COUNTERING CLIMATE CHANGE: BUILDING DECARBONIZATION + BUILDING RESILIENCY = IMPROVED HUMAN CONDITION

A key way to help counter climate change is by furthering building decarbonization and resiliency, which also improves the human condition.

By Nick Agopian

Climate change is now no longer an abstract concept that may or may not happen. The drastic effects are real and are already felt across the world, including in North America. In fact, according to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Handbook of Fundamentals: "We are now experiencing major changes in climate, both locally and globally, at rates 10 times greater than seen since the end of the last ice age 20,000 years ago—over decades instead of centuries or millennia."[1] For example:

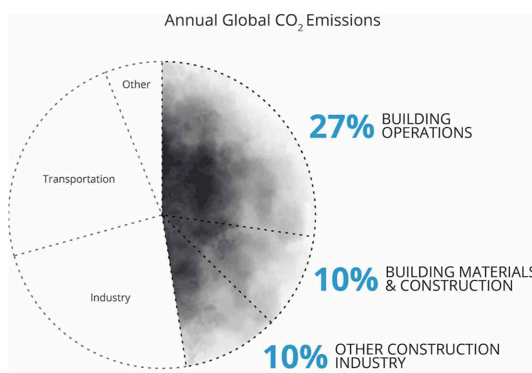
- Texas experienced energy shortages in 2021 that resulted in about a hundred deaths from cold.[2]
- The Northwest heatwave in 2021 resulted in hundreds of deaths, mainly in buildings without cooling.[3]
- Hurricane Maria struck Puerto Rico in 2017 and caused the world's second-largest blackout.[4]
- The Northern California wildfire seasons from 2017-2019 are the most devastating on record and sent the nation's largest investor-owned utility into bankruptcy.[5]
- Superstorm Sandy served as a wakeup call for the New York/New Jersey region when it hit with devastating force in 2012.[6]

To help counter climate change, we can start with our homes and buildings by making them better for the environment and for occupants. How so? The answer is via building decarbonization and resiliency, which can lead to improved human condition.

Energy recovery ventilators (ERVs) can play critical roles in the success of decarbonization and building resiliency initiatives.

The Built Environment Is a Major Contributor to Climate Change
Buildings generate tremendous amounts of carbon (CO2) emissions, which can seriously impact the climate. In fact:[7]

- The built environment generates about 47% of annual global CO2 emissions.
- Of those total emissions, building operations are responsible for 27% annually, while building materials and construction (typically referred to as embodied carbon) are responsible for an additional 20% annually.
- The global building floor area is expected to double by 2060. This is the equivalent of adding an entire New York City to the world, every month, for 40 years.



Annual global CO2 emissions. Data sources: Global ABC's Global Status Report 2021, EIA; Image source: Architecture 2030 [8]

[1] Jim Newman, "Sustainable and Resilient: The Future of Buildings," FacilitiesNet, https://www.facilitiesnet.com/green/article/Sustainable-and-Resilient-The-Future-of-Buildings--19374.

[2] David B. Goldstein, "Working Together: Resilience and Decarbonization," NRDC (Natural Resources Defense Council), August 2, 2021, https://www.nrdc.org/experts/david-b-goldstein/working-together-resilience-and-decarbonization.

[3] Ibid.

[4] Sohum Pawar, "Resilient Decarbonization for the United States," MIT Climate Portal, March 19, 2021, https://climate.mit.edu/posts/resilient-decarbonization-united-states.

[5] Ibid.

[6] Ibid.

