Carbon Neutral Buildings Roadmap

Achieving a carbon neutral building stock in New York State by 2050

Public Webinars – Day 2

June 16, 2021

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Roadmap Day 2

Today's Topics:

- Solutions sets for achieving carbon neutrality by building type
- Policy recommendations (building on those from the Energy Efficiency and Housing Advisory Panel) being inclusive of and benefitting those in historically disadvantaged communities
- Building out the workforce of jobs and boots on the ground who will make this a reality
- Continuing engagement and outreach to the public and those affected
- Real world case studies of buildings that have already made this a reality

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

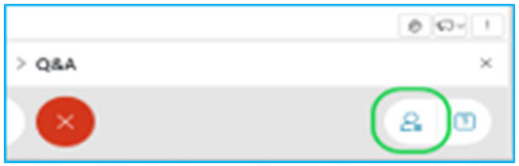
Syracuse University, NY

Meeting Procedures

Participation for Members of the Public:

- Members of the public are muted upon entry
- Questions and comments may be submitted in writing through the Q&A feature at any time during the event
  - Chat is disabled
  - Today's webinar is currently available on our website
  - A recording of the webinar will be posted on our website on June 24, 2021

You'll see  when your microphone is muted



If technical problems arise, please contact Sal.Graven@nyserda.ny.gov

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

John Williams

NYSERDA

Vice President for Policy
and Regulatory Affairs

Roadmap Presentation Speakers

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Patrick O’Shei

NYSERDA

Director, Market Development

Cara Carmichael

Rocky Mountain Institute

Principal

John Lee

NYSERDA

Contractor, Codes Products and Standards

Michael DiRamio

NYSERDA

Assistant Director,
Energy Affordability and Equity

Adele Ferranti

NYSERDA

Director,
Workforce Development and Training

Greg Hale

NYSERDA

Senior Advisor for Energy Efficiency Markets & Finance

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Chapters 8 and 9: The Economics, Benefits and Challenges for Building Solution Sets

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Carbon neutral buildings are a better solution – higher quality with better attributes and resulting in more value

Today, there is typically an upfront cost premium to achieve carbon neutral buildings, however...

