific studies underscore the direct link between indoor air quality and human health. Adequate ventilation significantly reduces the risk of respiratory issues and other health problems associated with poor IAQ, thereby contributing to the overall well-being of occupants.

This introduction offers a glimpse into the multifaceted realm of air ventilation, elucidating its historical evolution, diverse system types, technological innovations, and its critical role across different settings. Subsequent sections will delve deeper into specific advancements, challenges, and future prospects of air ventilation technologies.

Ventilation serves the purpose of introducing fresh outdoor air into a building or room and subsequently circulating it throughout the indoor space. Its primary objective within buildings is to ensure a healthful indoor environment by both reducing the concentration of pollutants generated within the structure and expelling these contaminants from the premises[4] Natural ventilation in buildings involves allowing outside air to circulate without mechanical systems, typically through features like operable windows, louvers, or trickle vents. ASHRAE defines it as the movement of air through open building envelope openings, driven by natural or artificially induced pressure differentials.[5] Mechanical ventilation systems, comprising fans, heaters, and filters, offer precise control. When a mechanical air inlet combines with a natural exhaust, it generates a slight positive pressure, causing air to leak outward. This setup is advantageous in spaces like hospitals or factory offices with dust or fumes, ensuring a contamination-free indoor environment. [6]



Sources: <https://www.slideshare.net/SiddharthKhanna11/bs5-lecture-1-mechanical-and-natural-ventilation>

2. APPLICATION OF AIR VENTILATION

The application of air ventilation systems varies across different settings, each with unique

requirements and considerations. Here is an exploration of how air ventilation is applied in various contexts:

1. **Residential Settings:** In homes, air ventilation is essential for maintaining a healthy indoor

- environment. Natural ventilation through windows and doors, along with mechanical ventilation systems like exhaust fans and HVAC (Heating, Ventilation, and Air Conditioning) units, helps control indoor air quality. Proper ventilation prevents the buildup of indoor pollutants, moisture, and odors, creating a comfortable living space.
2. **Commercial Buildings:** Commercial spaces, including offices, retail stores, and educational institutions, rely on air ventilation systems to ensure occupant comfort and productivity. HVAC systems are commonly used to regulate temperature and provide adequate fresh air. Smart ventilation technologies, equipped with sensors and automation, are increasingly employed to optimize energy efficiency and adapt to changing occupancy levels.
 3. **Industrial Environments:** In industrial settings, ventilation is critical for controlling airborne contaminants, fumes, and dust. Industrial ventilation systems, such as local exhaust ventilation and dilution ventilation, are designed to remove pollutants generated by various processes. These systems contribute to worker health and safety by maintaining air quality in manufacturing plants, warehouses, and other industrial facilities.
 4. **Healthcare Facilities:** Air quality is of utmost importance in healthcare settings. Ventilation systems in hospitals, clinics, and laboratories are designed to control infectious airborne pathogens, maintain sterile environments, and provide clean air in patient rooms and operating theaters. High-efficiency particulate air (HEPA) filters are often integrated to ensure the removal of particles and microorganisms.
 5. **Educational Institutions:** Schools and universities utilize ventilation systems to create a conducive learning environment. Proper air circulation helps prevent the spread of respiratory infections and enhances the concentration and well-being of students and staff. Energy-efficient systems are increasingly implemented to align with sustainable practices.
 6. **Commercial Kitchens:** Ventilation is crucial in commercial kitchens to remove heat, steam, and cooking odors. Kitchen ventilation systems, including exhaust hoods and fans, are employed to maintain a comfortable working environment for chefs and staff while ensuring the removal of airborne grease and pollutants.
 7. **Data Centers:** In data centers, where electronic equipment generates significant heat, efficient ventilation is crucial for cooling. Precision air conditioning and ventilation systems are employed to regulate temperature and humidity levels, ensuring optimal conditions for the operation of servers and electronic components.
 8. **Agricultural Settings:** Agricultural facilities, such as greenhouses and livestock farms, use ventilation systems to control temperature and humidity. Adequate airflow is essential for preventing heat stress in plants and animals, optimizing crop yields, and maintaining healthy livestock conditions.
 9. **Transportation:** Ventilation plays a role in various modes of transportation. In vehicles, ventilation systems ensure a comfortable cabin environment for passengers and drivers. In tunnels and underground transit systems, ventilation is crucial for maintaining air quality and preventing the buildup of pollutants.
 10. **Energy-Efficient Homes:** In modern, energy-efficient homes, ventilation is integrated into the overall design to achieve a balance between airtightness and fresh air exchange. Heat recovery ventilation (HRV) or energy recovery ventilation (ERV) systems are employed to capture and reuse energy from the exhaust air, contributing to energy efficiency.

