Feature

The Future of Sustainable Building Restoration with Deep Energy Retrofits

By David Hutchinson and Chuck Bundrick, CSI, LEED GA

AS THE GLOBAL focus on sustainability and climate change intensifies, the United States is seeing a new trend in building restoration—deep energy retrofits. The largest contributor to greenhouse gas (GHG) emissions in the US, buildings account for approximately 40% of energy consumption and 75% of electricity use nationwide.[1] Therefore, existing structures have been targeted for renovations to improve their energy efficiency and reduce their GHG emissions (i.e., carbon footprint).

But rehabbing buildings with energy conservation in mind can be a massive undertaking, requiring a holistic exterior and interior approach to decrease buildings' GHG emissions and energy consumption while minimizing disruption to current occupants. A deep energy retrofit is achieved when renovation activities reduce a building's site energy usage by at least 40%.[2]

While legislative measures spur the adoption of energy-efficient initiatives, local programs are incentivizing and supporting building owners, architects, and contractors throughout the implementation of deep energy retrofits.

Likewise, the construction and design industries are seeking to ease this process for stakeholders by introducing sustainable technologies to accomplish these retrofits more efficiently. One such strategy is the use of prefabricated exterior wall panels to reclad buildings with improved insulation and thermal performance, airtightness, and watertightness.

This article reviews the drivers (**Fig. 1**) behind energy performance regulations, how the building sector plays into reaching key milestones, and tactics to streamline the adoption of deep energy retrofits.

SETTING THE STAGE FOR WORLDWIDE ENERGY CONSERVATION AND REDUCTION

Designated as a global emergency by the United Nations (UN), the pollution from GHG emissions, which include carbon dioxide, methane, and other greenhouse gases, has led to substantial, often irreversible, environmental damage.[3] In 2015, the historic Paris Agreement was ratified by world leaders at the UN Climate Change Conference to commit to collective climate action to reduce emissions and limit the Earth's temperature increase to "1.5°C [2.7°F] above pre-industrial levels."[4]

The agreement went into effect in 2016, and as of early 2024, 195 parties have signed onto this legally binding international treaty. To accomplish this, global GHG emissions need to reach net-zero GHG emissions by 2050. Net-zero means cutting GHG emissions to as close to zero as possible and involves replacing coal, gas, and other fossil-fuel energy sources with more renewable energy sources such as wind and solar. Carbon neutrality refers to reducing GHG emissions and offsetting it or "neutralizing" it by producing clean energy. Net-zero GHG emissions is the primary objective necessary for climate management.

The Paris Agreement triggered an increase in sustainable policies worldwide to attain these goals. The first analysis of countries' progress toward these markers in 2023, known as the Global Stocktake, will measure the current state and chart solutions moving forward, with subsequent reviews occurring every 5 years.[5]

In the meantime, in the US, national and state programs are assisting with the practical and financial implications of these energy-saving measures and GHG emission reduction