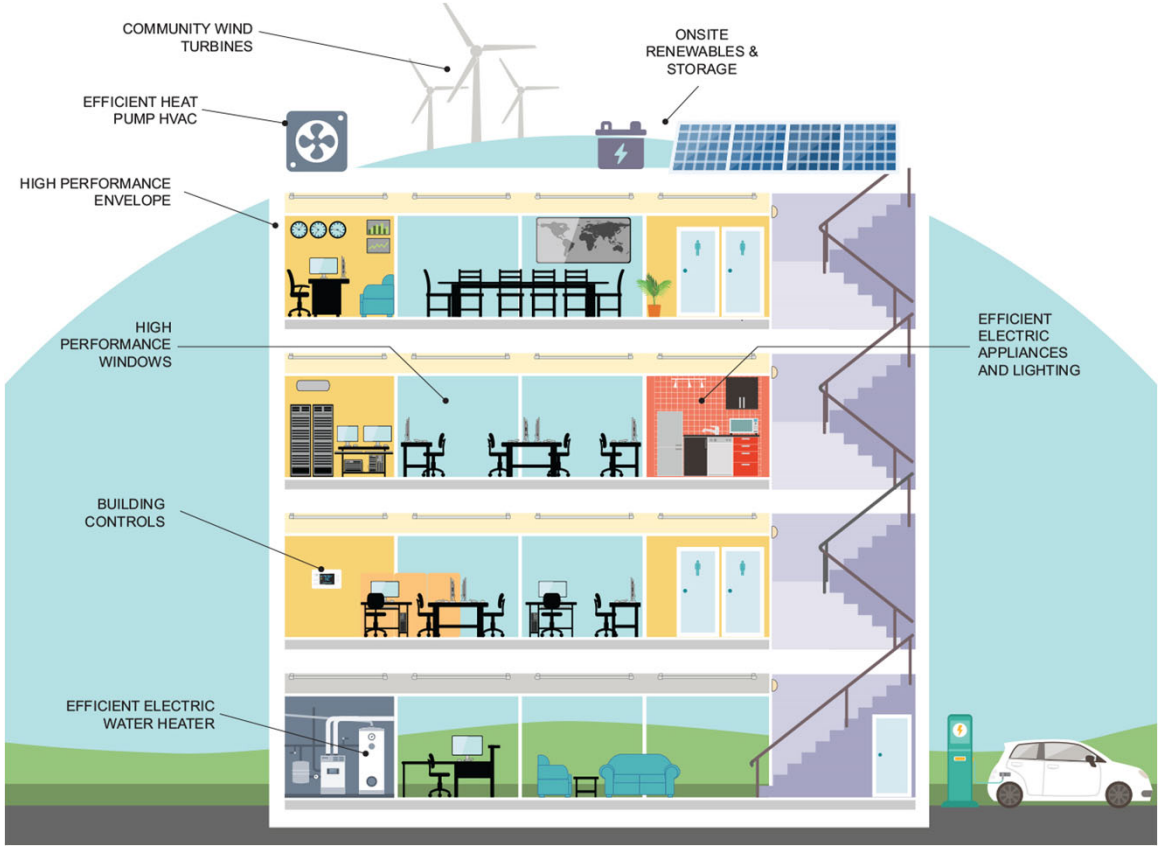
- Carbon neutral buildings provide many unquantified co-benefits (e.g. improved health, productivity, safety, and comfort)
- Community, building, home and grid resiliency is greatly improved by high performance envelopes, grid interactive controls and onsite thermal and battery storage
- Technology first costs are expected to decline 15-30% by 2030
- Available incentives and tax credits generally offset 25-50% of the upfront cost premium
- Carbon neutral buildings are maturing into cost-effective and highly reliable solutions today
- Real world projects are less expensive and out-perform modeled expectations in many cases

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Decarbonization = efficiency + electrification + grid interactive load management

To achieve a carbon neutral building stock by mid-century:

- all new construction projects should be efficient, all-electric, and capable of grid interactive operations
- all existing buildings should be updated over time to be more efficient, remove fossil fuel use and adopt grid interactive operations



Source: NYSERDA

Co-benefits of carbon neutral buildings

1
Minimize liability & future proof

Safeguard against a changing energy market where gas and other fossil fuels are likely to become less accessible and more expensive over time.

2
Maximize usable square footage

Electric HVAC equipment maximizes available square footage (e.g. heat pump units installed on walls near ceiling vs. steam radiator taking up floor space).

3
Health benefits

All-electric appliances, especially electric stoves and cooktops, reduce indoor air pollutants. Good building envelopes protect against pest infestation and other asthma triggers.

4
Increased resilience

Weatherization and solar + storage help keep the power on and temperatures consistent in the event of a power outage or extreme weather event.

5
Occupant comfort

Improved comfort from increased air-flow/movement, addressing previously unmet cooling needs (through heat pumps), and noise reduction.

6
Safety

Reduced risks associated with aging gas infrastructure leaks; induction cooktops reduce instances of fire and burns.

Challenges

1. First-cost premiums compared to fossil fuel-based systems, high cost of envelope upgrades
2. Current high cost of electricity vs. low cost of fossil fuels
3. Some decarbonization measures create site and building disruptions, especially in retrofit projects (e.g. electric panel upgrades, adding insulation)
4. Most benefits of decarbonization are not yet quantified (e.g., enhancements to resiliency, health, comfort, productivity and safety)
5. The economics are frequently better upstate compared to downstate, due to higher electricity costs, labor and material cost downstate

Managing costs for carbon neutral solutions is critical

- **Multiple pathways exist** to decarbonize buildings
- Each pathway results in **trade-offs on cost, co-benefits, and grid impacts**
- Improved manufacturing and experience with solutions is expected to **reduce costs 15-30% by 2030**
- Solutions in new construction/gut rehab can be **50% more cost effective by using integrated design** techniques with an experienced team
- Decarbonizing **existing buildings can be more costly** due to pre-existing building conditions

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Niagara Square and City Hall | Buffalo, NY

Multifamily
Solution Sets

- More than 50% of existing multifamily buildings in NYS were built before 1945
- Building upgrades can improve health for occupants due to better indoor air quality
- Older buildings are more likely to require electrical upgrades, structural, and remediation steps (mold, lead, asbestos, etc.)

