



PREPARED
FOR NYSERDA

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THE NEXT FRONTIER FOR ENERGY- EFFICIENT PRODUCTS

Urban Green Council is the New York Affiliate of the U.S. Green Building Council. Our mission is to transform NYC buildings for a sustainable future.

We believe the critical issue facing the world today is climate change. Our focus on climate change requires us to improve energy and other resource efficiencies in buildings, creating a more resilient, healthy and affordable city for all New Yorkers.

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EXECUTIVE SUMMARY

In just 300 square miles, New York City is home to over one million buildings, 3.4 million apartments, and the largest commercial real estate market in the country.

This exceptional density has created a construction market large enough to support unique building techniques and technologies. For instance, not many rooftops in San Francisco support wooden water towers. And in Chicago, curtain wall high-rises are not dotted with the grilles of packaged terminal air conditioning units (PTACs).

Recognizing the need for product innovation in New York City and State, the New York State Energy Research and Development Authority (NYSERDA) created the Advanced Buildings Program. This program offers funding for companies and inventors that develop new, energy-efficient, building technologies and business models.

To ensure alignment between their building product research and industry demand, NYSERDA engaged Urban Green Council to conduct a technology needs assessment within the building industry. Over the last two years, we identified and refined product ideas through surveys, focus groups, energy analyses and interviews with manufacturers. We gathered feedback from a broad audience of industry professionals to assess potential product demand and feasibility in the New York market.

Six product ideas rose to the top based on likely demand, ease of implementation and cost-effectiveness for buildings in

New York State.¹ Energy savings from these products range from 3 to 13 percent of site energy use.²

1. Advanced unitized curtain wall
2. Packaged condensing boiler for heat and hot water
3. Split heat pump designed for PTAC openings
4. Super-efficient modular cooling for commercial space
5. Insulated wrap for existing balconies and slab edges
6. Low-conductivity shelf angles for masonry walls

Several of these products could have significant impact on a few individual buildings, while others could have a smaller impact on a larger number of buildings across the city. Advanced curtain walls were found to lower site energy use most significantly at the building level. Condensing boilers that serve both heating and hot water demand had the greatest potential impact across NYC. An energy-efficient PTAC replacement, such as a split heat pump, had savings that varied widely depending on the type of existing PTAC. This solution would save energy and carbon, but it may cost more to operate due to high electricity prices. Super-efficient modular cooling for commercial offices, insulated wraps for balconies and slab edges, and low-conductivity shelf angles all had

¹ For additional details about the products studied in this report, see page 7.

² For details on how these savings were calculated and how many buildings could be impacted, see page 12.

about the same impact on building site energy (though the modular cooling product would usually save electricity, so its cost savings are more significant).

We also spoke to manufacturers, and some acknowledged they have certain energy-efficient product ideas that have not been pursued. Many of them felt that demand would be low or that knowledge gaps would limit uptake. Their lack of certainty regarding demand and the cost premiums on energy-efficient products were listed as the most common reasons that new products are not developed.

In addition to revealing interesting market opportunities, this research is the first step toward creating better communication between multiple stakeholders: building designers, owners, operators and product manufacturers. We hope to continue this work by soliciting new product recommendations from the industry on an ongoing basis and communicating that information back to manufacturers.

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WHAT MANUFACTURERS THINK

In parallel with our product research, Urban Green also explored manufacturing barriers for energy-efficient HVAC products.

Urban Green interviewed 14 different manufacturing firms of varied scale, location and type to better understand potential problems in the development and supply of energy-efficient products.

Manufacturers consistently indicated that many energy-efficient products already exist in prototype, but they haven't been brought to market for the following reasons:

Particularly novel or innovative products may not have an existing market. This means manufacturers must create one through marketing and outreach, which can be costly and risky. New products often get stuck in the small-scale testing and prototype phases of development, while prospective customers remain unaware of them. Manufacturers suggested that they would be interested in any marketing and outreach support that NYSERDA could provide to overcome this hurdle.