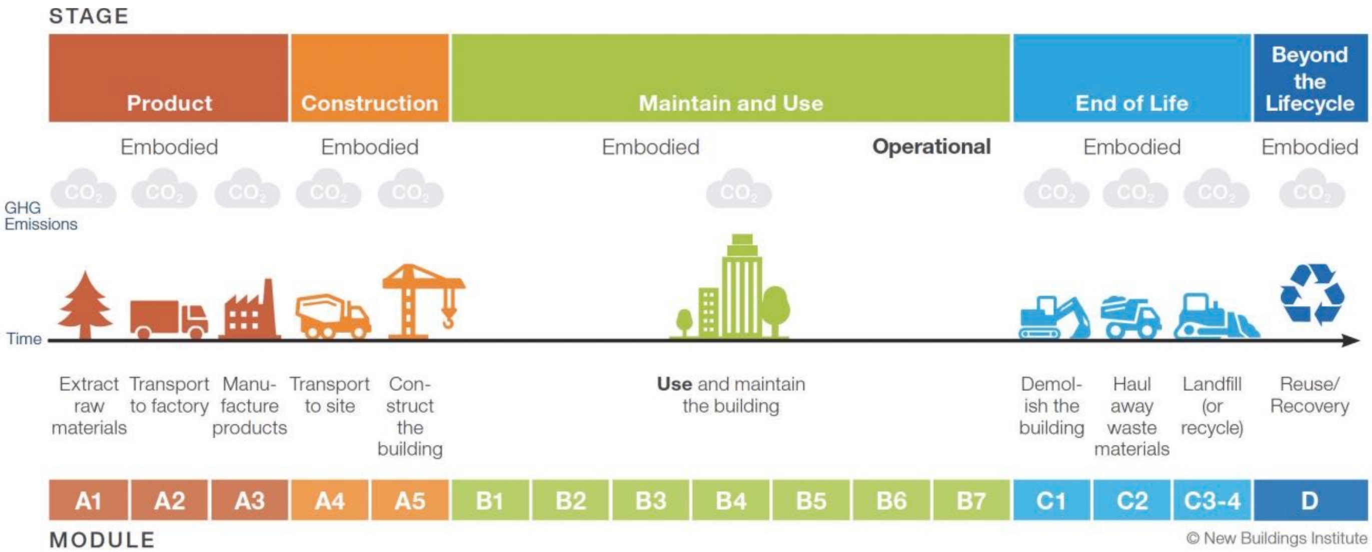
[7] All information in this paragraph and subsequent bullets sourced from: "Why the Built Environment?," Architecture 2030, https://architecture2030.org/why-the-building-sector/.

[8] Ibid.

The Solution? Building Decarbonization

Now we know why buildings must reduce carbon emissions to help counter climate change. Thus, if a building is to be decarbonized, we must first understand what building decarbonization is and what's involved with the process. In that vein, ASHRAE analyzed the situation and determined the following:[9]

- Building decarbonization encompasses a building's entire lifecycle, including building design, construction, operation, occupancy and end of life.
- Building construction, energy use, methane and refrigerants are the primary sources of greenhouse gas (GHG) emissions, such as CO2.
- Building lifecycle assessment involves consideration of operational and embodied emissions. Operational emissions are generally from energy use. Embodied emissions include GHG emissions associated with building construction, including extracting, manufacturing, transporting and installing building materials, as well as the emissions generated from maintenance, repair, replacement, refurbishment and end-of-life activities. Embodied emissions also include refrigerant releases across the building lifecycle.
- Of those total emissions, building operations are responsible for 27% annually, while building materials and construction (typically referred to as embodied carbon) are responsible for an additional 20% annually.
- The global building floor area is expected to double by 2060. This is the equivalent of adding an entire New York City to the world, every month, for 40 years.



Building carbon lifecycle stages. Source: ASHRAE [10]

As such, ASHRAE supports the following goal of the Building To COP Coalition: "By 2030, the built environment should halve its emissions, whereby 100% of new buildings must be net-zero carbon in operation, with widespread energy efficiency retrofit of existing assets well underway, and embodied carbon must be reduced by at least 40%, with leading projects achieving at least 50% reductions in embodied carbon. By 2050, at the latest, all new and existing assets must be net zero across the whole lifecycle, including operational and embodied emissions."[11]

How to Achieve Building Decarbonization

It's clear that building decarbonization is essential to combat climate change. Now the question is, how can it be achieved? It's a vital question that all cognizant authorities in the buildings industry are pondering. For example, below are ASHRAE's building-decarbonization strategies:[12]