Example Modeled Scenario:

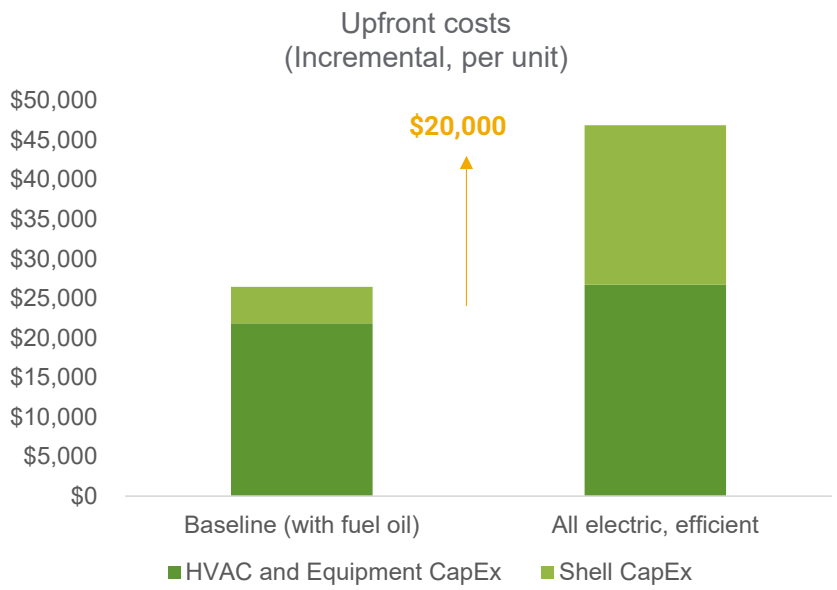
	All-Electric Retrofit & New Construction with current NYS Code Compliant Shell
Load reduction strategies	▪ Code compliant walls, roof* ▪ Double-pane windows ▪ Air sealing ▪ LED lighting ▪ Low-flow water fixtures
Building electrification technology	▪ Distributed cold climate air-source heat pumps ▪ Heat pump water heaters ▪ Efficient electric appliances, such as induction cooktops
Advanced controls	• Not modeled
Distributed energy resources	• Not modeled

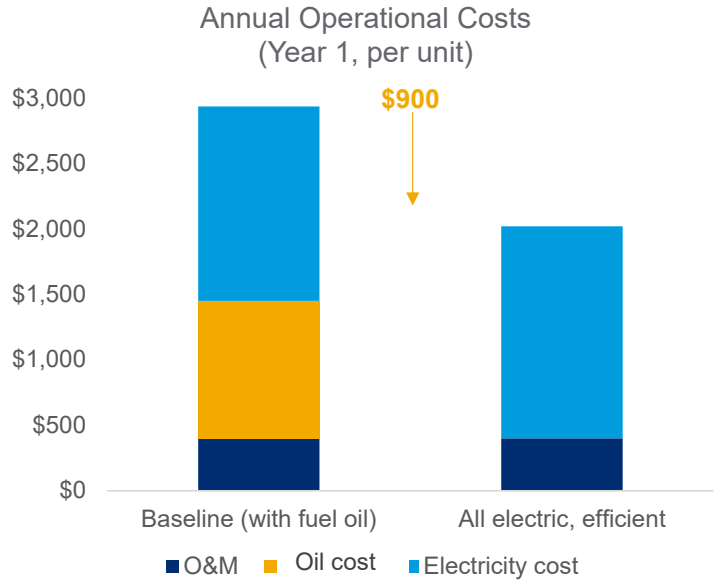
*Per 2020 New York State Energy Conservation Construction Code for new construction

