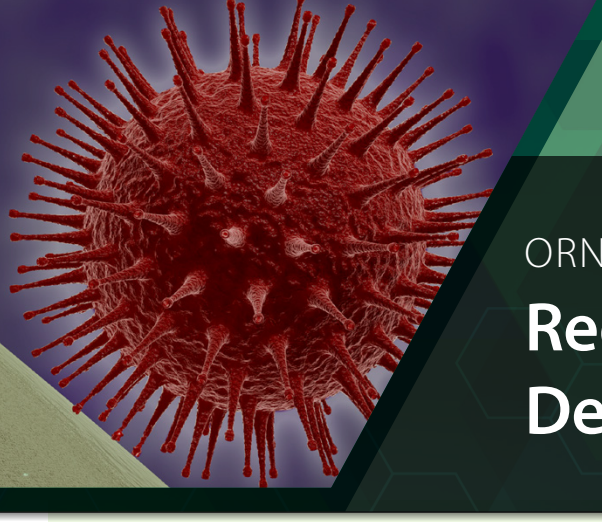


ORNL's Buildings Technologies COVID-19 Research:

Redesigning Ventilation, Delivering Refrigeration Innovation

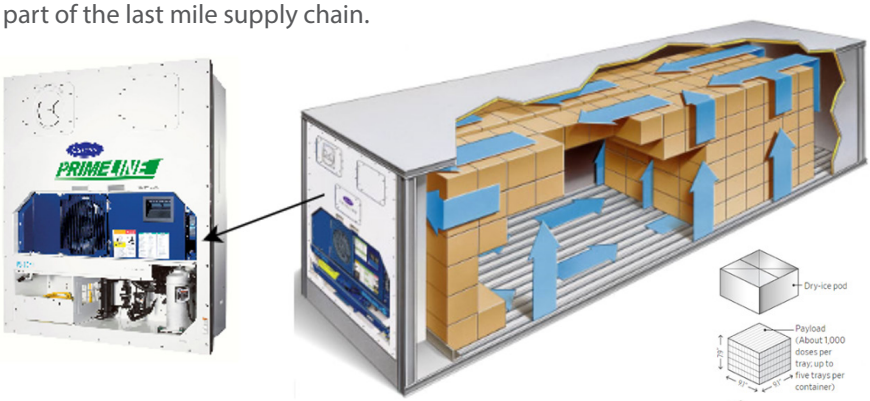
In the fight against COVID-19, building technologies research expertise is essential to providing solutions for mitigating virus transmission in indoor environments and developing refrigeration innovations for the safe delivery of vaccines. Oak Ridge National Laboratory's Building Technologies Research and Integration Center, a Department of Energy (DOE) user facility, serves as the primary development hub, where scientists conduct building equipment and envelope materials research to aid in the nation's rapid response to COVID-19. ORNL's researchers have contributed to the development of guidance, both through the DOE's Commercial Buildings Integration program and through the American Society of Heating, Refrigeration and Air-Conditioning Engineers Epidemic Task force.

ORNL buildings researchers transition their technologies to industry for commercial use so that throughout the U.S., these COVID-19 solutions reach communities in rural areas as well as densely populated cities. Researchers also advance scientific discoveries that will enable buildings to not only remain COVID-free but also adaptable in a changing global climate.

The projects outlined highlight ORNL's extensive unique capabilities for indoor environmental controls, the evaluation of contaminant transport, and the development of mitigation strategies.

Ultralow temperature for vaccine distribution:

Most COVID-19 vaccines require refrigeration temperature control for transportation and storage. Multiple types of vaccines have been developed by manufacturers and two of them are based on messenger RNA (mRNA) and lipid nanoparticles requiring low temperature storage. The last stage of vaccine distribution has been challenging, especially for rural or suburban areas, where local towns, pharmacy chains and hospitals may not have the infrastructure required to store the vaccine at the required temperature. Also, the need for a large amount of ultralow temperature refrigeration equipment in a short time period creates pressure on equipment suppliers. As such, there is a need for a quick, effective, secure and safe solution to mitigate vaccine distribution logistics. ORNL researchers collaborated with Carrier Global Corporation, one of the nation's largest refrigeration unit suppliers, to validate a refrigeration solution to address the ultra-cold last mile distribution challenge for some vaccines. The approach is to utilize commercially available refrigeration container units and evaluate them with optimal cargo layout and storage rack designs to ensure uniform temperature distribution to maximize the dry-ice extended storage life. The objective is to assess the technical merits of using commercially available products, such as Carrier Transicold container refrigeration units, with the ability to control air temperature to maintain vaccine package temperature at -30°C or -70°C as part of the last mile supply chain.