- **All building types:**
  - Heat pump equipment and other decarbonization strategies are readily available for a wide range of applications.
  - Geothermal systems can be designed to service an entire district.
  - Heat recovery from wastewater, data centers, refrigeration and industrial processes can supply heat to other buildings.
  - Whole-building life-cycle assessment (WBLCA) is an important tool for minimizing the environmental impact of buildings and their HVAC&R systems. WBLCA includes assessment of embodied and operational GHG emissions in addition to other environmental impacts.
  - Best practices in building Operations and Maintenance (O&M) can significantly impact emissions reduction, reducing energy use by 10% or more while extending the lives of building systems and equipment. Increasing the efficiency of O&M is also cost-effective, with a much shorter payback than building retrofits or other major improvement projects. Effective building O&M starts by installing an effective energy submetering and monitoring system and implementing a structured commissioning process followed by periodic or continuous building retuning and retrocommissioning. Although extending equipment life can reduce embodied GHG emissions from premature equipment replacement, the lives of inefficient equipment should not be extended, as this can result in greater operational emissions over the building lifecycle.

[9] All information in this paragraph and subsequent bullets sourced from: "ASHRAE Position Document on Building Decarbonization," ASHRAE, June 26, 2022, https://www.ashrae.org/file%20library/about/position%20documents/pd_buildingdecarbonization_2022.pdf.

[10] Ibid.

[11] Ibid.

[12] Ibid.

- **New construction:**
  - New buildings provide the opportunity to set decarbonization goals while in the design phase.
  - Energy consumption can be minimized and renewable energy integrated with energy storage to shift loads to align with lower carbon periods on the grid. For example, dispatchable building loads, which allow curtailment or load shifting, can use machine learning to anticipate peak loads.
  - In new construction, building codes are the primary policy instrument to foster widespread adoption of decarbonization practices.
- **Retrofits:**
  - Existing buildings are more complex, but up-front analysis and design choices can have dramatic long-term decarbonization payoffs.
  - Retrofitting may be most effectively accomplished at major building lifecycle events such as periodic audits and inspections, changes in ownership or tenancy, renewals of licensure, changes of building use and permitting of additions, alterations and end-of-life equipment replacement.
  - Existing building policies such as building construction codes, mandatory upgrades, appliance emission standards and building performance standards (BPS) are oriented around such triggers (ASHRAE 2021d).
  - ANSI/ASHRAE/IES Standard 100 is the only ANSI standard that sets energy performance targets for existing buildings and provides a strong technical framework for assessing current energy performance levels (ASHRAE 2018b).

Building Decarbonization, Ventilation and Indoor Air Quality

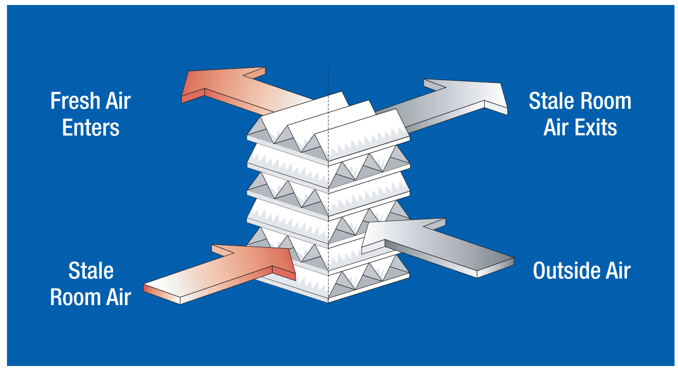
To effectively decarbonize a building, technologies must be applied that maximize energy efficiency. However, this can't be at the expense of indoor air quality (IAQ) because in the post-pandemic new normal, we know how critical clean indoor air is for occupant health and safety. Fortunately, innovative ventilation systems exist that enhance IAQ while also helping to decarbonize a building.