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Payback for decarbonizing multifamily buildings that heat with oil is better than for similar buildings that heat with gas at today's project installation and energy costs

7-Story, Retrofit of pre-1980 building, Climate Zone 4A, NYC: with upgrade to distributed ccASHP, code compliant shell, HPWH, LED lighting, smart appliances and induction range



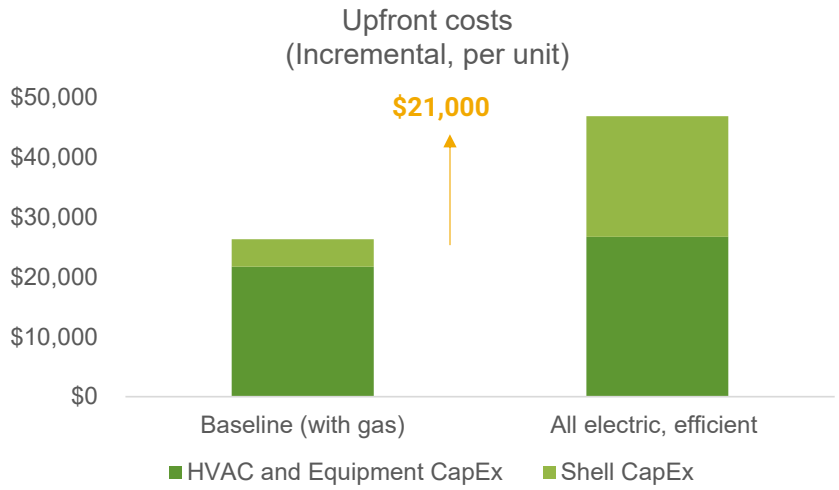


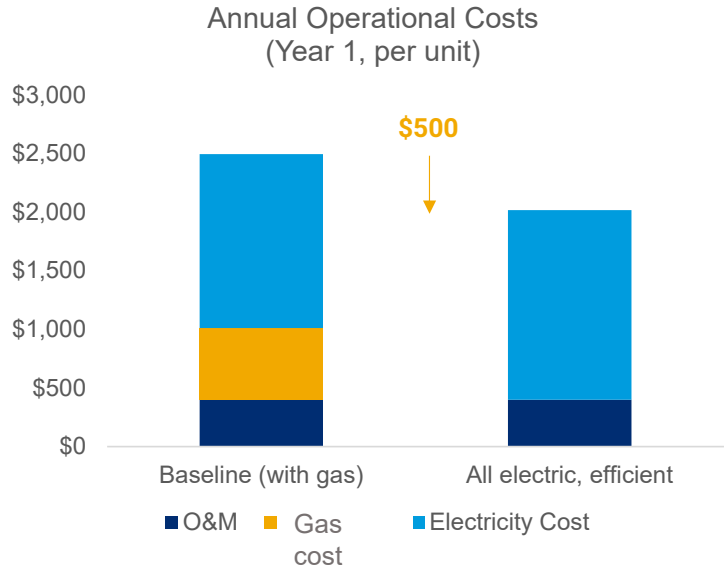
- **These figures do not include incentives or tax credits, which frequently account for 25-50% of incremental cost; Incremental cost does not include any anticipated technology cost reduction or savings from an integrated design process**

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

In multifamily buildings that heat with gas, retrofit paybacks are not attractive based on today's costs, highlighting the need to reduce project installation costs and account for co-benefits.