More than a third of companies indicated that the majority of replacement demand in the retrofit market is unplanned. This is usually the result of a 'run-to-fail' mentality among operators. In these situations, customers often have not budgeted for replacement equipment and need a product to be installed as quickly as possible to maintain building operations. This can make the initial capital investment a challenge, even if there are substantial energy savings to be had. It can also result in customers choosing the most readily available product without considering energy efficiency at all.

Because capital investments are expensive and infrequent, there is low tolerance by end users for taking on a new product that has not been widely tested. In addition, one manufacturer noted that in order to get their energy-efficient products installed, specification needs to be easier; the extra work and risk are the true barriers to market adoption.

Manufacturers suggested that increasing awareness, particularly among engineers specifying products in new construction, should be a big priority. Events, programs, case studies and demonstration projects could be valuable ways to convey information to this key market segment so that it is not brushed off as a sales pitch.

These market challenges and potential interventions all point to a key notion: Lack of ideation is not seen as a problem by manufacturers. To bring new energy-efficient building products to market and provide a true assessment of demand, we need increased communication and collaboration between manufacturers and building designers, owners and operators.

WHAT BUILDING FOLKS THINK

In 2016, Urban Green held a series of meetings with designers, owners and contractors to understand whether there is a demand for products that (1) do not yet exist, (2) exist but have major flaws, and/or (3) exist in other markets but are not readily available in New York. Twenty product suggestions emerged.

In collaboration with NYSERDA, we conducted a statewide survey in 2017 on these 20 products; over 200 building professionals responded.

The survey validated that there was indeed demand for many of the products suggested during the initial assessment. Respondents also ranked the products in order of market applicability and feasibility. The responses whittled down our list to five HVAC products and five envelope products. The resulting top 10 were then reviewed further in focus groups, as discussed on pages 8-11.

The survey also collected professional information about each respondent: There were 37 architects, 36 engineers, 35

consultants, 35 property managers and 60 other building professionals within the mix of responses (Figure 1). Based on their professional experience, respondents were directed to answer detailed questions about the products that matched their knowledgebase.

Figure 2 shows how all 20 products scored in terms of their suitability for the New York market. Each product's rank is based on the perceived immediate need and the feasibility of installing or using the product. The 10 highlighted in green were viewed by respondents to be most feasible (ease with which product could be incorporated into current design/construction practices) and to have the highest

More about the survey

Urban Green garnered feedback from a broad audience of industry professionals to develop a complete picture of the demand for each product and its feasibility in New York. The survey was distributed to members and contacts of Urban Green, AIA NY, SEIU 32BJ, ACEC NY, REBNY, NY Passive House, BOMA NY, The NY State Association for Affordable Housing, and USGBC Upstate.

