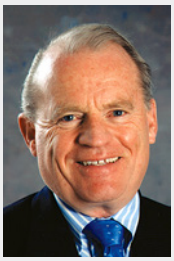
Industrial Ventilation: Global Perspectives



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The author will examine innovative scientific and engineering opportunities in the industrial ventilation field from a global perspective. Key factors such as low carbon economy and global competiveness have placed a new requirement on the proper engineering design of advanced industrial ventilation systems. Plans for the preparation of a revised Industrial Ventilation Design Guidebook (2021) will be discussed*.

Keywords: ventilation, Cleantech, Industry 4.0, Artificial Intelligence, contaminant control

*This article is an invitation to any REHVA researcher/expert/engineer/practitioner interested to contribute to any specific section of the revised DGB to contact Howard Goodfellow indicating the areas of interest. Contact quickly, as the Chapter leaders have already been selected by the Co-Editors but we need to make sure that we include the best science and best practices for industrial ventilation from the global community. We are also looking for reviewers for specific areas.

Driving Forces Today for Industrial Sectors

The manufacturing and processing industries are facing many challenges today. The fourth industrial revolution (Industrial 4.0) is happening at an accelerated rate and many companies are embracing disruptive technologies. This technology is an extension of the automation field which has seen the use of largely automatic equipment, including robots in a system of manufacturing or other production processes. Successful companies must adapt quickly, and new technical skills are required to implement this revolution. Many companies do not have technical personnel to implement these technological changes. Skills include Artificial Intelligence (AI) leaders, researchers, technologists, data scientists, engineers, etc. All of these innovative changes have a major impact on the proper design of industrial ventilation systems for the specific processes. There is an urgent need for a simple holistic model to provide technical guidance for implementation of Industrial 4.0. A proposed framework for a Smart Cleantech Model follows.

Smart Cleantech Model (SCM)

Cleantech is a general term used to describe products, processes or services that reduce waste and require as few non-renewable resources as possible. The goal is to develop a simple generic software platform for a wide range of industries to improve global competitiveness. This needs to be a multi-disciplinary approach (ventilation, sensors, AI) in a lab environment. This approach would require the integration of best practices for modeling, sensors, big data, and optimization (AI, deep learning). **Figure 1** identifies the framework for what SCM would look like for air (similar structures for the Cleantech model could be developed for water and solid waste).

A component of this model would be a SMARTVENT model for industrial ventilation which would be developed for manufacturing and processing plants.

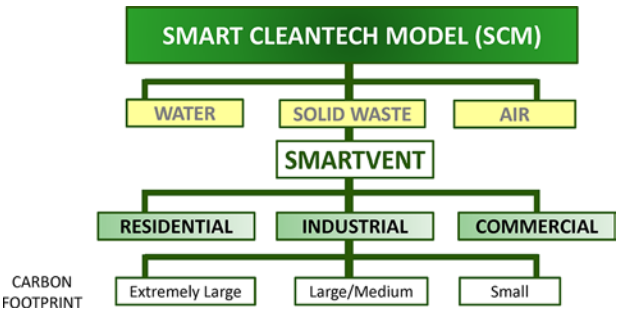

Figure 1. Smart Cleantech Model (SCM).

Industrial Ventilation DGB (2001)

In 2001, a scientific textbook edited by Howard D. Goodfellow and Esko Tahti was published by Academic Press. The **Industrial Ventilation Design Guidebook** addressed the design of air technology systems for the control of contaminants in industrial workplaces such as factories and manufacturing plants. It covered the basic theories and science behind the technical solutions for industrial air technology and included publication of new fundamental research and design equations contributed by more than 40 engineers and scientists from over 18 countries.

Readers were presented with scientific research and data for improving the indoor air quality in the workplace and reducing emissions to the outside environment. The Guidebook represented, for the first time, a single source for all current scientific information available on the subject of industrial ventilation and the more general area of industrial air technology. New Russian data was included that filled several gaps in the scientific literature.

