Newton's Approach to Sustainable School and Municipal Buildings

Josh Morse, Public Buildings Commissioner, City of Newton

The City of Newton is aggressively pursuing efforts to reduce our carbon footprint. A significant part of these efforts is how we approach the design and construction of our new and renovated school and municipal buildings, like the projects at Lincoln-Eliot, Countryside, Franklin, Horace Mann, and many others.

In general, the approach is straightforward. The details, however are anything but. To complete a major building project with a low carbon footprint, you must design a very efficient building with air source or ground source heat pump technology, maximize solar photovoltaics, and do so with a focus on minimizing the embodied carbon of the materials you use, while reducing the operating carbon during construction. See, it's easy!

To understand the details, let's break this down.

Building Design

Creating a low-carbon footprint building starts before you even have a foundation footprint. You must first consider solar orientation for the purposes of solar photovoltaics heat gain and loss. How you orient a building on the site can have a massive impact on the renewable energy output, and you will want to think about the heat loss/gain as it relates to the portions of your building that will want to have the most windows and doors.

We then turn our attention to creating the most efficient building envelope we can, while recognizing that every system has a point of diminishing returns. We use a combination of Passive House standards and LEED for Schools to help establish our design approach. This means that you want to create a very efficient building envelope, but at some point, the embodied carbon in the insulating materials starts to outweigh the diminishing returns on the increased thermal efficiency. Care should be given to the types of insulation used as the embodied carbon varies widely in this area.

It may seem obvious to have high-efficiency windows and doors, but careful consideration should be given to the amount of glass altogether. Windows are simply holes in your building envelope. The fewer holes you have, and the smaller the holes are, the more efficient the envelope will be. That being said, I am a huge proponent of ample natural light so my approach is to establish a "budget" for the amount of glazing/glass we will have on the project. We then choose carefully where to spend that budget. Windows that don't provide ample light should be avoided. You may want to consider reducing or eliminating windows that will be covered with window treatments most of the time based on the types of spaces inside. Other options allow soft light to enter with a higher thermal performance that may be used in these applications.

A tight building envelope is extremely critical to driving down our energy use intensity, which is a fancy way of saying that if our building envelope doesn't have any leaks, then we can reduce the size of our heating and cooling equipment and therefore reduce our energy consumption. Passive House standards help deliver a building with minimal air leakage, but we use the following to help pave the way for delivering a tight building envelope:

1. Green Engineer to perform field inspections at critical project milestones related to the envelope. Wall Insulation, Roof Insulation, Windows, etc. This is part of our building commissioning process.
2. Air flow testing of the mock-up classroom so that we can identify and correct any issues before the project the interior of the building envelope is closed up.
3. Spaces with exposed steel should be carefully analyzed during design and construction.
4. Thermal image scans of the windows and envelope should be conducted at the same time as our normal window leak testing. This is a good time in the project to know if we have any air leakage that we need to address.

5. Our design specifications make it clear that we will be taking the above steps, and that any envelope system performance deficiencies due to installation issues will be resolved by, or at the expense of, the corresponding contractor. This is important to establish upfront.
6. Our design services specify that an Air Barrier Continuity Plan, ABCP, shall be drafted and submitted during the design development phase. A final version shall be submitted for approval during the construction document development phase. The ABCP shall be included in the bid documents, and it will be reviewed by the Green Engineer, the OPM onsite Clerk, and the Public Buildings onsite Project Manager.

Heating and Cooling

Now that you've got an efficient building envelope, you must perform a heating and cooling load analysis to determine the size of the heating and cooling systems you need. A common mistake is letting the HVAC equipment be sized before you design a very efficient envelope. In this situation, you can end up with larger heating and cooling equipment than you need, which leads to higher up-front costs, operating costs, and operating and embodied carbon footprints. We ensure that we see the full heating and cooling load calculations and compare the building envelope assumptions carried against the values provided by the architect. This step is extremely important in driving down your energy intensity and makes achieving net-zero far less arduous.