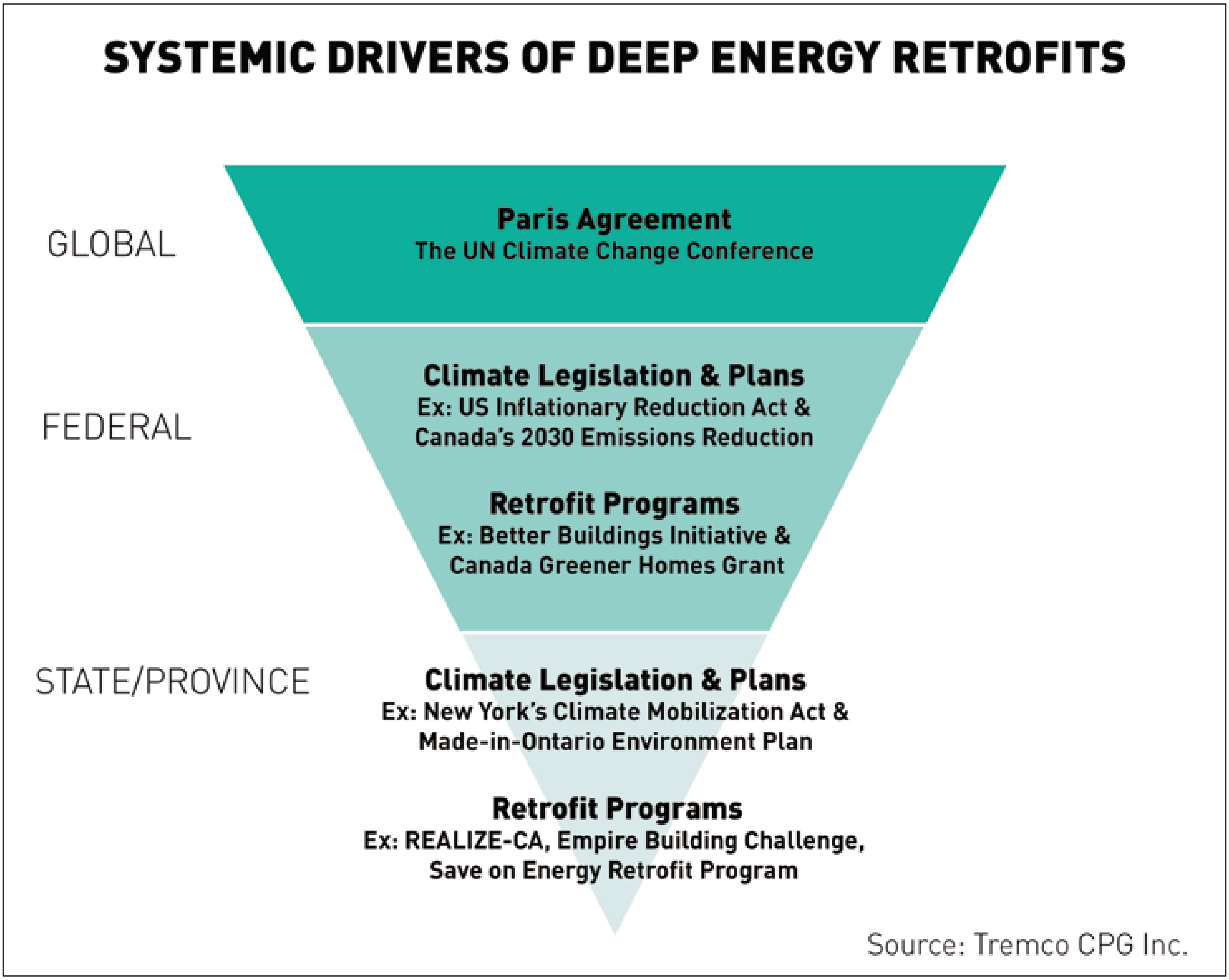


Figure 1. *From global to localized programs, numerous parties are driving deep energy retrofits of existing buildings.*

plans. In 2022, President Joe Biden signed the Inflation Reduction Act into law, "marking the most significant action Congress has taken on clean energy and climate change in the nation's history."[6] This agreement allocates $369 billion to create and invest in its Energy Security and Climate Change program that is spearheading an increase in clean energy, climate mitigation, and infrastructure resilience across the US.

Of this, over $2 billion (USD) is geared toward making new and existing buildings more energy efficient, including grants to state and local governments to update their building codes with more stringent energy standards.

Similarly, the National Building Performance Standards Coalition was established to assist participating cities in improving the performance of their buildings and lowering their emissions through overall efficiency and using clean sources of energy.[7]

At the state level, New York, California, and Massachusetts were early adopters, employing programs such as RetrofitNY[8], REALIZE-CA[9] and REALIZE-MA to kickstart financing for energy-efficient adaptations to the existing building stock.

HOW BUILDINGS IMPACT CARBON EMISSIONS

Building renovations, especially in densely populated areas, are pivotal in reducing both embodied carbon and operational GHG emissions. The term "embodied carbon" refers to the sum of GHG emissions tied to material extraction, manufacturing, transportation, and installation throughout the construction process and lifecycle of a building. **Figure 2**[10] illustrates embodied carbon and operational emissions used throughout each of these lifecycle phases of a building.

"Operational GHG emissions" are those generated throughout the building's ongoing use and maintenance, such as from heating and cooling.

While optimizing elements of new construction is important, it is a difficult initiative due to the countless variables associated with erecting a building. Alternatively, retrofitting occupied buildings saves between 50% and 75% of lifecycle carbon emissions compared to constructing the same structure new.[11]

In either case, strategies to reduce embodied carbon in building design and construction extend to reducing waste, incorporating recycled or reclaimed products, and using low-carbon, carbon-neutral, or carbon-storing materials. Together, the tangible improvements of deep energy retrofits can lead to dramatic urban transformation, and, as RMI, founded as Rocky Mountain Institute,