- Presents technology for energy optimization and environmental benefits
- A collaborated effort from more than 60 ventilation experts throughout 18 countries
- Based on more than 50 million dollars of research and development focused on industrial ventilation
- Includes significant scientific contributions from leading ventilation experts in Russia
- Presents new innovations including a rigorous design methodology and target levels
- Contains extensive sections on design with modeling techniques
- Content is well organized and easily adaptable to computer applications

This comprehensive digest of scientific know-how gained its origin from the International Industrial Ventilation Conferences that were conceived by Professor Jim Smith and Howard Goodfellow from the University of Toronto (September 1985). **Figure 2** conveys the ventilation conferences held every three (3) years with the most recent conference being held in Finland in 2018. These specialized conferences have resulted in the development of a critical global mass of engineers and scientists working in the industrial ventilation field. Since the conference inception, there have been twelve international symposiums with more than 3000 attendees and over 1250 technical papers. The 13th International Industrial Ventilation Conference is now being planned for 2021 in North America.

2018	Espoo, Finland	2000	Helsinki, Finland
2015	Shanghai, China	1997	Ottawa, Canada
2012	Paris, France	1994	Stockholm, Sweden
2009	Zurich, Switzerland	1991	Cincinnati, USA
2006	Chicago, USA	1988	London, England
2003	Sapporo, Japan	1985	Toronto, Canada

Figure 2. International Ventilation Conference Locations.

Revised Industrial Ventilation DGB (2021)

The proposed revised guide book covers the area of ventilation for contaminant control based on global research by world class researchers. This reference book is unique because it brings together global researchers and engineers to allow designers and engineers to solve complex ventilation problems using state-of-the-art design equations. Most of the equations and other scientific terms can be used in all ventilation and air conditioning fields, not only for ventilation contaminant control.

The recent awareness of climate change and a push by all industrial countries to embrace a low carbon economy has put a high pressure on industry to reduce their environmental footprint. European countries have taken a leadership role with the introduction of Industry *4.0* ~ automation plus sensors. For this to be implemented, engineers and scientists will be looking for a single reference source to find design equations and methodology to develop control algorithms for automation. Another key scientific component is the measurement of process parameters in real time using state-of-the-art sensors in the air and contaminant fields. These are specific areas that will be presented in depth for the first time in a detailed format based on global research in the sensor technology fields. Data will be presented both for leading edge sensor technology and well proven technology on a global basis.

The revised **Industrial Ventilation DGB (2021)** will be unique in the marketplace as it will present a single source for a holistic approach to industrial ventilation for contaminant control. Details will be presented for the four key steps:

Step 1: Design Methodology

Step 2: Design Equations

Step 3: Design Toolkits

Step 4: Specific Industrial Examples of Best Practice for Ten Major Sectors

The reasons for proposing this newly revised edition is because of the wealth of increase in new research technology in the broad field of ventilation for contaminant control on a global scale since the original Industrial Ventilation DGB was published in 2001. The preparation of the original book took ten years and major contributors from Europe and Russia where the level of science was the highest. Specific areas of advancement include: design methodology for ventilation systems for contaminant control, use of high-speed computers in modeling capabilities of air-flow and contaminant levels in both the workplace environment and the external environment, commercialization of the latest sensor technology such as lasers, etc., and the breakthrough of practical application of deep learning in the Artificial Intelligence (AI) field.

Our approach is to achieve harmonization of ventilation technologies on a global basis. Our extensive list of global experts will present for the first time a multi-sector cross cutting technology based on a holistic integrated approach of scientific research and engineering in the industrial ventilation field.

Figure 3 illustrates the major chapters being planned for the revised Industrial Ventilation DGB (2021). The revised book will have Professor Howard Goodfellow (University of Toronto) as Editor-in-Chief. The Co-Editors will be Professor Risto Kosonen (Aalto University, Finland) for *Volume I – Fundamentals* and Professor Yi Wang (Xi'an University, China) for *Volume II – Engineering Design and Applications*.