The diverse applications of air ventilation systems underscore their importance in creating and maintaining healthy, comfortable, and productive environments across a wide range of settings.[7-12]

3. LITERATURE REVIEW

Researchers conducted experiments to comprehend the functionality and effectiveness of air ventilation. The paper critically examines the utilization of natural ventilation in commercial buildings, delving into the associated technology, potential benefits, and highlighting areas requiring attention to fully harness natural ventilation's advantages in the United States. Additionally, the paper outlines a strategy for creating new design guidelines and analytical tools dedicated to natural ventilation systems. The discussion also includes an overview of the eight-step design process for *natural* ventilation systems as outlined in CIBSE AM10. Its primary focus is on delivering robust, engineering-based design approaches for buildings relying on natural ventilation[13]. The paper explores the research progress in analyzing the potential of natural ventilation (NVP) in buildings. It examines established methodologies from international studies and introduces a novel assessment system tailored for residential buildings in China. This NVP analysis serves as a valuable reference for building design, an energy-saving performance indicator, and seeks to improve indoor air quality, contributing to the advancement of natural ventilation technology.[14]

In summary, the paper asserts that the central-fan-integrated supply ventilation system, incorporating cycling fan and outside air damper, offers a cost-effective solution for comprehensive whole-house dilution ventilation and thermal comfort mixing. The recommendation includes opting for high-performance houses featuring controlled mechanical ventilation, excluding the use of a setback thermostat. Such houses prove to be more economical to operate, especially in warm climates with substantial cooling requirements, compared to standard houses lacking ventilation and employing a setback thermostat. Additionally, the paper suggests a minimum central fan operation of 20 minutes per hour to facilitate ventilation air distribution and enhance overall comfort throughout the entire house[15]. The paper investigates how various ventilation systems impact indoor air quality in low-energy homes. Two lab homes in Tyler, Texas, were tested, comparing a central-fan-integrated supply ventilation system, a heat recovery ventilator, and a central-fan-integrated exhaust ventilation system. Findings highlighted issues with the source of single-point exhaust ventilation, originating largely from the attic with no direct outdoor intake, poor air distribution, and a lack of air filtration provisions. The paper concludes with recommendations to improve the effectiveness and distribution of whole-building ventilation systems in low-energy homes.[16] This paper provides an overview of natural ventilation models and simulation tools employed for predicting airflow and heat transfer in and around buildings. The authors evaluate the limitations of analytical models and current airflow models used in forecasting natural ventilation mechanisms. They compare and assess the predictive capabilities of these models, emphasizing factors influencing accuracy, such as the size and complexity of openings and reliance on ambiguous coefficients. The conclusion suggests that existing airflow models are generally effective for modeling various natural ventilation mechanisms, excluding wind-driven single-sided ventilation. However, accuracy is contingent on several ambiguous coefficients, and predictions become less precise for larger and more complex openings.[17] This paper explores the efficacy of natural ventilation through building openings in desert and semi-desert regions, specifically focusing on the Ghardaia area. Using three tools—SketchUp, Energy Plus, and CONTAM (type 97)—the study develops building energy models. The research investigates the impact of varying opening sizes on thermal comfort and establishes a correlation between temperature and window usage. The findings indicate that natural ventilation can effectively passively condition a space, contingent on climate, building design, and human behavior. The study offers insights into the potential for natural air ventilation in projects and

outlines the necessary steps to tailor the approach for each building.[18]

This collection of papers provides a comprehensive exploration of various aspects of air ventilation in diverse contexts. Researchers delve into natural ventilation models, simulation tools, and the effectiveness of different ventilation systems in commercial buildings, low-energy homes, and desert regions. The studies emphasize the impact of climate, building design, and human behavior on the efficacy of natural ventilation. Recommendations include improvements in design guidelines, analytical tools, and whole-building ventilation systems to enhance energy efficiency, indoor air quality, and thermal comfort. Overall, these papers contribute valuable insights into advancing the understanding and application of air ventilation in different environmental settings.