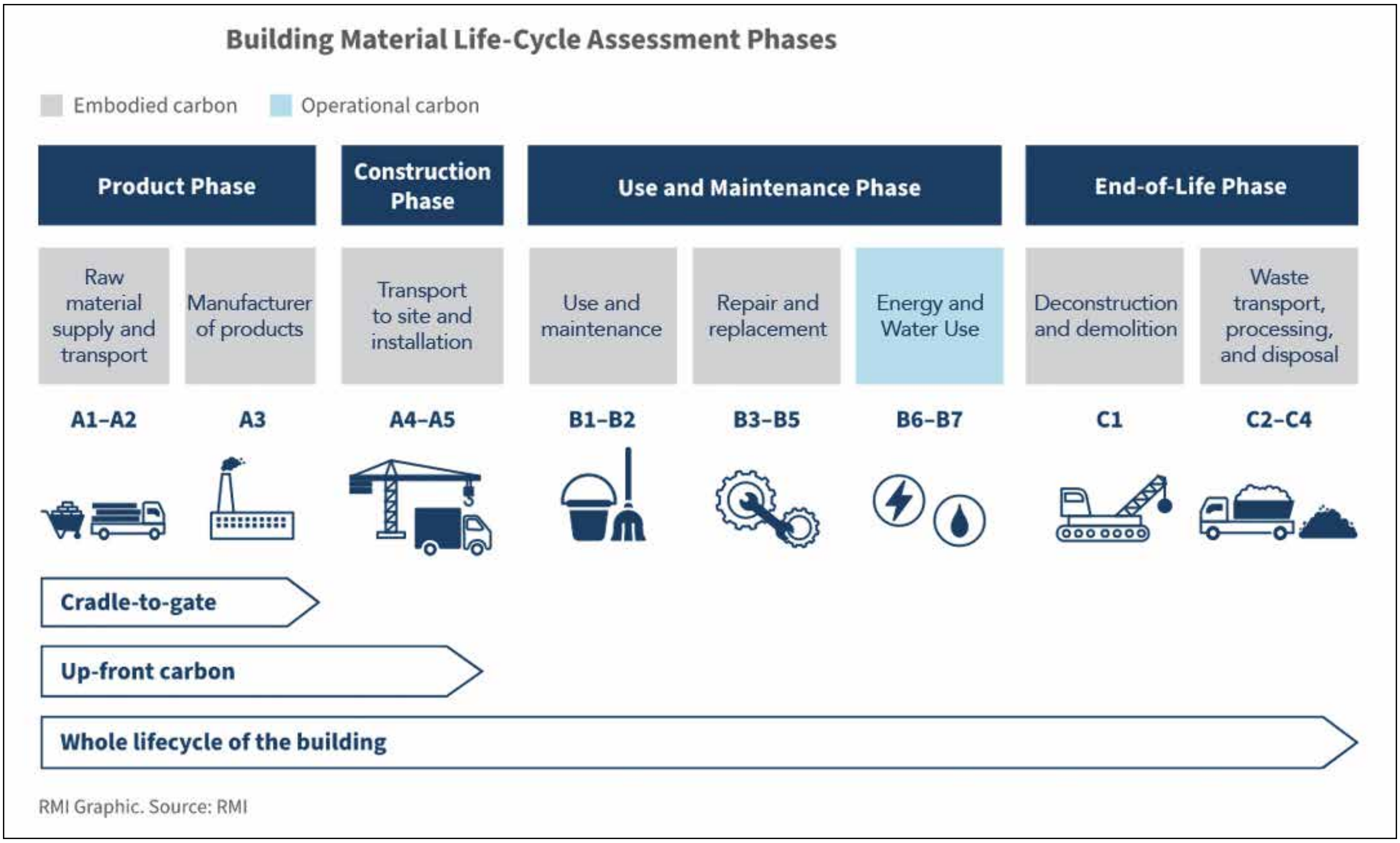


Figure 2. *This diagram shows the stages of a structure's lifecycle, from building material extraction to demolition.*

describes, help cities "move from climate commitment to climate action."[12]

Actuating these sustainable renovation plans requires buy-in from stakeholders across the construction and design fields, including architects, contractors, engineers, building material manufacturers, and tradespeople. Therefore, industry associations, independent researchers, and nonprofit organizations are backing these decarbonization and retrofit strategies with data, training, and financing to ease the learning curve and project deployment. Some, like the International Institute of Building Enclosure Consultants (IIBEC) and the National Institute of Building Sciences (NIBS), focus on education and advocacy related to the design and implementation of high-performing buildings, while others take a regional approach or tackle more specific areas like HVAC optimization, energy auditing, or solar power.

NEW YORK'S APPROACH TO EMISSION REDUCTION

In April 2019, New York City's Climate Mobilization Act kickstarted a range of initiatives aimed at reducing energy consumption and GHG emissions with targets, including a 40% reduction in GHG emissions by 2030 and an 80% reduction by 2050.[13] Entities like Syracuse University[14] and the New York City Housing Authority[15] are taking these goals seriously, emphasizing comprehensive and long-term energy solutions instead of one-off fixes.