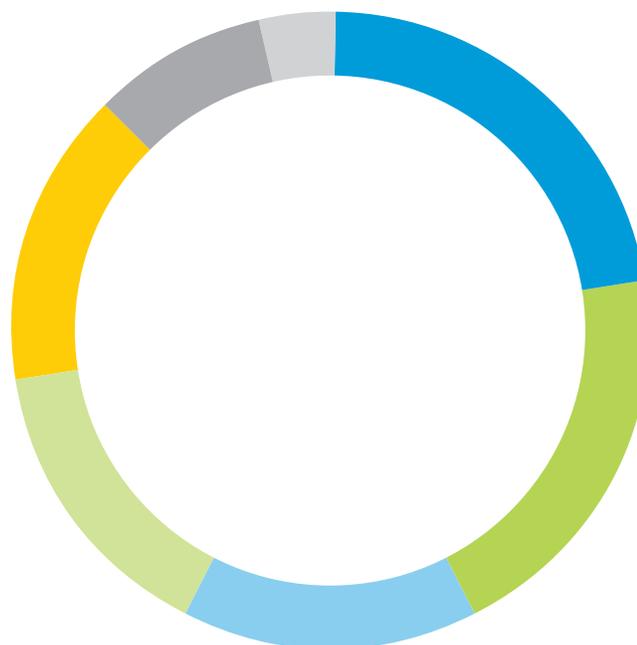


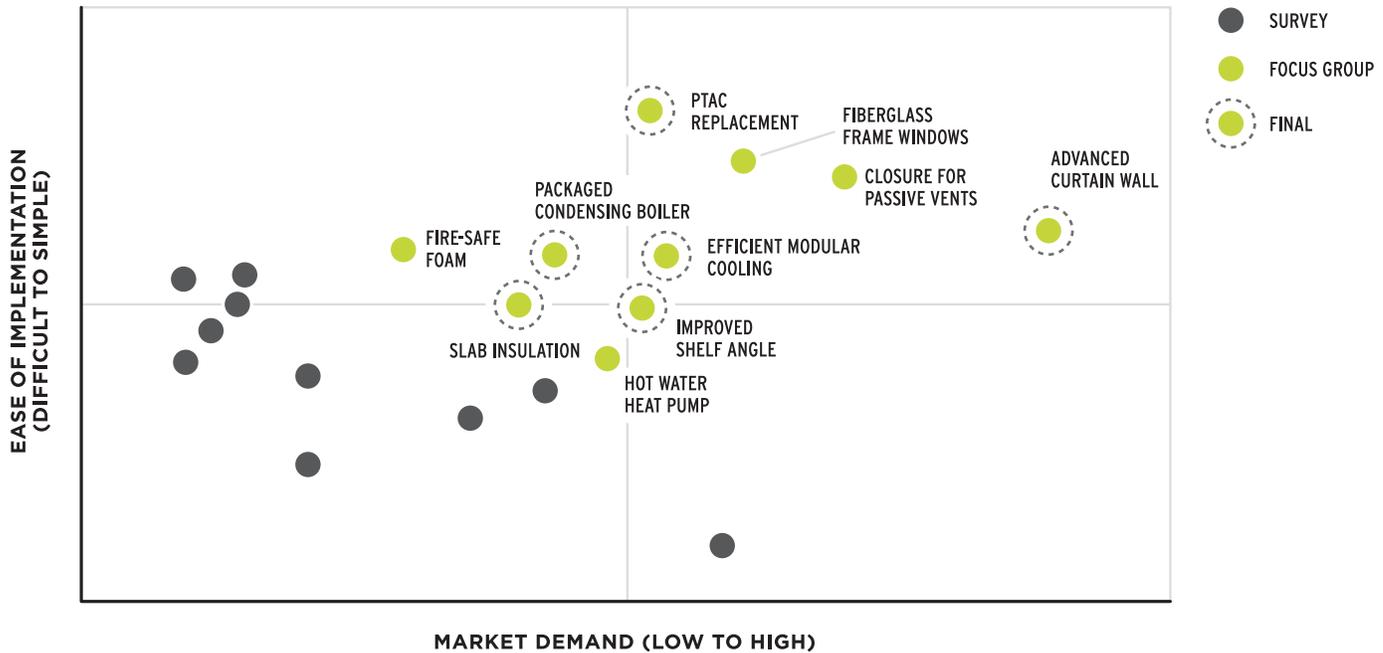
FIGURE 1
Who Did We Survey?

- 22% ENGINEER
- 20% ARCHITECT
- 15% OTHER
- 15% CONSULTANT
- 15% PROPERTY MANAGER / MAINTENANCE
- 9% REALTY PROFESSIONAL
- 4% PRODUCT MANUFACTURER

FIGURE 2

Survey Results and Selection

Over 200 building experts judged the market demand and ease of implementation of 20 products. The top 10 products were refined in focus groups, which then picked six product ideas that warranted further research and analysis.



perceived market demand (likelihood that product would be recommended for a current or upcoming project).

These top 10 products, listed from highest survey score to lowest, were:

1. Closure for passive vents

Open vents at the top of stairwells and shafts allow conditioned air to escape from buildings. A product to retrofit these vents for automatic control should be easy for building managers to install and ensure code compliance. Existing fire detection technology could trigger the vent louvers to automatically open when needed and allow smoke to escape. Building managers and owners could also benefit from manual control of the damper position for routine maintenance.

2. Fiberglass frame window

Typical window frames are made from steel or aluminum and conduct heat well. Windows made from insulated fiberglass or comparable low-conductance materials exist, but they need improvements to

compete in cost and strength with metal framed windows. Going from double to triple pane glass can mean a 30 to 50 percent cost premium, so improving the overall window assembly performance could be a cheaper solution than focusing on the glazing alone.