> *"...the **EPA** states that '**ERVs provide** excellent **opportunities for saving energy, controlling humidity** and providing sufficient outside air to **promote IAQ.**'"*

The most effective way to enhance IAQ is via increased and balanced ventilation. As long as enough controlled and filtered fresh outdoor air is coming in and stale indoor air is exhausted out, interior spaces will enjoy high-quality air. In fact, the American Lung Association states that proper ventilation is essential for keeping the air fresh and healthy indoors.[13]

Further, to stop the spread of airborne viruses, a layered approach with increased ventilation at its core is recommended. For example, the Centers for Disease Control and Prevention (CDC) advises using multiple mitigation strategies, including improvements to building ventilation, to reduce the spread of disease and lower the risk of exposure.[14] Additionally, ASHRAE states: "Ventilation and filtration can reduce the airborne concentration of SARS-CoV-2."[15]

Indeed, if there was a silver lining to the COVID-19 pandemic, it would be the fact that many aspects of our society have been forced to improve—including building ventilation rates. With increased ventilation rates, indoor air contaminants are continuously diluted. Along those lines, ASHRAE states: "Building operators could increase their systems' outdoor air ventilation to reduce the recirculation air back to the space. The guidance indicates that this should be done, if it is the selected mitigation strategy for this system, as much as the system and or space conditions will allow."[16]



ERVs use otherwise-wasted total energy (heat and humidity) from the exhaust airstream to condition incoming outdoor air. Source: RenewAire

However, conventional ventilation machines waste energy. The way to improve IAQ while supporting decarbonization is via energy recovery ventilators (ERVs). ERVs use otherwise-wasted total energy (heat and humidity) from the exhaust airstream to condition incoming outdoor air. This leads to substantial reductions in energy and equipment costs. Consequently, the EPA states that "ERVs provide excellent opportunities for saving energy, controlling humidity and providing sufficient outside air to promote IAQ."[17]

Building Resiliency Supports Decarbonization

Climate change poses numerous challenges to the built environment, such as more heat, higher amounts of precipitation and rising sea levels. On top of that, the COVID-19 global pandemic emphasized the critical role buildings play in safeguarding occupant health. Thus, it's imperative that buildings become more resilient to this changing world, which ultimately helps to further decarbonization. Let's take a look at how this is possible.

First, what exactly is building resiliency? The National Academy of Sciences defines it as "the ability to prepare and plan for, absorb, recover from and more successfully adapt to adverse events or threats." According to ASHRAE, these events or threats may be financial, political or environmental, as well as disaster-, conflict- or climate-related.[18]

In fact, ASHRAE and the Chartered Institution of Building Services Engineers (CIBSE) put out a joint statement on building resiliency. In it,

[13] "Ventilation: How Buildings Breathe," American Lung Association, https://www.lung.org/clean-air/at-home/ventilation-buildings-breathe.

[14] "Ventilation in Buildings," Centers for Disease Control and Prevention (CDC), June 2, 2021, https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html.

[15] "ASHRAE Epidemic Task Force Filtration & Disinfection," ASHRAE, October 21, 2021, https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-filtration_disinfection-c19-guidance.pdf.

[16] "Building Readiness," American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf.

[17] "IAQ Building Education and Assessment Model (I-BEAM)," U.S. Environmental Protection Agency (EPA), January 19, 2017, https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/text_modules_energy_efficiency.pdf.

[18] "ASHRAE and CIBSE Position Document on Resiliency in the Built Environment," ASHRAE, July 11, 2019, https://www.ashrae.org/file%20library/about/position%20documents/ashrae_cibse_resiliencyinthebuiltenvironment_2019.pdf.

they say that resiliency will continue to have major impacts on how the built environment and engineered systems in buildings are designed and operated. Specifically on this topic, their position is the following: "Building design and operation must consider resiliency as part of an overall risk assessment and planning approach and that major new efforts in research, education, standards and guidance development are required to increase building resiliency."[19]

So how does building resiliency support decarbonization? The main way is by enabling buildings to stay online as much as possible, even aftera major climate event. And here's why. Building decarbonization is only as good as the energy that's coming from the electric grid. If grid energy is dirty, then decarbonization is hampered. Thus, clean grid energy is crucial to successful building decarbonization. And unfortunately, in 2020, the majority of grid energy was still produced using fossil fuels (see chart at left).