One key measure of the NYC Climate Mobilization Act is Local Law 95, which introduced energy-efficiency ratings for buildings, much like health ratings for restaurants. Ratings are posted publicly for transparency, which could discourage potential tenants like a leasing business or apartment seeker from selecting those buildings. This accountability is a motivator for a building owner that receives a low score to make changes to their energy efficiency rating or else risk vacancies and decreased revenue.

NYC Local Law 97, which applies to buildings over 25,000 ft^2 (2,300 m^2) in New York City, imposes penalties for structures exceeding emissions limits or failing to comply with reporting requirements beginning in 2024.[16] This legislation has serious implications for building owners, developers, designers, and engineers, and will likely spark a boom in the retrofitting industry.

For architects and construction professionals working across state-lines, New York and Massachusetts are striving to achieve alignment between their energy efficiency codes and building decarbonization efforts to streamline the process. The Empire Building Challenge[17] and REALIZE-MA[18] are leading the way with the goal to not just meet climate targets but also to pay attention to buildings that are often overlooked, such as affordable housing. These programs also offer technical retrofit solution guidance and help building owners secure gap funding to invest in innovative energy efficient solutions and retrofits.

John Mandyck, CEO of the New York City-based Urban Green Council, notes that "Most buildings have done the easy stuff already so if you're not going to pay for it now, you better take a look at where the law is going and where the carbon emissions are going, because maybe now is the time to electrify to future proof the building."[19]

CALIFORNIA AND ENERGY EQUITY

California has an ambitious energy management plan, striving to reach carbon neutrality by 2045, 5 years ahead of the Paris Agreement's target.[20] However, California's