3. Advanced curtain wall

Curtain walls are becoming increasingly common, but low-conductance implementations are not. The industry is in need of a complete unitized design that optimizes the vision glazing panel, frame (mullions), anchors, construction behind opaque (spandrel) areas and perimeter details. Fully thermally broken mullions are one aspect of this product. Standardized and high-performance curtain walls exist in Europe, and custom curtain walls in the US can have low conductivity, but the New York market needs a product that can easily scale for new construction and possibly retrofit existing curtain walls.

4. Split heat pump designed for PTAC openings

Packaged terminal air-conditioners (PTACs) are housed in holes that dot the façade of many New York buildings. They are typically the cheapest option for heating and cooling, but they have low efficiencies and introduce air gaps that create infiltration problems. A compact air-source heat pump or similar high-efficiency system could be developed to fit into PTAC sleeves. The product would rely on electrical energy to create heating and cooling, incorporate air-sealing and insulation to stop heat loss and provide a temperature turn-down. The product could also incorporate outdoor air ventilation to be controlled by the tenant.

5. Super-efficient modular cooling for commercial space

Direct-expansion air-handler units provide cooling for many commercial spaces, but their compressors achieve low efficiencies. A 'turbo-style' compressor that operates at high efficiency but serves small loads

(3 to 20 tons) could solve this problem. This compressor would allow a cooling system to operate using 30 percent less electricity than the typical modular system. The increased efficiency would allow modular systems to compete with complex central plants in terms of energy savings.

6. Packaged condensing boiler for heat and hot water

Condensing boilers exist today, but they are challenging to install. An integrated boiler/domestic hot water (DHW) package is needed to simplify installation and expand their use. A heat exchanger in the boiler exhaust could preheat DHW, reducing the energy necessary to produce hot water. A packaged solution would include all of the parts, equipment and raw materials necessary for the contractor. This standardization would help ensure that an efficient setup would be implemented.

7. Fire-safe Foam

A closed-cell spray polyurethane foam (SPF) that meets fire safety requirements without additional coating would allow for simpler and more effective insulation techniques. New construction buildings would achieve higher insulation levels and air barriers without the added costs of coatings. Retrofit applications in occupied buildings would be simplified without the safety precautions and complexity of an applied coating.

8. Low-conductivity shelf angles for masonry walls

A shelf angle is a structural element that attaches to the building frame and supports masonry walls. A low-conductivity shelf angle that works with common design details could stop the thermal bridging that occurs at the intersection of the wall and frame. This product should have the compressive and tensile strengths of existing shelf angles, as well as the typical fire resistance. Materials like pultruded plastic or composites could fulfill these

requirements. This product would have a much simpler installation than using existing thermal breaks along a conventional steel shelf angle.

9. Insulation wrap for existing balconies and slab edges

Balconies and floor slabs extend beyond a building's insulation in many cases; this is a small but important area of heat loss. For retrofit projects, a thin insulating material that could be easily applied to existing slab edges would help stop heat loss. On new construction projects, this type of product could be applied to concrete slab balconies that protrude continuously through the envelope, as well as to exposed slab edges along the façade.

10. Air-to-water heat pump tailored to NYS DHW retrofits

Almost 90 percent of the multifamily floor area is heated by an old boiler that works double duty as a DHW heater. This configuration works well for a condensing boiler, but it can waste energy if the boiler isn't controlled properly. A heat pump could serve the hot water load separately with greater efficiency and control, especially during the summer. It could also pull heat from inside the building and cool common spaces during the cooling season. Large-scale heat pumps are not yet available in our market, but they have been implemented on a limited scale in Europe.³

Focus Groups

The focus groups brought together a diverse group of professionals to dive more deeply into the 10 top product proposals from the survey. We convened engineers and building owners to discuss the HVAC products (the "mechanical group"), and a group of architects, building owners and manufacturers to discuss envelope products (the "envelope group"). Each group selected the three most crucial products for energy modeling and impact analysis. The participants primarily judged products on their

cost-effectiveness for owners and developers—a critical hurdle to implementation.