New features of the book will be as follows:

- Major new innovative technologies from researchers in China (book will become truly global)
- Further validation of design methodology and target levels based on plant experience
- Integration of automation and sensors (Industry 4.0)
- Closer collaboration with engineering schools and end users and the design/consulting communities
- Focus on gaps in ventilation using search engines to ensure all recent developments and innovations are included
- A new and expanded section on sensors technology and methodology of selecting the best sensor for each unique application
- Section on modeling and its practical applications will be expanded based on recent advances in research
- A new chapter on Best Practices for specific industrial sectors. The initial edition will be based on 10 industrial sectors with a proposed template that can easily be updated in the future to include other industrial sectors. An outline for the template for Best Practice is presented below

The template for Industrial Sectors for the Chapter on "*Best Practices*" for Industrial Ventilation for

Contaminant Control – Industry Specific Sectors for selected industrial sectors includes:

- Overview – Role of Ventilation
- Design Methodology
- Design Equations
- Design Toolkits
- Case Studies – Best Practice
- Future Challenges /Opportunities
- Selected Bibliography

Table 1 illustrates the features and benefits of the revised Industrial Ventilation DGB (2021).

The professional audience faces many issues. The first is that the literature (research and engineering) is highly fragmented in the research world (no specific home and often in different disciplines in different countries). The proposed book will provide a single source for relevant research and engineering in the industrial ventilation for contaminant control field.

Table 1. Industrial Ventilation DGB (2021) – Features/Benefits.

FEATURES	BENEFITS
Systematic Holistic Approach to Design with new section on best practices for ten selected industries	Accelerate implementation of best practice for end users
Global team of researchers and engineers as contributors	Single source of all recent research and best practice for industrial end users. Benefit for training of future researchers, designers and engineers to use IOT to achieve energy efficiencies, cleantech, climate change, etc.
Innovative state-of-the-art development of sensors, modeling, deep learning system performance evaluations, hyper linked equations	Provide key technical inputs required for challenges of low carbon economy and industrial 4.0