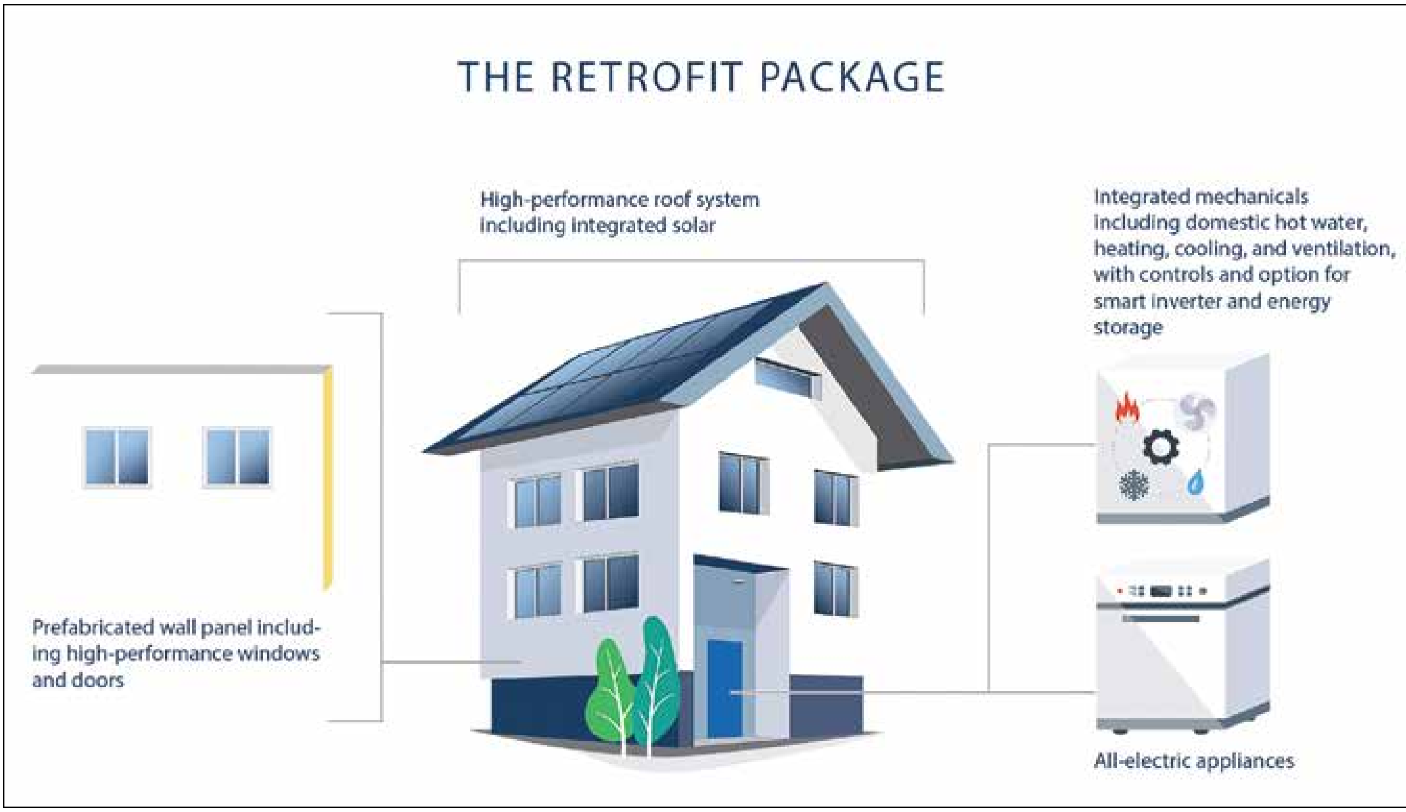


Figure 3. *This graphic illustrates the building elements included in a REALIZE retrofit package depending on building needs.*

energy-saving programs tackle the restoration of existing buildings in addition to establishing more sustainable models for new construction projects. Since new buildings require added energy consumption, the *Zero Code for California*, developed in conjunction with AIA California, dictates that new, non residential commercial buildings, high-rise residential buildings, and hotel/motel buildings must offset the load through renewable energy production.[21] Using their prescribed strategies to optimize clean energy usage throughout the build process can result in nearly zero carbon impact.

Under the California Energy Commission, the Equitable Building Decarbonization Program provides low- or no-cost retrofits for homes as well as incentives to drive greater use of low-carbon technologies.[22] The program also prioritizes construction that will improve resiliency to extreme heat, indoor air quality, and energy affordability to make sustainable, safe homes more accessible to low- and moderate-income households.

This consideration for energy equity is also being taken by the REALIZE-CA program, which advocates for the use of deep energy retrofits in the affordable housing sector to reach California's aggressive energy goals. The program recognizes that "low-income residents face a disproportionate energy burden," so innovative technologies and multi-disciplinary programs are necessary to expand these environmentally friendly strategies to vulnerable populations.[23] The Low-Income Energy Affordability Data (LEAD) Tool from the US Department of Energy (DOE) allows stakeholders to visualize the intersection of housing, income, and energy data in a geographic region to assess the energy challenges across the country.[24]

REALIZE-CA is working to standardize the retrofit process to easily deploy and scale the building rehabilitations while minimizing disruption to the tenants. The program is engaging with owners, manufacturers, community leaders, and policymakers to show that deep energy retrofits are both attainable and part of the solution for reducing carbon emissions statewide.

While the road to achieving California's lofty climate goals is challenging, collaborative partnerships combined with new technologies are being utilized to make strides toward carbon-free buildings in the state.

THE IMPORTANCE OF THE BUILDING ENCLOSURE IN DEEP ENERGY RETROFITS

Reducing GHG emissions at the rate needed to hit the global milestones requires drastic changes to the aggregate building stock. Minor building repairs and upgrading interior elements, such as lighting, mechanical systems, and appliances, are not sufficient. While quick wins are helpful, their energy conservation is not substantial enough to meet the required international standards in the given timeframe.

Deep energy retrofits involve a whole-systems approach, with the aforementioned smaller, minor building repairs and upgrading interior elements, plus more extensive changes to the exterior shell of a building and adding renewable energy sources like solar or wind. Inevitably, retrofits are more efficient and produce more sizable and long-lasting results, but they are also more expensive and have longer return-on-investment periods.

The process of retrofitting for energy efficiency is complex because it takes a whole-building lens. These adaptations look to optimize all the structure's unique facets, which vary depending on the building typology, location, construction materials,

Figure 4. *A worker applies finishing material to an exterior wall panel in a factory.*

Figure 5. *Prefabricated wall panels are raised with a crane and attached to the horizontal brackets on the building exterior.*

and occupancy. The goal of most retrofits is to execute all improvements in a short period of time to minimize wasted time, space, effort, and cost.

REALIZE retrofit packages (**Fig. 3**) can include some combination of prefabricated wall panels, high-performance windows, doors, and roofs, solar power, all-electric appliances, and more efficient mechanical systems.[25]

For many retrofits, the importance of the entire building enclosure as the primary barrier between the interior and exterior environments is critical.