How can grid energy be as clean as possible? The answer is it depends on the time of day. For example, in California, the electric grid is projected to be quite clean in the mornings in the first half of the year, while remaining pretty dirty at others—usually late at night or early morning in autumn and winter.[21]

What does this have to do with building resiliency? By keeping homes and buildings online, even during adverse climate conditions, the grid will be able to produce energy at times that are optimal for clean energy. Thus, building resiliency can be the strong foundation upon which effective building decarbonization is established.

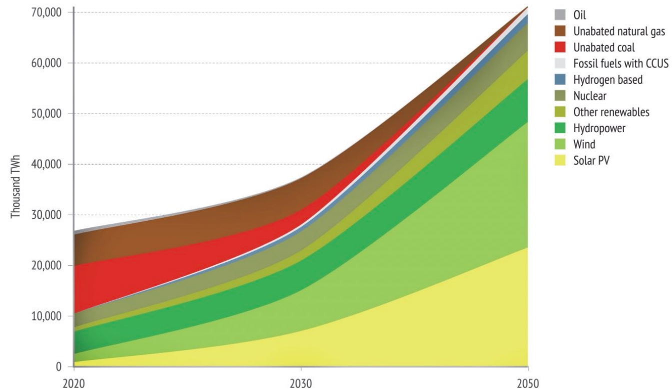
How to Achieve Building Resiliency

In order to achieve building resiliency, ASHRAE and CIBSE list the following recommendations:[23]

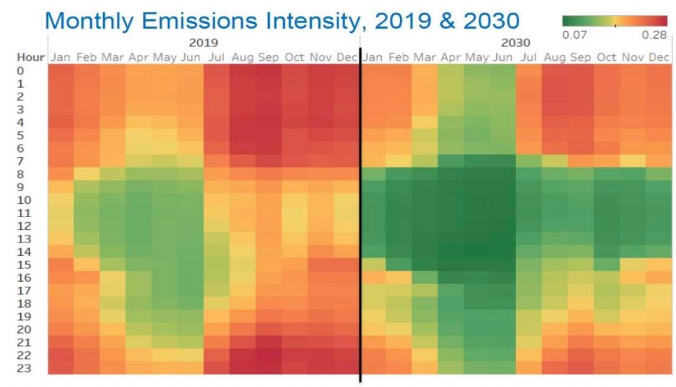
- Design and operate HVAC&R and other building systems to extend beyond increasing energy efficiency and occupant health and comfort to address lifecycle costs, resistance to extreme events and continued operation and/or reduced recovery time in the event of catastrophic events and in the face of climate change.
- Design and maintain building envelopes that support resistance to and recovery from extreme events.
- Conduct site considerations, including both overall building site and HVAC&R locations within a building, that may affect building performance.

In addition, due to the substantial threats posed by climate change in New York City, the NYC Mayor's Office compiled the below strategies for building resiliency. They focus on three threats posed by climate change: increasing heat, higher precipitation and rising sea levels. Although these are specific to New York City, many of them can be applied to buildings in other geographies.[24]

- **Strategies to deal with increasing heat:**
  - Reduce urban heat island effect
    - A minimum of 50% of the project's site area shall be shaded, vegetated and/or utilize high sola reflectance surfaces
    - Minimize heat pollution from industrial process via:
      - Waste heat recovery technology



Global electricity generation forecast by source in the Net Zero by 2050 scenario. Data source: IEA 2021a. Image source: ASHRAE[20]



Average Hourly Grid Emissions Profile, Full Year; Source: Brook, M. 2018. Building Decarbonization. Docket 18-IEPR-09. Sacramento, CA: California Energy Commission

Average hourly California electric grid emissions in 2019 and projections for 2030. Source: National Resources Defense Council (NRDC)[22]

      - Electric charging infrastructure for medium and heavy-duty vehicles
      - HVAC controls for intermittent ventilation
  - Design a heat-resilient facility
    - Design based on forward-looking climate data
    - Select materials and systems using climate change projections
    - Identify heat-related points of failure
  - Ensure occupant thermal safety
    - Incorporate mechanical cooling/other cooling in occupied spaces
- **Strategies to deal with increasing heat:**
  - Precipitation design adjustment for on-site stormwater system
    - Identify the required retention/detention volume and release rates based on relevant New York City Department of Environmental Protection (DEP) stormwater rules

[19] Ibid.