7-Story, Retrofit of pre 1980 building, Climate Zone 4A, NYC: with upgrade to distributed ccASHP, code compliant shell, LED lighting, smart appliances, HPWH and induction range





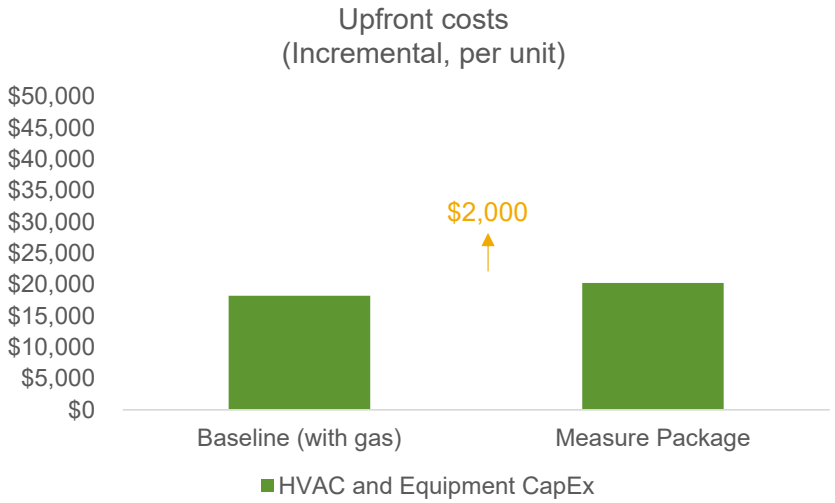
- **Retrofits of older multifamily buildings that are heating with gas are among the most challenging building types to decarbonize**

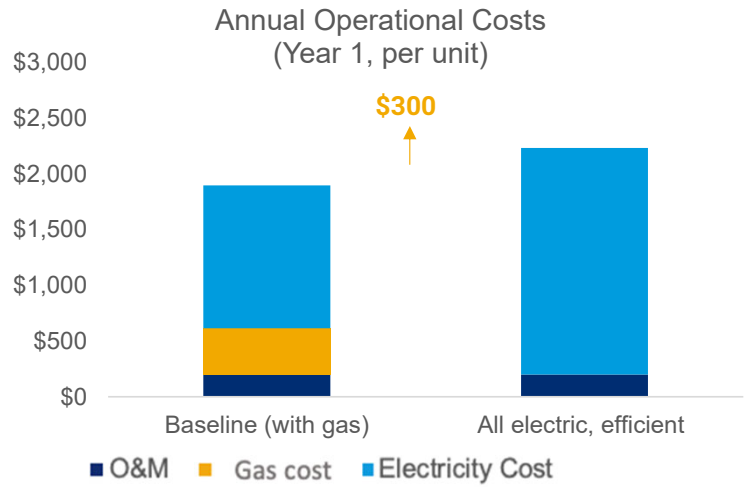
Modeled results do not include technology cost reduction, incentives, tax credits, integrated design, and cost savings due to co-benefits or grid optimization.

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Electrification of multifamily new construction is nearing cost parity with conventional gas construction, but modestly increases operating costs

7-Story, new construction, Climate Zone 4A, NYC: with upgrade to distributed ccASHP, code compliant shell, HPWH, LED lighting, smart appliances and induction range