Specifically, the sessions aimed to define specific performance requirements and pertinent codes, explore possible market barriers, and generate new product ideas. Three questions guided each conversation:

1. Is there a business case for a building owner or developer to use this product?
2. What are the specific performance and physical requirements necessary for this product to fit into existing building infrastructure?
3. Which barriers, if any, would inhibit this product from being successfully incorporated into the market?

Focus group participants narrowed the list down to six products that were most cost-effective and met a market need. They also provided the technical details that enabled our energy modeling.

³Based on audit data reported in The 2017 NYC Energy and Water Use Report, over 70 percent of large commercial buildings that use direct-expansion cooling employ air-cooled compressors. Air-cooled systems are less expensive than water-cooled systems and tend to serve smaller loads.

Mechanical Group Feedback

The mechanical group agreed on three products that were worthy of analysis and further research:

PTAC Replacement

The PTAC replacement was viewed as the product having by far the biggest potential to change the landscape of the city. Mini split heat pumps have sporadically been retrofitted to fit into PTAC openings, but a standard solution would allow these replacements to scale up. Based on audit data from NYC's Local Law 87, there are over 120,000 PTAC units in NYC, and that number will increase as more audits are completed.⁴ The technology is ready to be packaged into a product, but placing heating costs on tenants would be a huge issue. The vast majority of NYC tenants pay for heat indirectly through their rent, but an in-unit heat pump would allow landlords to measure and charge tenants directly for the electricity used for heat. That would be a large

added cost for tenants, and it's unlikely that owners would lower rents.

Packaged Condensing Boiler

While condensing boilers exist today, there are still many issues with their implementation; for example, they are typically more expensive than a conventional boiler and their installation is much more complex. A packaged solution that includes all of the necessary piping could help installers ensure that the boiler condenses water vapor in its exhaust and operates above 90 percent efficiency.

Efficient Modular Cooling

On the commercial side, super-efficient cooling is hampered by physical and regulatory limitations. New York City requires a refrigeration system operating engineer to be onsite where there is a compressor with greater than 50 horse-power (Hp) or when the sum of all compressors in the machines larger than 15 Hp exceed a total of 100 Hp. To avoid this, many

buildings opt to install as many small compressors as needed. Restricting the number of compressors permitted would allow a larger compressor to serve each floor. This compressor could have a much higher efficiency if it also included components like magnetic bearings, variable speed drives and better controls.