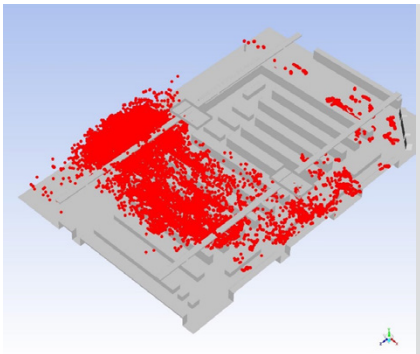
COVID 19 Vaccine Distribution-Solution to the LAST MILE challenge

Cryogenic Refrigeration to facilitate maintaining ultralow temperatures

Air handling and mitigation strategy for transmission of aerosols through buildings: Among the many ways for COVID-19 to spread, airborne transmission is the most critical, particularly within high-population density areas where people reside in multi-family housing with combined ventilation and air conditioning systems. ORNL building technologies researchers have been conducting experiments for the far-field transmission to investigate viral spread in residential and commercial buildings. This includes the development of a framework to generate aerosol with detectable fluorescence, instrumentation of a flexible research platform, modulation of an air management system through the air handling system, and data analysis for a range of operating conditions. ORNL's initial study has enabled the research team to validate theoretical models, complemented by near-field experimentations in progress at other national labs. This research is funded by the DOE Office of Science through the National Virtual Biotechnology Laboratory.

UV-based mitigation of airborne transmission of COVID-19: UV-based disinfection technology has been used in selected commercial applications including hospitals and other mission-critical facilities. A recent study on airborne transmission has indicated that after sneezing or coughing, droplets smaller than 10 microns stay suspended in the air, even 20 minutes after the initial episode. Micron-sized droplets may stay airborne for some time, long enough for the rate of evaporation to be critical. These droplets can count in the thousands and active carriers of COVID-19. The overall goal of ORNL's proposed research is to establish the most optimum deployment strategy (including placement, residence time, etc.) to maximize the mitigation potential of the UV-based air sterilization process while utilizing minimum energy.

Needlepoint bipolar ionization for indoor air-quality management: ORNL researchers have been investigating the potential of using bipolar ionization to generate localized plasma which can then be deployed to trap water. This technology could provide some level of mitigation for the transmission of droplets and aerosols which have been identified as major carriers of COVID-19. Besides trapping droplets and aerosols, the plasma also acts as a catalyst that could potentially inhibit the virus and other biological entities (bacteria and fungi) by ion interactions. Researchers have been investigating the feasibility of the process to mitigate COVID-19 and to establish compatibility with current and future heating, ventilation and air conditioning infrastructure.



Particle distribution from a moving infected person, transit time of 6 minutes.

Single and multizonal dispersion modeling of SARS-CoV-2 aerosols: Transmission of COVID-19 within buildings is an area of great concern for occupants and operators. ORNL researchers have been investigating both transmission and mitigation strategies using simulation tools. One example of an essential business is a grocery store. People rely on grocery stores to buy food, daily necessities and medicines. A grocery store could have a high load of people from many areas, which increases the infection risk of customers and employees. ORNL building technologies researchers have developed a computational fluid dynamics model for a grocery store to investigate the spread of the COVID-19 virus. The model is based on a real store with ventilation system design and represents the air flow and temperature distribution. The initial study has been used to visualize the spread of infectious aerosols when an infected person is coughing in the store. ORNL researchers have also been working with bulk flow models to study transmission at the whole building scale. Building upon previous work to represent the DOE prototype buildings as multizone airflow models, dispersion of SARS-CoV-2 aerosols is being investigated in a medium office prototype building model. ORNL researchers are exploring the use of suitable metrics to quantify and compare the spatial distribution of exposure dose across multiple zones within a single building and thus provide a whole-building risk map along with applicable mitigation strategies such as increasing outdoor air ventilation rates through Heating, Ventilation and Air-Conditioning systems and air filtration, the use of portable air purifiers, and ultraviolet germicidal irradiation air disinfection.

CONTACT:

Melissa Lapsa
Building Technologies Program Manager

lapsamv@ornl.gov
865-576-8620

One Bethel Valley Road,
Oak Ridge, TN 37830

ornl.gov/buildings