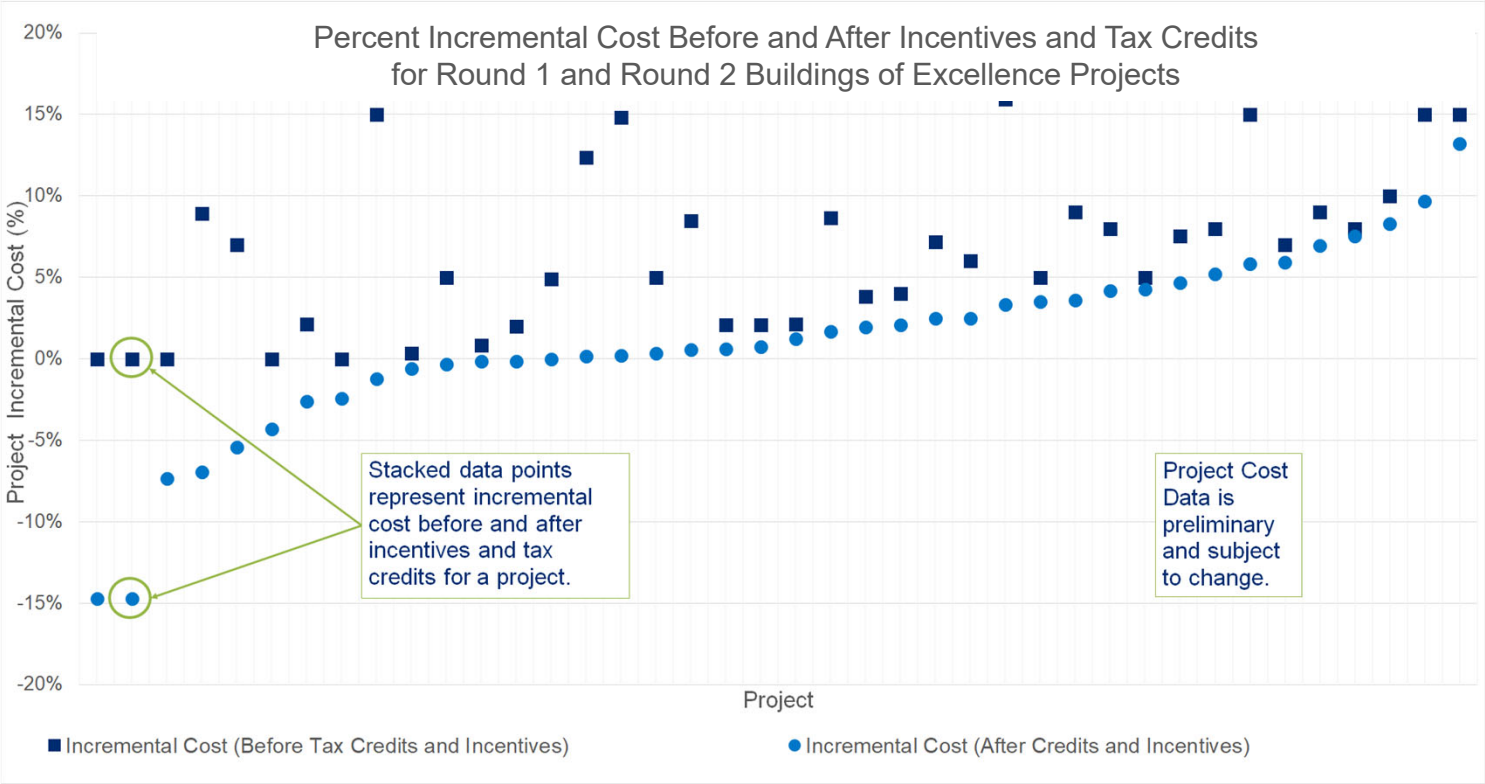
- **Fully electrified buildings provide better indoor air quality, reducing triggers for asthma and allergies**

Modeled results do not include technology cost compression, incentives, tax credits, integrated design, and cost savings due to co-benefits or grid optimization.

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Multifamily new construction and gut renovation in the real world – First cost parity in many cases and improved health, resiliency and comfort with lower operating expenses