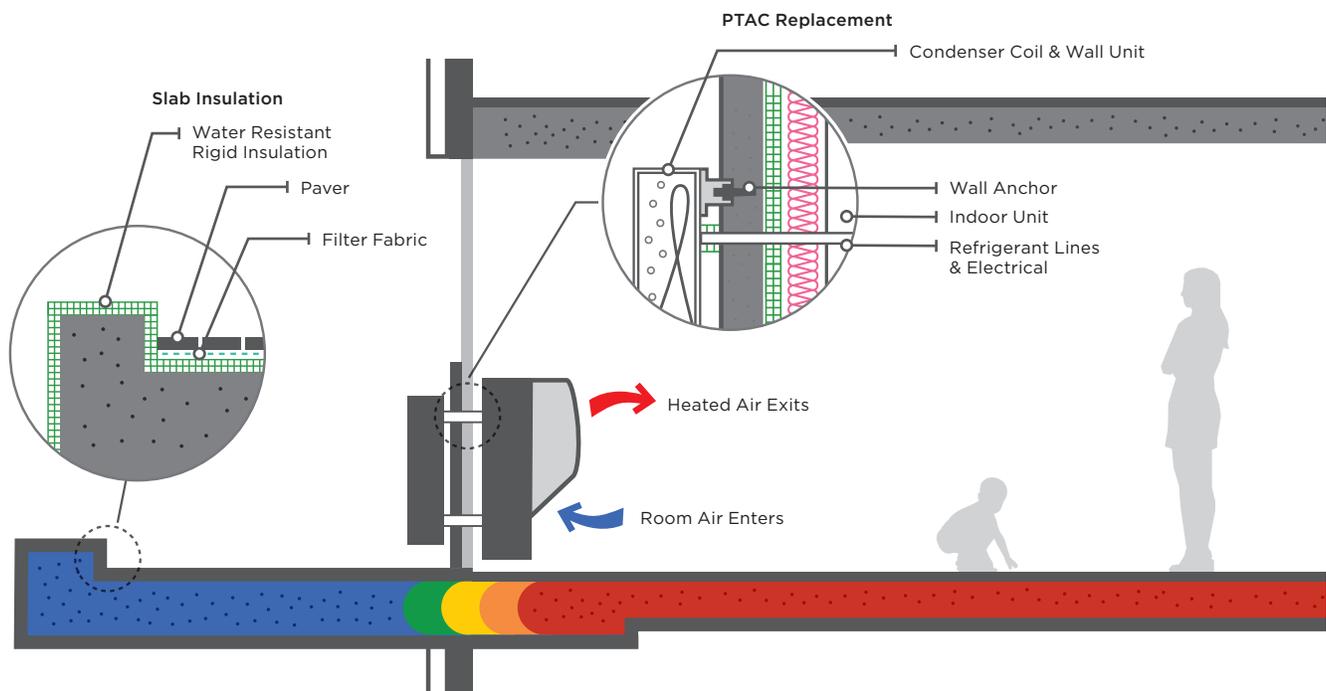
Other Conclusions

Finally, this group felt that air-source heat pumps were needed to reduce emissions from hot water production. However, switching the production of hot water from natural gas to electricity would raise costs considerably for owners. If the heat pump could heat water and cool space simultaneously, then a business case may be more feasible. This would work best in a mixed-use building that needs cooling year-round; for example, a residential building that has a few office floors with many people and computers.

FIGURE 3

Residential Product Applications (Winter Conditions)

Split heat pumps retrofitted into PTAC openings heat and cool the space with less energy. Balconies and slabs get insulated to keep the heat in and floors comfortable during winter.



⁴ This is based on three years of LL87 of 2009 audit data, or approximately 30 percent of all NYC buildings greater than 50,000 square feet.

The group thought dampers that close passive vents at the top of shafts were important but shouldn't be on the final list. They felt that the energy lost through vents could instead be prevented by providing the necessary training to supers and facility managers on how to ensure safety without an open vent. Linking the dampers directly to the fire alarm system was seen as an overly complicated and costly solution that would require hiring a certified alarm practitioner.

Envelope Group Feedback

After receiving feedback on HVAC products, we turned to the building façade. The envelope group agreed that the following three products warranted more analysis and research:

Advanced Curtain Wall

A unitized curtain wall solution was viewed to have the most potential. The advanced curtain wall product

evolved from an initial idea to insulate the mullions between glass panels. The architects involved in the group felt that this was only part of the problem and that a 'Ferrari of curtain walls' must be developed in order to showcase how all the best components could come together. On past projects, they had seen well-insulated, custom-built curtain walls, but there is demand for a standardized product that can be used inexpensively.

Slab Insulation and Improved Shelf Angle

Balcony and slab thermal breaks are available for new construction, but insulation that can be applied effectively for existing buildings needs more development and availability. Heat loss from steel shelf angles can be stopped today with ceramic thermal breaks, but they complicate the installation. A low-conductivity shelf angle that gets installed as simply as a steel shelf angle would be much better.