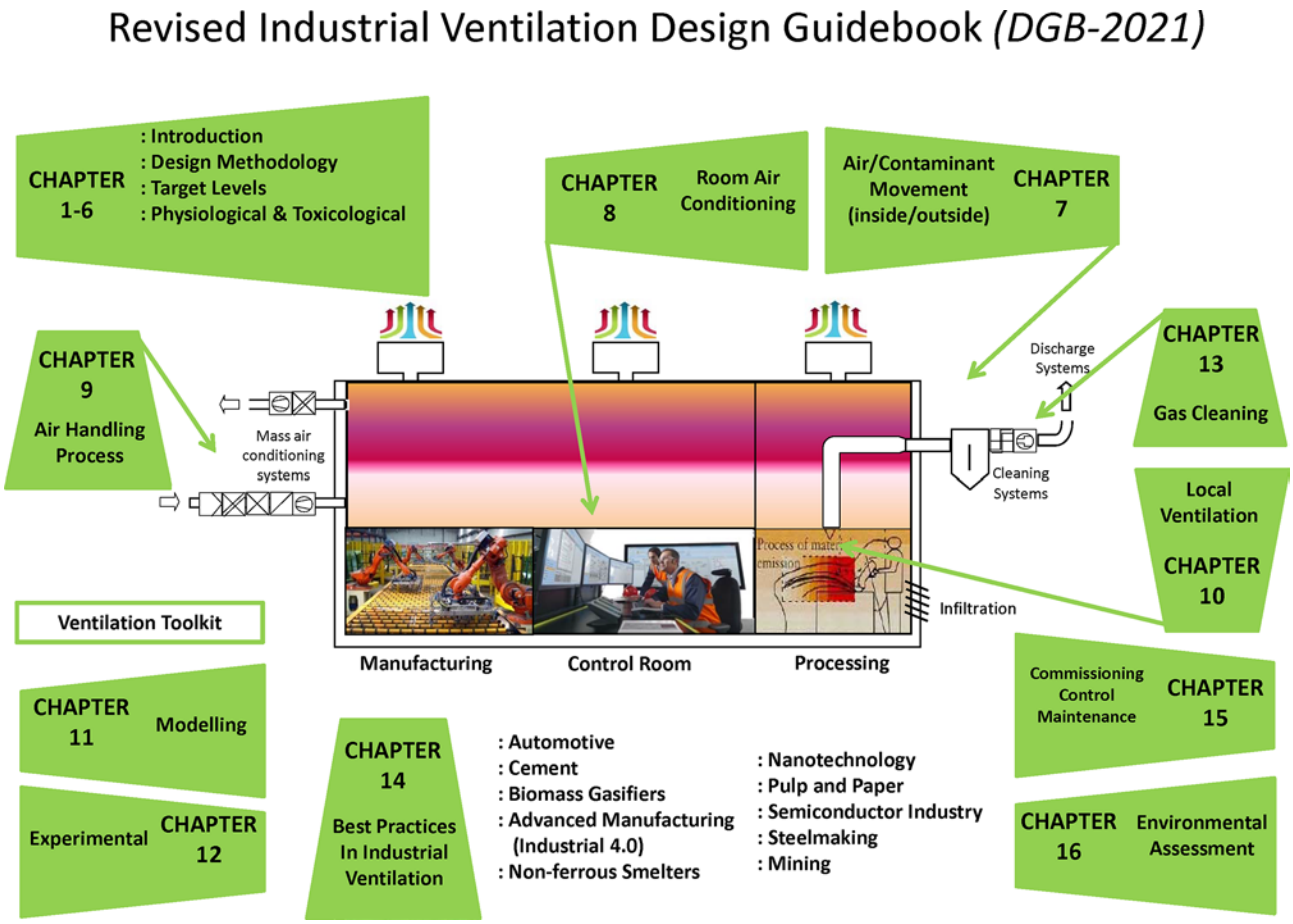

Figure 3. Outline of DGB (2021).

A second issue is that many of the text books, reference books and engineering books in this field have not been updated for a couple of decades or so, and do not reflect state-of-the-art for ventilation technology today and do not include the significant innovations in design criteria, modeling, sensors, AI (deep learning), etc., that are available to meet the new challenges of sustainability and a low carbon economy. The proposed book will focus on these recent developments.

The target audience will be at two levels and for a multi-sector industrial approach for processing plants and manufacturing. The proposed two levels for this revised DGB will be to bring researchers, engineers (both design and plants) and scientists to develop a fundamental scientific understanding of ventilation and to provide trained engineers to implement this state-of-the-art ventilation technology on a global basis. It is envisaged that the revised Industrial Ventilation DGB can be used as a core text book in an academic setting for mechanical engineers and process engineers. It is envisaged that it can be used as a background for specific industry based 1–5 day workshops and for plant and process engineers looking for a design methodology, sensors and control algorithms for specific industrial operations to meet the challenging low carbon economy. The textbook will also be a valuable reference book for consulting engineers working in the design of air pollution and sustainability for their industrial clients (processing and manufacturing).

Future Directions and Opportunities

The science and technology of industrial ventilation is at a crossroads and key decisions need to be made to capitalize on the unbounded opportunities. Three key areas to be pursued are:

- Better communication (scientific and engineering community of ventilation and contaminant control)
- Develop a global collaborative community
- Embrace disruptive technologies (sensors, modeling, automation, AI, etc.)

In the area of better communications, it is important to recognize that there are many common areas of scientific research and engineering in the ventilation and contaminant control field. The goal is to develop a holistic approach for the science of ventilation. **Figure 4** illustrates many of the common areas of science and technology for the residential, commercial and industrial sectors.