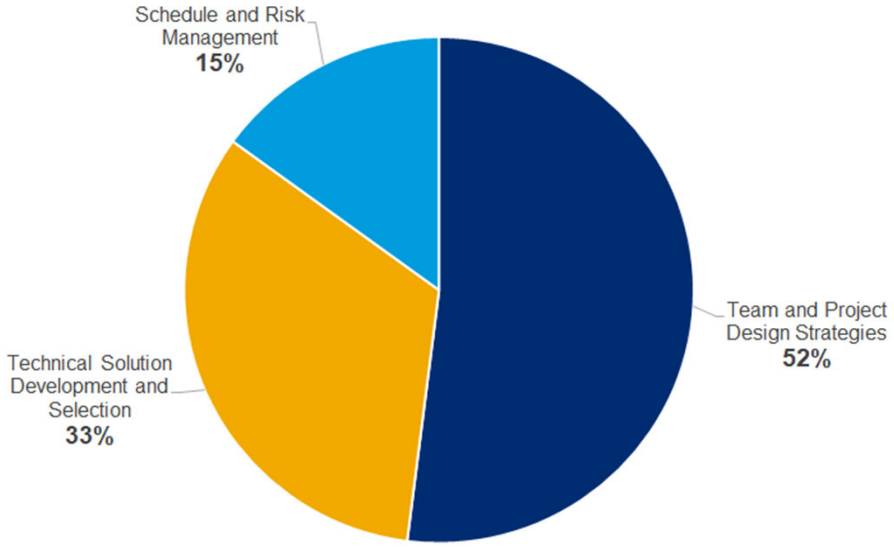
Actual projects show design and construction teams are exceeding modeled and predicted results, with first cost premium after incentives and tax credits averaging 2%.



NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Team experience and design strategies contribute to over half of demonstrated savings

Measure impact on overall project savings
(Average percent savings from Buildings of Excellence projects)



Technical Solution Development & Selection

- Detailed comparison of systems, components, and tradeoffs
- Advanced solutions aimed specifically as reduction of cost
- Utilization of manufactured solutions

Team and Project Design Strategies

- Experienced, engaged, and skilled team involved early in the project - Integrated Design
- Repeat Team – teams that have worked together across many projects
- Flexible Team and Design – teams that are willing to change and adapt
- Repeatable and adaptive design – a standard design used by teams that can be improved upon incrementally
- Simplified design – simple designs that allow for minimal variations of materials and practices that is easy for subcontractors to quote and execute

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Multifamily Buildings → Carbon Neutrality

Benefits

- Improved health for occupants due to better indoor air quality and better pest control
- Improved comfort and acoustics due to better shell
- Improved passive survivability and resilience due to better shell
- Reduced fire and/or burn risk with induction stove tops
- Significant grid benefits due to higher levels of efficiency and smaller HVAC equipment
- Improved net operating income for owners

Challenges

- Certain current HVAC configurations are more challenging to electrify (e.g., steam heat and through the wall air conditioning)
- Financial impacts of remediation during a retrofit may add additional costs
- Electrification must be coupled with efficiency to minimize cost impacts for ratepayers
- Split incentive, potential tenant disruption and the need to ensure housing affordability
- Low relative cost of gas compared to electricity

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Single Family Home
Solution Sets

- Over 2/3 of energy in single family homes is used for space and water heating
- Technologies to electrify loads are viable today
- A comfort level of shell efficiency coupled with electrification lowers operating costs when compared to oil heat
- Electrification of single-family new construction is nearing cost parity with conventional fossil fuel construction (not shown)

Example Modeled Scenarios:

	All-Electric Retrofit with Comfort Shell	All-Electric Retrofit with Code Compliant Shell	Ground Source Heat Pump with Comfort Shell
Load reduction strategies	▪ Comfort shell – air sealing and attic insulation	▪ Code compliant* walls, roof, windows and air sealing	▪ Comfort shell – air sealing and attic insulation
Building electrification technology	▪ Cold climate air-source heat pump ▪ Heat pump water heater	▪ Cold climate air source heat pump ▪ Heat pump water heater	▪ Ground source heat pump ▪ Heat pump water heater
Advanced controls	▪ Not modeled	▪ Not modeled	▪ Not modeled
Distributed energy resources	▪ Not modeled	▪ Not modeled	▪ Not modeled