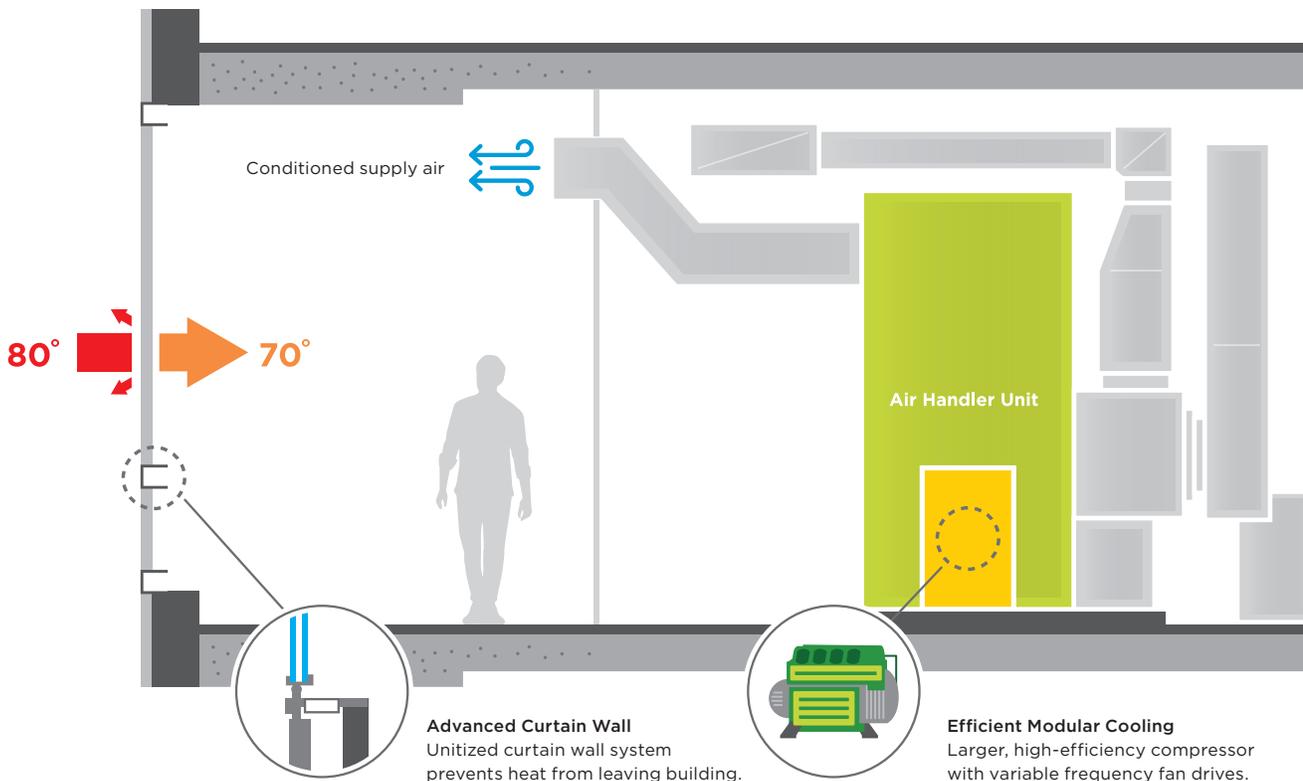
Other Conclusions

The envelope group determined that closed-cell spray foam with fire resistance could potentially be useful—but only in a minuscule market. They also felt that foam insulation may become obsolete as high-performance insulation with low embodied energies becomes available.

The group agreed that two of the other products exist in the market already: fiberglass windows for high-rises and controllable passive vent dampers. Existing fiberglass windows are high-priced and need better testing and certification, but the group felt that natural market forces would overcome these problems.

FIGURE 4
Commercial Product Applications (Summer Conditions)

Advanced curtain walls use thermally broken connections with insulated, multi-pane glazing. These walls keep heat out in the summer or in during the winter. High-efficiency compressors cool the space with less electricity but give tenants control.



POTENTIAL IMPACT

After the building experts weighed in on which products needed more research, they developed specifications that the products should meet.

With those requirements in mind, our team analyzed the six finalists and estimated the scale of their potential impact on New York City’s building stock.

We modeled the products using widely accepted simulation tools (DOE-2.2 and Energy Plus). Each model was sized to match a typical residential or commercial building from the city’s benchmarking data. Internal plug, lighting and occupancy loads were apportioned using ASHRAE 90.1 Appendix G and DOE-2 internal assumptions. Each baseline model was then modified with a proposed design condition that included one of the products.

Each product was assumed to make a significant improvement on one aspect of the building’s performance. The advanced

curtain wall could lower overall glazing assembly conductance by 40 percent on facades made of 60 percent glass or more. The condensing boiler could improve fuel efficiency by 10 percentage points over a properly maintained conventional boiler. Super-efficient modular cooling for offices could cut the electricity used by compressors by 30 percent, down to 0.35 kW/ton.

