Operational Carbon in Building Energy Codes

Background

Operational carbon is the term used to describe emissions that are associated with the "operations" of a building, specifically the energy used to power, heat, cool, and ventilate a building and the water consumed during a building's life cycle for heating, filtration, or sewer processing. Operational carbon makes up 28 percent of total global greenhouse gas emissions,[1] which presents a massive opportunity for decision makers to implement codes to tackle these emissions. However, the United States currently does not have any model energy codes with provisions directly related to operational carbon. This means that new homes and buildings constructed today can operate for years without the need to reduce emissions over time. This lack of oversight creates further complications that will hinder solving the climate crisis. Model energy codes must take into consideration these concerns and directly address operational carbon.

Embodied Carbon vs.

Operational Carbon

In addition to operational carbon, 11% of global greenhouse gas emissions are attributed to embodied carbon, which refers to the greenhouse gases released during:

- Extraction of raw materials for products that will be used in a building
- Transportation of these materials to the factory
- Production of products
- Transportation of products to a site
- Construction of a building
- Final deconstruction and demolition of a building

Barriers

Why haven't energy codes included operational carbon? In the past several years, there has been increased research, emphasis, and focus on a building's life cycle, which is an analysis of a building's energy performance throughout every stage of its use. Historically, building professionals are not taught nor trained to think about the life and operation of a system over time, and are instead only focused on getting a building to meet current codes and market demands. This means there could be significant pushback in response to proposals to add operational carbon to codes. Additionally, there may be opposition to phasing out fossil fuels and reducing their usage over time. There are also challenges associated with measuring carbon within a building, which makes it even harder to incorporate into a code.

Case Studies

Several countries have developed codes that address operational carbon.[2] In Canada, the Toronto Green Standard provides a tiered system of emission reductions over time, with required set

[1] https://newbuildings.org/wp-content/uploads/2022/04/LifecycleGHGImpactsinBuildingCodes.pdf

[2] Posterity Group. Final Report: Scan of Code Requirements to Address Global Greenhouse Gas Emissions. 11/14/2022.

emissions limits per year for new residential and commercial buildings, and voluntary lower tiers with stricter emissions limits. The Canada Green Building Council (CaGBC) provides a voluntary standard for zero carbon building design for existing buildings that requires carbon offsets and exported green power to compensate for the yearly operational emissions of a building. Even though both of these standards address operational carbon, they do so on a voluntary basis so there is no strict enforcement requirement.

New Zealand's Transforming Operational Efficiency Report

New Zealand proposes to reduce operational carbon emissions that will:

1. Set a mandatory operational emissions cap of total allowable annual emissions per year based on the size of a building for fossil fuel combustion, electricity use, and water use for all new buildings.
2. Set a mandatory water use cap of total allowable potable water per year based on the size of a building.
3. Define indoor environmental quality parameters for new buildings.

France's Environmental Regulation 2020 (RE 2020) sets operational emissions limits over a 50-year period for an average home and an average multi-unit residential building. These limits decrease over time and there is an opportunity to set stricter limits year-to-year as buildings become more efficient.

Although there are currently no national codes in the United States that address operational carbon, several states and municipalities have started to adopt similar provisions in codes, where emissions and energy use are compared with a "baseline" building, which is a standard reference design that reflects a "typical" building or home. This baseline can be compared side-by-side to different variations of construction to determine the increase or decrease in efficiency. The state of Washington's energy code requires that a new building's heating, ventilation, and air conditioning (HVAC) systems have a total system performance ratio (TSPR) that is the same or better than the baseline building. [3] The town of Ithaca, New York's energy code supplement has a performance compliance pathway that requires emission reductions of 80 percent savings compared to the baseline building for both residential and commercial buildings starting in 2023. [4]

Building Performance Standards vs. Operational Emission Limits

Another policy option available to reduce emissions are building performance standards, which require existing buildings to meet energy- or emission-based performance targets. Building performance standards only apply to existing buildings and are retroactive; whereas operational emission limits are proactive and can be factored into the initial design stage, where the impact of carbon over time is taken into consideration before a new building or home is even constructed.

[3] Section "C403.1.1: HVAC total system performance ratio (HVAC TSPR)" of 2018 Washington State Energy Code

[4] Section "C404.6.2/R504.6.3: Changes to Greenhouse Gas Emissions Calculation-Based Compliance" of Ithaca NY Energy Code Supplement

Looking to the Future

Innovations such as the Residential Energy Services Network (RESNET) Carbon Rating Index, which can be used as a metric to measure building emissions, make it possible to track operational carbon. This metric could be used to compare baseline emissions with actual emissions, making it possible to easily track the operational carbon for code compliance. Since RESNET is also responsible for the Home Energy Rating System (HERS) Index, that can be used for the performance path to energy code compliance, this additional tool makes it feasible to add another step to code enforcement that tracks emissions without any added costs or labor. The Carbon Rating Index uses projected hourly emission rates for electricity and carbon dioxide and factors these values into the energy consumption calculation in a HERS Index to create this new metric for measuring operational carbon. Using a quantifiable number to measure carbon makes it even easier for codes to add well defined limits that help achieve carbon reduction goals.

As climate change continues to be a threat to our well-being, future model energy codes in the United States must be updated to address operational carbon. There is some forward progress, with the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) Position Document on Building Decarbonization, which directly states that operational emissions are under consideration for inclusion in the next ASHRAE 90.1 Standard, which is typically adopted for commercial buildings. The International Energy Conservation Code (IECC) has yet to directly address operational carbon. However, it has taken steps to address decarbonization in buildings and has a goal of a zero net energy base code by 2030 which means that there will likely be innovative measures in upcoming codes cycles that could include operational carbon.

Conclusion

As we learn more about advanced building design techniques and as we shift priorities because of the need for more resilient energy systems, national model codes have evolved over time. Codes and regulations that still apply after the initial design stage and take into consideration future operations will be a more effective tool for combatting climate change and decarbonizing our building stock. Operational carbon provisions in codes could be the key to unlocking further energy savings, and their inclusion should be a top priority in upcoming model and stretch code adoptions.