The external building performance, namely thermal efficiency and air- and watertightness, impacts the ultimate effectiveness of the structure's internal heating and cooling mechanisms. The positive environmental impacts of an energy-efficient HVAC system are essentially negated if the building enclosure has significant thermal bridging and air infiltration and exfiltration. Air leakage alone is responsible for 6% of the energy used by commercial buildings in the US.[26]

A high-performance building enclosure is dictated by numerous factors, including the wall systems' thermal mass, quality and continuity of insulation, airtightness, and watertightness. The National Institute of Standards and Technology (NIST), in partnership with ASHRAE, Oak Ridge National Laboratory (ORNL), and the Air Barrier Association of America (ABAA), cited that improving airtightness is one of the most cost-effective ways to decrease energy loads.[27]

To help measure this return on investment, whole-building air-leakage testing, such as through ASTM E779-19, *Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*,[28] can be conducted before and after the retrofit to quantify these improvements.

PANELIZED CLADDING SOLUTIONS TO SPEED ENERGY SAVINGS

To alleviate the threat of wasted energy due to the building enclosure, deep energy retrofits can incorporate exterior wall panelization for an air- and watertight facade with increased *R*-value. Over-clad systems, often composed of a framing material, drainage, insulation, and a durable architectural finish, can be prefabricated and assembled in a factory (**Fig. 4**) so the resulting wall panels can be quickly shipped and installed on the building without removing the existing cladding.

Once brackets are mechanically attached to the vertical slab in the field, the wall panels are ready to be hung in place (**Fig. 5**). Then, installers mount and detail the window assemblies. Expansion joints are sealed with a flexible thermal barrier that can accommodate any slight building movement.

Figure 6. *The retrofit of the Corona del Rey apartments proves a dramatic visual transformation as well as an impressive reduction of the buildings' energy usage.*

Prefabricated wall panels can eliminate harmful thermal bridging, thus maximizing operational efficiency, decreasing occupant disruption, and reducing ongoing utility costs for the owner. The wall panels also have infinite artistic possibilities, giving architects complete design versatility to refresh the building's appearance to the owner's desired aesthetic.

The off-site construction method of assembling the various components of a wall system in a factory as opposed to on the jobsite also promotes year-round restorations and minimizes weather-related delays. The exterior wall panels are built indoors with a consistent environment for greater quality control and can be shipped to the jobsite whenever the project is ready. This speed enables the buildings to achieve an air- and watertight envelope almost immediately after hanging the panels.

Deep energy retrofits can be streamlined further by consolidating scopes of work with design, construction, and building material partners who understand the interconnected facets of energy-conscious renovations. Using reliable companies for wall panel design, fabrication, and installation will enable faster, more efficient retrofits which can reduce costs for all parties. Projects can also utilize manufacturers who offer products suitable throughout the building enclosure to ensure material compatibility, effective joint connections, and long-lasting thermal performance to meet the energy-code requirements.

RETROFIT SUCCESS IN CORONA, CALIFORNIA

Such an exterior wall panel solution was successfully deployed in Corona, California, in 2023. Two buildings in the affordable multi-family housing development of Corona del Rey (**Fig. 6**) were identified as candidates for a deep energy retrofit as part of a research-driven project by the California Energy Commission and REALIZE-CA.[29] These structures were over 70 years old and required updates to their heating and cooling systems, plumbing, insulation, roof, and facade. Instead of tearing off the existing stucco, prefabricated wall panels were incorporated into the design to overclad the exterior. The prefabricated wall panel install improved the structures' energy efficiency, aesthetics, and comfort.

The principal architect, Katie Ackerly of David Baker Architects, describes how the "subtle tapering of the panels and use of accent color, and leveraging the design flexibility to incorporate building signage" effectively modernized a once-outdated structure.

FINANCIAL FACTORS AND OPPORTUNITIES

After understanding the logistics of a deep energy retrofit, the next question is always about the fiscal feasibility. Funding streams are available through a variety of federal and state-sponsored agencies as well as third-party institutions and insurers. These can come in the form of grants, rebates, loans, and tax reductions.

The DOE is continuing to fund technology advancements and pilot projects to see these retrofits through to fruition.[30] Local jurisdictions are taking their own approaches to accelerate these climate mitigation efforts and accommodate the economic factors involved. Some municipalities extend tax incentives and gap funding for owners and developers who implement these energy-saving measures, while others threaten fines to those whose buildings do not attain a certain level of energy performance.

Property Assessed Clean Energy (PACE) programs offer financing for energy-efficiency and renewable-energy improvements on commercial and residential properties.[31] Even if owners do not have the capital up front, they can participate and repay their loan across upwards of 20 years. A noteworthy element of PACE programs is that the debt is tied to the property itself, not the owner, so any repayment obligations can be transferred if the ownership changes. The program for commercial properties, which also includes multi-family housing, is known as C-PACE and is accessible in more than 37 states plus Washington, DC, while residential PACE is currently only available in California, Florida, and Missouri.[32]

The Better Buildings Solution Center is a helpful resource to find eligible financing options based on the property location, size, type of ownership, and other features.[33] Their financial opportunities can help owners and developers measure their return on investment at the onset of a project and see the deep energy retrofit through to completion.