The New York City Energy and Water Use Report was used to determine the building count that could be affected by each new product. Since that report included only 30 percent of the audits required by Local Law 87, these values are estimates from conservative projections. Some products were assumed to be applicable to all audited buildings with a given system, such as curtain walls and direct-expansion

FIGURE 5
Product Energy and Building Impacts

	PREDICTED SITE ENERGY SAVINGS	ESTIMATED NUMBER OF LARGE BUILDINGS IMPACTED (LARGER THAN 50,000 SF)
Advanced Curtain Wall	13%	400
Packaged condensing boiler for heat and hot water	6%	2,500
Split heat pump designed for PTAC openings	4%	500
Super-efficient modular cooling for commercial space	3.5%	1,000
Insulated wrap for existing balconies and slab edges	3%	NA*
Low-conductivity shelf angles for masonry walls	3%	NA*

*Existing balconies, slab edges and shelf angles could not be estimated due to insufficient information.

air-handler units in commercial buildings. But products like condensing boilers were assumed to be applicable in any building where it was recommended as a measure by auditing engineers.

Three of these products have the largest potential impact. Advanced curtain walls, packaged condensing boilers and super-efficient modular cooling would deliver the biggest energy savings across New York City. Each would require a different development process. The advanced curtain wall needs an easy-to-replicate demonstration project of all the current best practices. This would allow designers to see how the pieces come together, get comfortable with the curtain

wall's aesthetics and provide tested and reproducible specifications for their models. The condensing boiler would require significant communication between designers, installers and manufacturers to package the right components and standardize the installation process. Super-efficient modular cooling would need a regulation change to allow for larger compressors in commercial buildings; then, manufacturers can incorporate all of the best components into one compressor.

NEXT STEPS

Many product manufacturers believe there is a lack of demand for energy-efficient products, versus a lack of ideas.

However, our findings confirm that in actuality, there is pent-up demand for these products in New York City. Here is how we can improve the entry of energy-efficient building products into our market:

1. Improve communication between building owners, designers, contractors and product manufacturers.

a. Designers want some products that manufacturers do not offer. Manufacturers believe there is no market demand for their energy-efficient prototypes. Communication is lacking between these groups.

b. Urban Green Council and NYSERDA will continue to improve this feedback loop through ongoing publications and industry events.

2. Incentivize specific products that package existing technologies in new ways.

a. Super-efficient modular cooling is hampered by regulations that encourage small compressors. If those regulations were modified in cooperation with labor organizations, larger compressors could be used with higher-quality components to yield higher-efficiency cooling.

b. PTACs are common in NYC, but they are generally considered an undesirable product and manufacturers do not invest in them. Efficient heat pumps that fit into PTAC wall openings could be incentivized. Manufacturers could then package inverter compressors, ECM fans and split condensers and evaporators to make an easy retrofit product.

c. NYSERDA can help with product development by supporting safe building code updates, creating incentive programs and funding demonstration projects.

3. Help create markets in new construction and retrofits.

a. Manufacturers seek some certainty for market demand so as to develop new products. Building designers and contractors want to ensure novel products will work for owners and tenants.

b. NYSERDA can help lower this risk by creating long-term incentive programs aimed at specific technologies. This would allow manufacturers to develop products on longer timelines and give end users better options in emergency replacement situations. NYSERDA can also help train industry on the benefits and reliability of new technologies to reduce the likelihood of them being cut as part of value engineering. State and local governments and industry associations could specify targeted products in their construction guidelines. Associations of building owners and designers could collectively champion particular new technologies.

4. Target unplanned replacements.

a. To ensure a market for energy-efficient products, building owners need to plan replacements effectively. If equipment is run to failure, then the most likely outcome is a like-for-like replacement. Quick turnarounds and low-risk technologies are needed to replace their older systems.

b. NYSERDA can help ensure energy-efficient replacements by offsetting equipment premiums through incentive programs. Further investigation is warranted on how to encourage building owners, operators and managers to develop equipment upgrade plans.

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