[20] Ibid.

[21] David B. Goldstein, "Working Together: Resilience and Decarbonization," Natural Resources Defense Council (NRDC), August 2, 2021, https://www.nrdc.org/experts/david-b-goldstein/working-together-resilience-and-decarbonization.

[22] Ibid.

[23] All information in this paragraph and subsequent bullets sourced from: "ASHRAE and CIBSE Position Document on Resiliency in the Built Environment," ASHRAE, July 11, 2019, https://www.ashrae.org/file%20library/about/position%20documents/ashrae_cibse_resiliencyinthebuiltenvironment_2019.pdf.

[24] All information in this paragraph and subsequent bullets sourced from: "Climate Resiliency Design Guidelines," NYC Mayor's Office of Sustainability, September 2020, https://www1.nyc.gov/assets/orr/pdf/NYC_Climate_Resiliency_Design_Guidelines_v4-0.pdf.

- Identify design interventions based on DEP's Stormwater Management Practice Hierarchies
- Incorporate climate change projections into DEP drainage planning

- **Strategies to deal with rising sea levels:**
  - Assess tidal inundation due to sea level rise
  - Address risks in the current floodplain
  - Address risks in the future floodplain
  - Identify appropriate design interventions

The above strategies are just one example of approaches being developed across North America to counter climate change that incorporate strategies for the built environment. For example, Boston has an initiative called Climate Ready Boston,[25] Atlanta developed a Climate Action Plan,[26] Miami has a Climate Action Strategy[27] and Los Angeles has a Green New Deal, which is an update to the city's Sustainable City pLAn.[28]

"...because most structures were built to withstand environmental conditions of their time. Thus, ***new structures must anticipate*** *future* ***climatic conditions in their design to avoid*** *structural and* ***environmental challenges****."*

Building Resiliency, Ventilation and Indoor Air Quality

Buildings that are resilient to climate change also support better IAQ. This is the case because as adverse conditions caused by climate change increase, a building that can withstand those events will be able to better safeguard occupant health and wellbeing. This includes maintaining clean and healthy indoor air for occupants to breathe via increased and balanced ventilation.

The EPA agrees with this notion in a report entitled, "Adapting Buildings for Indoor Air Quality in a Changing Climate." It states that homes and buildings protect us from the outdoors, but face threats to IAQ due to climate change. That's because most structures were built to withstand environmental conditions of their time. Thus, new structures must anticipate future climatic conditions in their design to avoid structural and environmental challenges.[29] In a nutshell, resilient structures will be better able to protect IAQ.

Furthermore, the EPA stresses in the same report the significance of utilizing ventilation in resilient structural design. It states that ventilation is an important part of a building's heating and cooling system because it helps reduce indoor pollutants. Weatherizing—which makes structures more resilient to the elements—without maintaining proper ventilation can negatively affect indoor air.[30]

Government Action for Building Decarbonization and Resiliency

One of the fastest ways to achieve building decarbonization and resiliency is if governments step in with relevant legislation. Are governments up to the challenge? The United States Federal Government took a huge step in that direction recently with the Inflation Reduction Act. Also, in other regions across the U.S., legislators heeded the call and implemented their own laws. Here's an overview of these efforts:

- **The U.S. Government's Inflation Reduction Act:**
  - This new law provides $9 billion for states to issue rebates to homeowners for whole-home retrofits and for efficient heat pumps, heat-pump water heaters, other electrical equipment and training and education for contractors. It also restores and greatly increases tax credits for heat pumps and smaller home improvements, such as insulation, and strengthens the criteria for and the amount of the tax deduction for commercial building retrofits. Tax incentives for building highly efficient new homes and commercial buildings also get a big boost, including extra incentives for "zero-energy-ready" homes and buildings. The law also gives $1 billion in additional aid to help states and cities adopt and implement strong building energy codes.[31]
- **New York City's Local Law 97:**
  - This law will limit GHG emissions for most buildings larger than 25,000 square feet. This process of rulemaking involves finalizing a number of definitions of how carbon emissions are calculated and what are appropriate exceptions and allowances for buildings that have specific requirements and limitations related to their function.[32]
- **California's 2022 Zero Code:**
  - This is a Zero Carbon Building (ZCB) energy standard for new nonresidential, high-rise residential and hotel/motel buildings, which are the prevalent building types being constructed in cities today.[33]
- **Maryland's 2022 Climate Solutions Now Act:**
  - This law creates a building energy performance standard that requires most buildings over 35,000 square feet to start reporting their direct emissions from heating, starting in 2025. Those buildings will then be required to reduce those emissions by 20% below 2025 levels by 2030 and to achieve net-zero carbon emissions by 2040.[34]
- **Vermont's 2021 Climate Action Plan:**
  - This law is a blueprint for future climate action. It lists two major suggestions for cutting GHG emissions from buildings. The first is to dramatically scale up the pace with which the state is weatherizing homes, and the second is heating buildings without fossil fuels through a clean heat standard.[35]

[25] "Preparing for Climate Change," City of Boston, https://www.boston.gov/departments/environment/preparing-climate-change.

[26] "City of Atlanta Climate Action Plan," City of Atlanta, July 23, 2015, https://atlantaclimateactionplan.files.wordpress.com/2016/02/atlanta-climate-action-plan-07-23-2015.pdf.

[27] "Climate Action Strategy," Miami-Dade County, https://www.miamidade.gov/global/economy/resilience/climate-strategy/home.page.

[28] "Sustainability," City of Los Angeles, https://lamayor.org/sustainability.

[29] "Adapting Buildings for Indoor Air Quality in a Changing Climate," U.S. Environmental Protection Agency (EPA), https://www.epa.gov/indoor-air-quality-iaq/adapting-buildings-indoor-air-quality-changing-climate.

[30] Ibid.

[31] "Lowell Ungar, Alexander Ratner, "Congress Is Set to Vote on the Largest Efficiency Investments in History," The American Council for an Energy-Efficient Economy (ACEEE), August 2, 2022, https://www.aceee.org/blog-post/2022/08/congress-set-vote-largest-efficiency-investments-history.

[32] "How Decarbonization Could Affect Tomorrow's Built Environment," ASHRAE, https://www.ashrae.org/news/esociety/how-decarbonization-could-affect-tomorrow-s-built-environment.

[33] Ibid.

[34] "Maryland just passed one of the most aggressive climate laws in the US," Canary Media, April 12, 2022, https://www.canarymedia.com/articles/policy-regulation/maryland-just-passed-one-of-the-most-aggressive-climate-laws-in-the-us.

[35] "Which pieces of the Climate Action Plan will lawmakers take up this session?," VTDigger, January 2, 2022, https://vtdigger.org/2022/01/02/which-pieces-of-the-climate-action-plan-will-lawmakers-take-up-this-session/.