CONCLUSION

The push to achieve net-zero GHG emissions by 2050 requires a focus on operational GHG emissions within existing buildings. State and national organizations are driving local efforts with tactical and economic backing to support the distinct needs of the design and construction professionals, owners, community leaders, and households.

To meet these benchmarks, deep energy retrofits, including prefabricated solutions such as exterior wall panels, are vital to streamline the process for all stakeholders.

Leading the pack in the adoption of retrofits are New York, California, and Massachusetts, who are pioneering energy-efficiency programs with ambitious goals for reduced GHG emissions. While monetary and logistical challenges persist, various programs can help incentivize and aid the undertaking of these massive upgrades. As these states continue to lead the way, their experiences serve as valuable blueprints for others to follow in the pursuit of greater sustainability and energy equity in their markets.

Overall, the success of such climate-management programs depends on a multifaceted approach that combines technological innovation, financial and logistical viability, and long-term performance of efficient building materials.

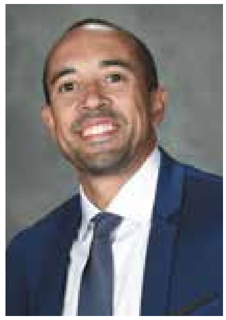
REFERENCES

1. "About the Building Technologies Office." n.d. Energy.gov. https://www.energy.gov/eere/buildings/about-building-technologies-office.
2. "Deep Energy Retrofits." GSA. Accessed 2023. https://www.gsa.gov/climate-action-and-sustainability/greening-federal-buildings/deep-energy-retrofits.
3. "The Paris Agreement." United Nations. Accessed 2023. https://www.un.org/en/climatechange/paris-agreement.
4. "The Paris Agreement." United Nations. Accessed 2023. https://www.un.org/en/climatechange/paris-agreement.
5. "Global Stocktake." United Nations Climate Change. Accessed 2023. https://unfccc.int/topics/global-stocktake.
6. "Inflation Reduction Act Guidebook," The White House, December 5, 2023, https://www.whitehouse.gov/cleanenergy/inflation-reduction-act-guidebook/.
7. "About the National BPS Coalition." National BPS Coalition, November 13, 2023. https://nationalbpscoalition.org/.
8. "RetrofitNY Program." NYSERDA. Accessed 2024. https://www.nyserda.ny.gov/All-Programs/RetrofitNY-Program.
9. "Realize-CA." RMI, March 9, 2023. https://rmi.org/our-work/buildings/realize/realize-ca/.
10. Weir, Madeline, Audrey Rempher, and Rebecca Esau. "Embodied Carbon 101: Building Materials." RMI, March 27, 2023. https://rmi.org/embodied-carbon-101/.
11. Rosenbloom, Eva, Chris Magwood, Heather Clark, and Victor Olgyay. "Transforming Existing Buildings from Climate Liabilities to Climate Assets." RMI, July 2024. https://rmi.org/insight/transforming-existing-buildings-from-climate-liabilities-to-climate-assets/.
12. "Urban Transformation." RMI, March 29, 2023. https://rmi.org/our-work/urban-transformation/.
13. "Climate Mobilization Act." New York City Council, n.d. https://council.nyc.gov/data/green/.
14. Stirling, Diane. "Deep-Energy Retrofits Research Yields Promising Cost Savings, Human Well-Being Outcomes." Syracuse University News, January 9, 2024. https://news.syr.edu/blog/2024/01/09/deep-energy-retrofits-research-yields-promising-cost-savings-human-well-being-outcomes/.
15. "New York City Housing Authority (NYCHA)." Better Buildings Initiative, n.d. https://betterbuildingssolutioncenter.energy.gov/partners/new-york-city-housing-authority-nycha.
16. "Local Law 97." NYC Sustainable Buildings. Accessed January 25, 2024. https://www.nyc.gov/site/sustainablebuildings/ll97/local-law-97.page.
17. "Empire Building Challenge." NYSERDA. Accessed December 8, 2023. https://www.nyserda.ny.gov/All-Programs/Empire-Building-Challenge.
18. "Realize-MA." RMI, February 15, 2023. https://rmi.org/our-work/buildings/realize/realize-ma/.
19. "Decarbonizing Buildings in New York." Urban Green Council, December 13, 2023. https://www.urbangreencouncil.org/.
20. "AB 32 Climate Change Scoping Plan ." n.d. California Air Resources Board. https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan.
21. "2022 Zero Code for California." 2020. Zero Code. August 2020. https://zero-code.org/wp-content/uploads/2020/08/2022_ZERO_Code_for_California.pdf.
22. "Equitable Building Decarbonization Program." n.d. California Energy Commission. https://www.energy.ca.gov/programs-and-topics/programs/equitable-building-decarbonization-program.
23. "Realize-CA." RMI, March 9, 2023. https://rmi.org/our-work/buildings/realize/realize-ca/.
24. "Low-Income Energy Affordability Data (LEAD) Tool." n.d. State and Community Energy Programs. https://www.energy.gov/scep/slsc/low-income-energy-affordability-data-lead-tool.
25. "Realize-CA." RMI, March 9, 2023. https://rmi.org/our-work/buildings/realize/realize-ca/.
26. Hun, Diana E., and Mahabir Bhandari. 2016. "ORNL Tech Demo: Achieving Energy and Cost Savings with Advanced Air Barrier System Technologies." Better Buildings. U.S. Department of Energy. December 2016. https://betterbuildingssolutioncenter.energy.gov/solutions-at-a-glance/ornl-tech-demo-achieving-energy-