The design of whether to use ground source heat pumps, GSHPs, or air sourced heat pumps, ASHPs, often comes down to the size of your building, the available site for GSHP wells, and for this region, the heating demands. GSHPs can offer an ultra-low energy use intensity, but they cost significantlyupfront front for projects of oASHPse than ASHP's. Additionally, we often do not have the land area needed to support the well-fields. For example, an elementary school project needs roughly 75 wells to support GSHP and we often don't have the land area to support this. We are carefully monitoring the utility rebates and government subsidies for GSHPs as they have expanded rapidly over the past year making the return on investment shorter than the 'ystem's life. ASHP's have been the most common approach to achieving net-zero schools and driving down carbon footprints. These systems operate at obscenely high efficiency levels. They are now less expensive to buy and install, operate, and are comparable in maintenance costs to a traditional high efficiency natural gas-fired design approach. The City of Newton began our transition to fully electric buildings in 2016, and really ramped up efforts in 2018. With the support of the voters this spring on the Countryside, Franklin, and Horace Mann projects as well as the funds within the operating override for the permanent electrification funding source, we will be able to convert 20% of the total gross square footage of our school and municipal buildings to fully electric over the next 6 years.

For our projects, we also install automated building management systems that help optimize the building's energy performance 24/7/365 by controlling heating and cooling temperature setpoints, peak electrical demand response, night setbacks, and much more. These systems must be commissioned, operated correctly, and retro commissioned occasionally to maintain their efficacy.

Solar Photovoltaics

As I mentioned in the beginning, proper solar orientation of your building is critical in maximizing the solar array output potential. We focus on the specified solar output capacity of the panels themselves, as maximizing the output capacity can have a very significant impact on the total array capacity, and thus the renewable offset that helps drive towards a net-zero building. Also, push the envelope with regards to the size of the array. Often you can squeeze some additional output out by getting into partially shaded areas. We also utilize solar carports to increase our onsite renewables, as these can often generate a large amount of renewable energy while also improving the security lighting of our parking lots and providing shelter over the staff and visitor vehicles. We couple our solar carports with electric vehicle charging stations to help incentivize EV vehicle purchase and use.

Embodied Carbon

Embodied carbon consists of all the greenhouse gas emissions associated with building construction, including those that arise from extracting, transporting, manufacturing, and installing building materials on site, as well as the operational and end-of-life emissions associated with those materials.

Our approach to reducing our embodied carbon starts at the very beginning of the design process. One way to significantly reduce your embodied carbon is to carefully consider reusing the existing building. In some cases, this is not possible or practical. In cases where your existing building is significantly smaller than the building you need, saving the existing structure may not net a lower carbon footprint. Either way, you'll want to select a design team with the ability to conduct a whole building life cycle carbon analysis, LCCA. The LCCA should be done when comparing renovation and addition to new construction, but also periodically during the design process to assist in the decision-making process concerning building design, material, and system specifications.

We do not design a building, or any spaces within a building, that are larger than we need. This includes not only the footprint of every space, but the volume. It will be far easier to control your embodied carbon if you have little to no wasted space in your building. High ceilings may look attractive, but they contain more volume of air that must be treated and require more building materials to construct.

Once we've nailed down a spatially efficient design, we can shift our attention to the building materials and specifications. Concrete, steel, windows, asphalt, and metal panels, are all examples of building materials with high levels of embodied carbon. Depending on the project, using a wood-framed design has far less embodied carbon than a steel-framed approach. Reducing the structural demands of the building can also help drive down the embodied carbon. We try and keep our site layouts as efficient as possible to help reduce the amount of site asphalt and concrete, which also helps with stormwater management and heat island impacts. Reduce the amount of concrete needed in your foundation systems if possible, and then explore and implement the use of one of the many lower embodied carbon concrete systems in the market today. We carefully push back on the structural engineers if they try and specify concrete ratings that are excessive for the application. We use metal panels and miscellaneous metals very judiciously, as these have high embodied carbon values as well. The types of insulation specified can be very impactful as well. Closed-cell spray foam has far more embodied carbon than rockwool for example. It's not just building materials either. We carefully consider what we put in the building for furnishings when looking at our embodied carbon.

Beyond using the LCCA to help guide the embodied carbon decision-making process, we like to list the building material options sorted by embodied carbon for every major building system. This really helps guide the decisions on every design detail as you move through the process.

Honorable Mentions

There are hundreds of sustainability features in and around our building projects. LED lighting and lighting controls are a given these days. Water conservation measures exist throughout our buildings. Water bottle fill stations help reduce one-time plastic use. Our kitchens are designed with the ability to support compost efforts. We go above and beyond with our stormwater designs to improve climate resiliency. We carefully consider our landscaping plans to reduce the watering demands with a focus on future carbon sequestration potential. We have also committed to creating pollinator gardens on all our projects going forward.

The City of Newton is resolutely dedicated to achieving carbon-neutrality by 2050. To achieve this goal, we are strongly committed to creating ultra-efficient, fully electric, low embodied carbon, sustainable facilities.