Building Decarbonization + Resiliency = Improved Human Condition

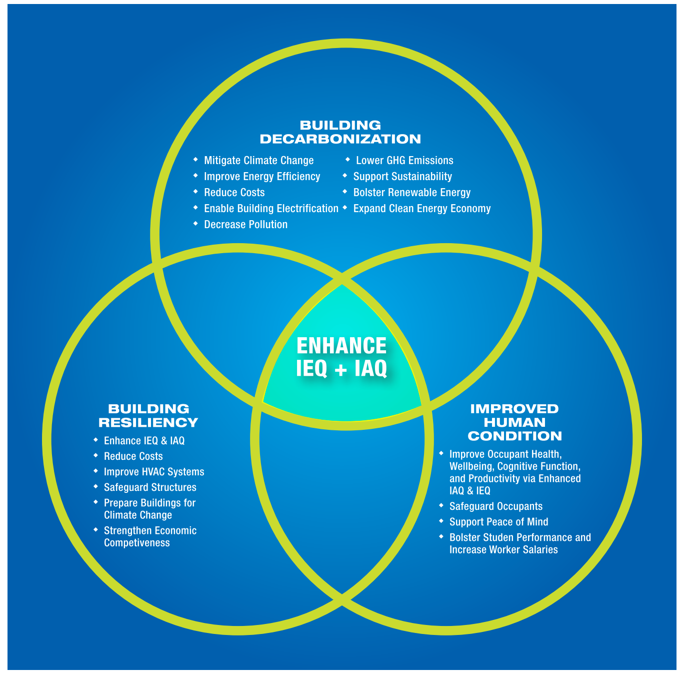
When buildings are decarbonized and made more resilient, an underlying focus is not just maintaining sufficient IAQ, but actually improving it. That's where energy-efficient ventilation technologies, such as ERVs, come into play as mentioned above. Thus, decarbonization and resiliency can directly improve not just IAQ, but also a building's entire indoor environmental quality (IEQ).

Moreover, when a decarbonized and resilient building also enhances IAQ and IEQ, this leads to an improved human condition. Why is this the case? Because four of the principal elements to an improved human condition—health, wellbeing, cognitive function and productivity—are supported by building decarbonization and resiliency. Here's how:

- **Better health:**
  - Building decarbonization and resiliency are opportunities to also enhance IAQ and IEQ. When this is the case, occupants will be able to breathe in cleaner and healthier indoor air, which improves health.
- **Bolstered Wellbeing:**
  - Decarbonized and resilient building helps to keep occupants safe from external risks. This fosters greater peace of mind, which leads to bolstered wellbeing.
- **Greater Cognitive Function:**
  - When a decarbonized and resilient building also enhances IAQ, this can increase cognitive function. A Harvard study found that, on average, when compared to an indoor environment with deficient IAQ, cognitive scores were 61% higher in a simulated green-building environment with a low volatile organic ccompounds (VOCs) concentration. It also found that scores were 101% higher in a simulated green-building environment coupled with doubling the outdoor-air ventilation rate from 20 CFM per person (the rate recommended by ASHRAE) to 40 CFM per person.[36]
- **Increased productivity:**
  - If occupants are experiencing cognitive improvement due to enhanced IAQ in a decarbonized and resilient building, they could also be more productive. Another Harvard study found that doubling the rate of a conventional ventilation system from 20 CFM per person 40 CFM per person only costs about $32 per person, per year and leads to a productivity increase of $6,500 per person, per year. And if an ERV is added, the anticipated increase in energy costs can be reduced by up to 60%.[37]

Venn Diagram: Building Decarbonization, Building Resiliency and Improved Human Condition

Now we see that to counter climate change, buildings must be decarbonized and made more resilient. In the process, the human condition can be improved. In essence, these are the three pillars of better buildings: decarbonization, resiliency and improved human condition. To demonstrate how they're interconnected, I've compiled the below Venn diagram that shows at the core is enhanced IAQ and IEQ.



In this Venn diagram for Building Decarbonization, Building Resiliency and Improved Human Condition, at the core are enhanced IAQ and IEQ. Source: RenewAire

In Summary

Climate change is growing in severity, and action must be taken so it can be curbed. The built environment can play a central role in countering climate change via building decarbonization and resiliency. Such actions can help to support sustainability, while also improving the human condition. It's a win-win for the environment and building occupant health and wellbeing.

To learn more about how energy recovery ventilation can enhance IAQ energy-efficiently, cost-effectively and sustainably, click here.

Nick Agopian *is Vice President, Sales and Marketing at RenewAire. For over 35 years, RenewAire has been a pioneer in improving people's health, cognitive function, productivity and wellbeing by enhancing IAQ via energy recovery ventilation technologies. This is done energy-efficiently, cost-effectively and sustainably via fifth-generation, static-plate, enthalpy-core Energy Recovery Ventilators (ERVs) and Dedicated Outdoor Air Systems (DOAS). For more information, visit: www.renewaire.com.*