The second area is to develop a global collaborative network in the ventilation technology field. This global network would include scientific research (academic, research institutes), professional associations (ASHRAE, REHVA, SHASE), international technical conferences, low carbon economy, disruptive technologies (Industrial 4.0, AI, sensors, etc.), scientific publications (revised Industrial Ventilation DGB (2021)). Success depends on a holistic, multi-disciplinary and a sustain-

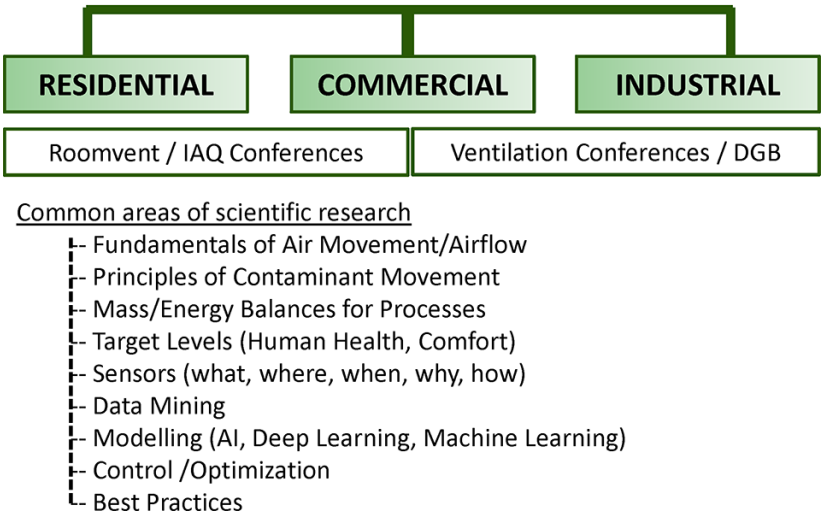

Figure 4. Science of Ventilation.

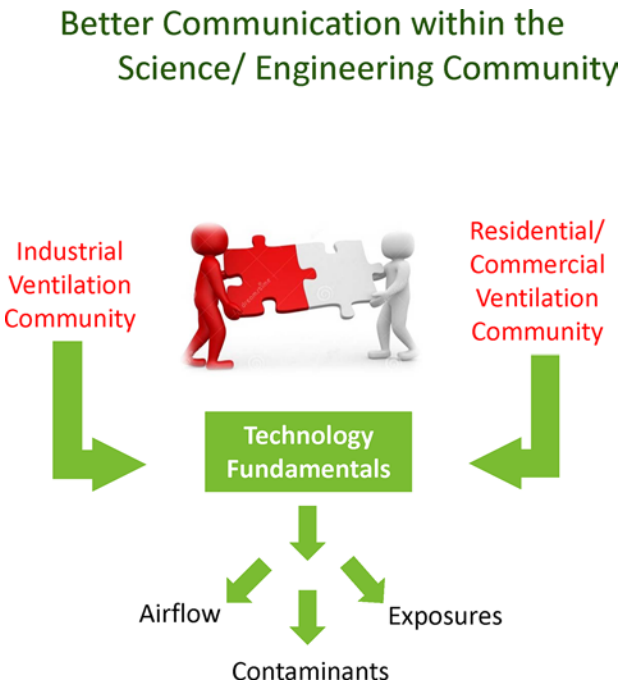

Figure 5. Communications Model.

able funding model. An excellent example of this goal to breakdown the silos is the leadership shown by ASHRAE President Professor Oleson in his August 2017 article in ASHRAE Journal entitled, ***Extending our Community***. The specific goals outlined in the report was the urgent need for the ventilation community to *"extend the global community"* and to *"extend the technological horizons."*

Figure 5 illustrates a model for better communications with the science and engineering community.

Disruptive technologies are happening at an accelerated rate and will have a major impact on the future directions of the science and technology of industrial ventilation. Disruptive technologies such as robotics, AI, models for low carbon economy, innovative sensors, etc., are impacting many sectors and researchers must embrace the cross transfer of these technologies. For example, innovative sensors are being developed that are wireless, non-invasive, cheap, remote, in-situ. Many of these sensors have wide applications for many different sectors (ie. autonomous vehicles) for advanced design of ventilation systems. ■

In summary, I urge all researchers and engineers in the industrial ventilation field to be:

BOLD

EMBRACE LEARNING

SUCCESS DEPENDS ON SIMPLICITY

The issue is never how to get new innovative thoughts into your mind ... but how to get old ones OUT.

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