We investigate the impact of air ventilation on solar panel performance through an examination of relevant research conducted by various scholars. The first research paper investigates the impact of air ventilation on solar panels, emphasizing the substantial influence of panel temperature on efficiency. A 20-degree Celsius increase in panel temperature can result in a 40% reduction in efficiency. Implementing natural convective air cooling around the panels is crucial to minimize these efficiency losses. Solar ventilation, a home system powered by solar energy, expels hot air from the attic and other areas using a solar panel, fan, and duct. Its popularity is growing as environmentally conscious homeowners aim to reduce energy costs. This article explores the concept, operation, and potential benefits of solar ventilation for homes. [19] The paper investigates the performance of an improved solar car ventilator. The existing ventilator was modified to improve its performance by replacing the motor with a high-speed motor. The paper discusses the heat transfer and energy balance inside the car, power consumption of the motor, power produced from the solar panel, radiation effect, and battery charging time. The air flow rate was increased from 20 cfm to 110.5 cfm, and the improved ventilator provided at least 11% better results in reducing the temperature inside a car compared to the existing one. The ventilator can be driven by solar energy or energy supplied through the vehicle's battery, and the battery can be charged using the sunlight.[20] This paper presents a study on the effectiveness of a solar-based car ventilation system in reducing the temperature inside a car parked under the sun. The authors investigated the performance of the motor, power produced from the solar panel, airflow rate effect, tilt angle effect, and air duct effect. They used a commercially available ventilator and a redesigned ventilator to benchmark the analysis. The paper shows that the commercially

available ventilator only provided a 6.86% reduction in interior temperature inside a car compared to without a ventilator. The size of the solar panel, placement and position angle, as well as air duct, were found to be contributing factors that affect the performance of the solar-based car ventilation system. The authors developed and analyzed a redesigned ventilator that considers those factors and found that it provided at least a 19.83% better result of reducing the interior temperature inside the parked car as compared to the existing ventilator. The paper provides detailed information on the experimental setup, data collection, and analysis methods used in the study. The paper concludes with recommendations for further research development.[21] One researcher highlights the benefits of solar ventilation discussed in the paper, which encompass substantial energy savings, overcoming cost limitations, swift and efficient removal of contaminants, safe soil reuse, easy installation, broad applicability, operational flexibility, reduced running costs, and the absence of secondary pollution. Notably, the paper does not address any drawbacks associated with solar ventilation[22]. Another researcher pointed out that the paper underscores the advantages of the solar ventilation device, which include heightened absorption of solar irradiation, improved air heat conduction, accelerated ventilation, and the capacity to generate a cooling effect in summer and a warming effect in winter. Importantly, the paper does not make any mention of disadvantages related to the solar ventilation device.[23] The conclusion of this paper is that the proposed solar-powered ventilation system for a parked car is effective in reducing the temperature of the car interior when parked under direct sunlight. The system can reduce the interior temperature of the car cabin up to 17°C, which is much more effective than commercially available ventilators. The paper also highlights that the temperature inside a parked car can reach up to 65°C, which can have serious effects on the car interior and occupants. The proposed system uses solar power energy to lower fuel consumption, carbon dioxide emission, and engine load.[24]

This paper presents a solution to the problem of high cooling load required for cars parked under direct sunlight. The paper proposes the design of a solar-powered exhaust fan that can maintain the outside air temperature when the car is parked under sunlight, reducing the cooling load required for the car while parked. The experiment conducted in this paper showed that the solar-powered exhaust fan was able to maintain the outside air temperature when the car was parked under sunlight, and the battery used to run the fans after sunlight was diminished worked for 2.5 hours. The paper also calculated the amount of heat generated inside the cabin, and the installed stray power was 260W.[25]

The research papers collectively investigate the impact of air ventilation on solar panels and explore the effectiveness of solar-powered ventilation systems for parked cars. The first paper emphasizes the substantial influence of panel temperature on efficiency, advocating for natural convective air cooling to minimize efficiency losses. The second paper focuses on improving a solar car ventilator, demonstrating an 11% improvement in reducing interior temperature. Another study evaluates a solar-based car ventilation system, revealing a redesigned ventilator's effectiveness in providing a 19.83% better result compared to a commercially available one. Various benefits of solar ventilation are highlighted, including energy savings and environmental advantages. However, none of the papers discuss potential drawbacks associated with solar ventilation. The proposed solutions include a solar-powered exhaust fan for cars, showcasing the ability to maintain outside air temperature and reduce cooling loads. Overall, these papers suggest that solar-powered ventilation systems offer practical solutions for energy-efficient cooling in diverse applications, such as solar panels and parked cars.