and-cost-savings-advanced-air-barrier-system.

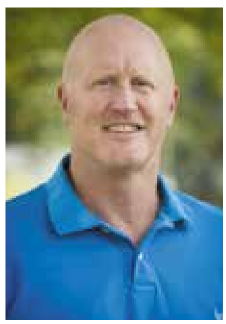
27. Shrestha, Som, Diana Hun, Lisa Ng, Andre Desjarlais, Steven Emmerich, and Laverne Dalgleish. 2016. "Online Airtightness Savings Calculator for Commercial Buildings in the United States, Canada, and China." https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=920497.
28. "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization." 2019. www.astm.org. January 23, 2019. www.astm.org/e0779-19.html.
29. Egerter, Amy. 2021. "REALIZE-CA: Retrofit Solutions in California." Passive House Accelerator. June 15, 2021. https://passivehouse-accelerator.com/articles/realize-ca-retrofit-solutions-in-california.
30. 2023. "Unlocking the Value of Deep Energy Retrofits". United States. https://www.osti.gov/servlets/purl/2229868.
31. "Property Assessed Clean Energy Programs." n.d. State and Community Energy Programs. https://www.energy.gov/scep/slsc/property-assessed-clean-energy-programs.
32. "Property Assessed Clean Energy Programs." n.d. State and Community Energy Programs. https://www.energy.gov/scep/slsc/property-assessed-clean-energy-programs.
33. "Solutions." 2023. Better Buildings. U.S. Department of Energy. 2023. https://betterbuildingssolutioncenter.energy.gov/solutions.

ABOUT THE AUTHORS



DAVID HUTCHINSON

David Hutchinson *is an expert in retrofit solution generation for the constantly aging existing building stock. Leading the Tremco CPG'Deep Energy Retrofit Development program, he works with building owners and architects to bring turnkey solutions to the market and address the challenges facing carbon reduction. Additionally, Hutchinson is the founder and director of the Tremco CPG Rising Stars Program, which focuses on creating opportunities for diverse workforce development through training, education, and networking.*



CHUCK BUNDRICK, CSI, LEED GA

Chuck Bundrick, *CSI, LEED GA, is a veteran of the exterior insulation and finish system (EIFS) and construction industry with nearly 30 years' experience in senior sales and business management roles. He assists a team of professionals that help building owners, architects, and their design and engineering consultants consider prefabricated solutions for their projects. This team helps address the critical issues associated with building envelope renovations, including making decisions about improving building performance and transformation of the building exterior. Chuck also helps owners access the specialized services often needed in prefabrication and renovations such as fabricators, third-party inspectors, forensic engineers, and energy analysts.*

Please address reader comments to chamaker@iibec.org, including "Letter to Editor" in the subject line, or IIBEC, *IIBEC Interface Journal,* 434 Fayetteville St., Suite 2400, Raleigh, NC 27601.

IIBEC

Publish in IIBEC interface

IIBEC Interface is seeking submissions for the following issues. Optimum article size is 2,000 to 3,000 words, containing five to ten high-resolution graphics. Articles may serve commercial interests but should not promote specific products. Articles on subjects that do not fit any given theme may be submitted at any time.

ISSUE	SUBJECT	SUBMISSION DEADLINE
July/August 2024	Restoration/Forensics	March 15, 2024
September 2024	Climate Adaptation	May 15, 2024
October 2024	Testing	June 14, 2024