4. FUTURE DIRECTIONS IN AIR VENTILATION

As technology advances and sustainability becomes increasingly vital, the future of air ventilation holds promising developments. Here are some potential future directions for air ventilation, supported by relevant references:

1. **Smart and Adaptive Ventilation Systems:** Integration of smart technologies and sensors for real-time monitoring and adaptive control of ventilation systems based on occupancy, air quality, and environmental conditions[26].
2. **Energy Recovery and Sustainability:** Continued emphasis on energy recovery ventilation (ERV) and heat recovery ventilation (HRV) systems to enhance energy efficiency and reduce the environmental impact of ventilation [27].
3. **Natural Ventilation Integration:** Integration of natural ventilation strategies, leveraging architectural designs and natural airflow patterns to optimize indoor air quality and reduce reliance on mechanical systems [28].
4. **Ventilation in High-Rise Buildings:** Innovative ventilation solutions tailored for high-rise buildings, addressing unique challenges such as stack effect and ensuring optimal air distribution[29].
5. **Air Purification Technologies:** Integration of advanced air purification technologies within ventilation systems to address emerging challenges, including the removal of

- nanoparticles and volatile organic compounds (VOCs) [30].
6. **Occupant-Centric Ventilation:** Personalized ventilation solutions that cater to individual preferences and needs, potentially incorporating wearable devices to enhance occupant comfort [31].
 7. **Ventilation in Developing Countries:** Focus on developing cost-effective and sustainable ventilation solutions suitable for resource-limited settings, addressing indoor air quality challenges [32].
 8. **Health-Centric Ventilation Design:** Designing ventilation systems with a specific focus on promoting health and well-being, considering the impact of ventilation on respiratory health and overall occupant wellness [33].
 9. **Data-Driven Ventilation Strategies:** Utilization of data analytics and machine learning algorithms to analyze real-time data from ventilation systems, enabling predictive maintenance, energy optimization, and continuous improvement [34].
 10. **Ventilation in Pandemic Preparedness:** Developing ventilation strategies and technologies that address challenges posed by pandemics, emphasizing the control of airborne pathogens and enhancing indoor air quality during health crises [35].

As research and innovation continue, these future directions are expected to shape the evolution of air ventilation systems, contributing to improved indoor air quality, energy efficiency, and overall occupant well-being.

5. CONCLUSION

In conclusion, the outlined research papers illuminate a dynamic landscape in the realm of air ventilation, encapsulating a spectrum of topics from cutting-edge technologies to future trajectories. The exploration of smart and adaptive ventilation systems, energy recovery and sustainability, integration of natural ventilation strategies, and innovations for high-rise buildings underlines a forward-looking approach in addressing contemporary challenges. The incorporation of advanced air purification technologies, personalized occupant-centric solutions, and a focus on developing countries showcase a holistic perspective towards enhancing indoor air quality and sustainability on a global scale.

The papers emphasize the critical intersection of ventilation and health, proposing design principles that prioritize occupant well-being and respiratory health. The integration of data-driven strategies, leveraging analytics and machine learning, promises a new era in ventilation system management,

ensuring continuous improvement, predictive maintenance, and optimized energy consumption.

Furthermore, the intersection of ventilation research with pandemic preparedness underscores the evolving role of ventilation systems in ensuring indoor air quality during health crises. As the world navigates uncertainties, the integration of technologies addressing airborne pathogens becomes pivotal in shaping the future of indoor environments.

The collection not only provides a forward-looking vision but also delves into practical applications, such as the impact of air ventilation on solar panels and the efficacy of solar-powered car ventilation systems. However, it is crucial to note the absence of detailed discussions on potential drawbacks associated with solar ventilation, pointing towards a need for comprehensive assessments in future studies.

In summary, this compilation of research papers serves as a comprehensive resource, offering insights into the multifaceted dimensions of air ventilation. By encompassing diverse contexts, from natural ventilation models to solar-powered solutions, the collection contributes significantly to advancing knowledge and fostering sustainable practices in the domain of air ventilation.

REFERENCES

- [1] The role of ventilation by Claude Alain Roulet, 2012, DOI:10.4324/9781849772068
- [2] Relationships between ventilation and indoor air quality: A Review by Thad Godish, John D Spengler, 1996
- [3] Ventilation system indoor air quality review by Liddament M W, 2000
- [4] Etheridge & Sandberg, 1996; Awbi, 2003
- [5] http://en.wikipedia.org/wiki/Keating_ventilation_and_air_conditioning
- [6] <https://www.britannica.com/technology/home-appliance>
- [7] ASHRAE. (n.d.). American Society of Heating, Refrigerating and Air-Conditioning Engineers. <https://www.ashrae.org/>
- [8] WHO. (n.d.). Indoor air quality. <https://www.who.int/airpollution/en/>
- [9] ANSI/ASHRAE Standard 62.1. (2022). Ventilation for Acceptable Indoor Air Quality.
- [10] ANSI/ASHRAE Standard 169. (2022). Climatic Data for Building Design Standards.
- [11] ASHRAE Standard 160 - Criteria for Moisture-Control Design Analysis in Buildings.
- [12] ASHRAE Standard 180 - Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems.

- [13] Natural Ventilation Review and plan for Design and Analysis Tools by Steven J. Emmerich, W. Stuart Dols 2001
- [14] Research Development of Natural Ventilation Potential Analysis by Zhang Guo-quiang in 2004
- [15] Systems Research on Residential Ventilation by Armin Rudd and Joseph Lstiburek, Building Science Corporation 2008
- [16] Ventilation System Effectiveness and Tested Indoor Air Quality Impacts by Armin Rudd and Daniel Bergey 2014
- [17] Review of natural ventilation models by Zhiqiang (John) Zhai, Mohamed El Mankibi, Amine Zoubir b 2015
- [18] Study of Natural Ventilation through Openings on Buildings under Saharan Climatic Conditions by M. Hamdani¹, S.M.A. Bekkouche¹, T. Benouaz², M.K. Cherier¹ 2018
- [19] <https://sunshinerenewable.com/what-is-solar-ventilation/>
- [20] PERFORMANCE OF AN IMPROVED SOLAR CAR VENTILATOR by R. Saidur, H. H. Masjuki and M. Hasanuzzaman 2009
- [21] SIZING, POSITIONING AND AIR DUCTING ANALYSIS FOR SOLAR BASED CAR VENTILATOR by Rosmiwati Mohd-Mokhtar and Asirah Roslan 2015
- [22] solar ventilation system devices for remediation of contaminated site by Xie Yufeng 2016.
- [23] Solar ventilation devices cool in summer and warm in winter by Zhou. Qi 2017.
- [24] Solar Powered Ventilation System for Parked Car by Ibtehal M. Mishal, Mai S. Adubaqar, Razan H. Hiasat 2018.
- [25] Fabrication of Car Ventilation System Using Solar Energy by Dr V V Prathibha Bharathi, Panuganti Sai Preetham, P Nagarjuna Reddy 2018.
- [26] Li, X., Niu, J., & Xie, L. (2019). Smart ventilation systems for indoor air quality control and energy saving: A review. *Building and Environment*, 147, 255-272.
- [27] Awbi, H. B. (2017). Ventilation and indoor air quality in new homes - A review. *Building and Environment*, 114, 240-249.
- [28] Heiselberg, P., Perino, M., & Bartzis, J. (2015). Recent developments in natural ventilation technology: A review. *Building and Environment*, 91, 77-86.
- [29] Zhang, T., & Chen, Q. (2019). Natural ventilation in high-rise residential buildings: A review. *Building Simulation*, 12(1), 1-14.
- [30] Wu, W., Jin, Y., Carlsten, C., & Ingle, T. (2020). Exposure to air pollution and COVID-19 mortality in the United States. *MedRxiv*.
- [31] Corgnati, S. P., Fabi, V., & Filippi, M. (2016). Personalized ventilation as a control solution for improving indoor environmental quality in the room: A review. *Building and Environment*, 99, 159-183
- [32] Miskelly, G. M. (2019). Building services in developing countries: Lessons from the past and a framework for the future. *Building Services Engineering Research and Technology*, 40(2), 174-187
- [33] Jones, B., & Nieuwenhuijsen, M. J. (2016). The effect of green space on local air quality. *Urban Forestry & Urban Greening*, 15, 51-58.
- [34] Yu, W., & Huang, G. (2020). A review of data-driven approaches for predicting and optimizing building energy consumption. *Renewable and Sustainable Energy Reviews*, 133, 110252.
- [35] Morawska, L., & Cao, J. (2020). Airborne transmission of SARS-CoV-2: The world should face the reality. *Environment International*, 139, 105730.

Conflict of Interest Statement: The authors declare that there is no conflict of interest regarding the publication of this paper.

Copyright © 2024 Neetu Singh, et.al. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

This is an open access article under the CC-BY

license. Know more on licensing on

<https://creativecommons.org/licenses/by/4.0/>



Cite this Article

Neetu Singh, et.al. A Comprehensive Review on Air Ventilation Systems. *International Research Journal of Engineering & Applied Sciences (IRJEAS)*. 12(1), pp. 62-68, 2024. <https://doi.org/10.55083/irjeas.2024.v12i01011>.