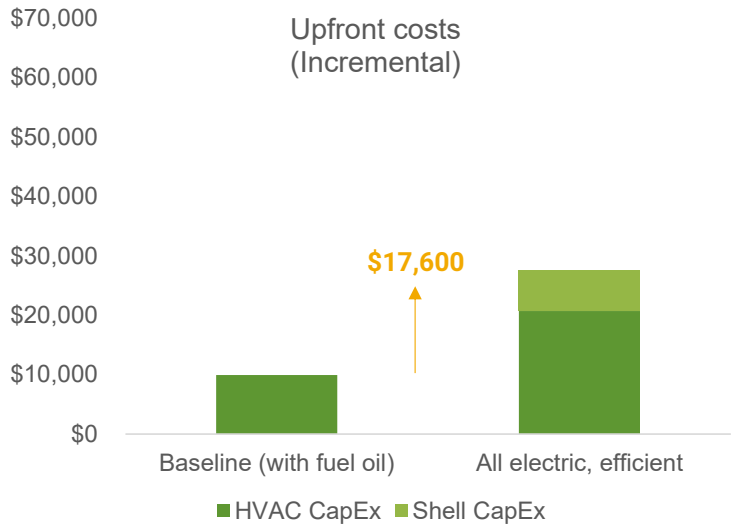
**Per current New York State Energy Conservation Construction Code for new construction*

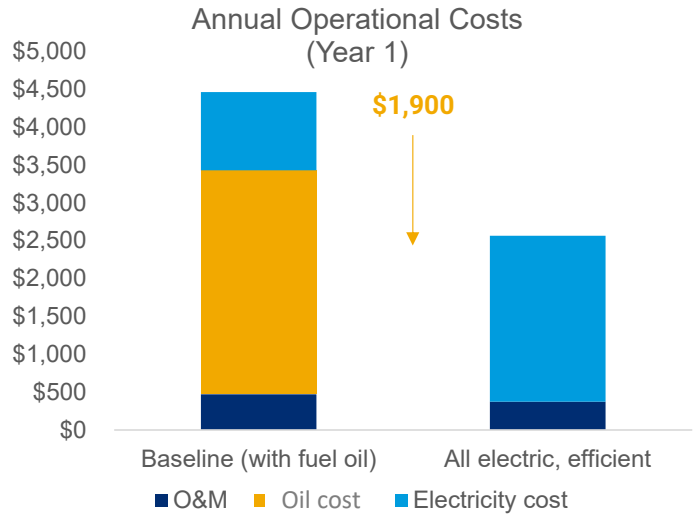
NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Chs. 8&9: The Economics, Benefits and Challenges for Building Solution Sets

Decarbonization retrofits of single-family homes with oil heat are often cost effective today even before incentives

Retrofit of pre-1980 home with ducted ccASHP plus HPWH with comfort shell upgrade in Climate Zone 6A, Upstate NY





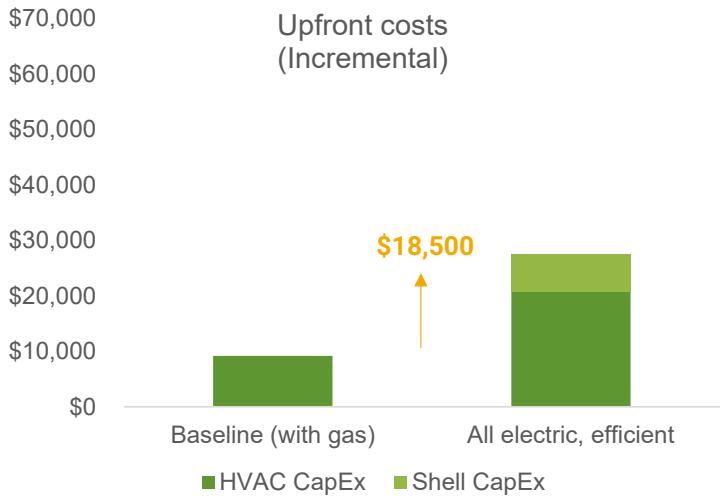
- **Comfort shell upgrades of air sealing and attic insulation reduce energy load and heat pump sizing, saving both upfront and operational costs**
- **For homes currently heated with oil, comfort shell upgrades in conjunction with electrification have a 9-year simple payback**

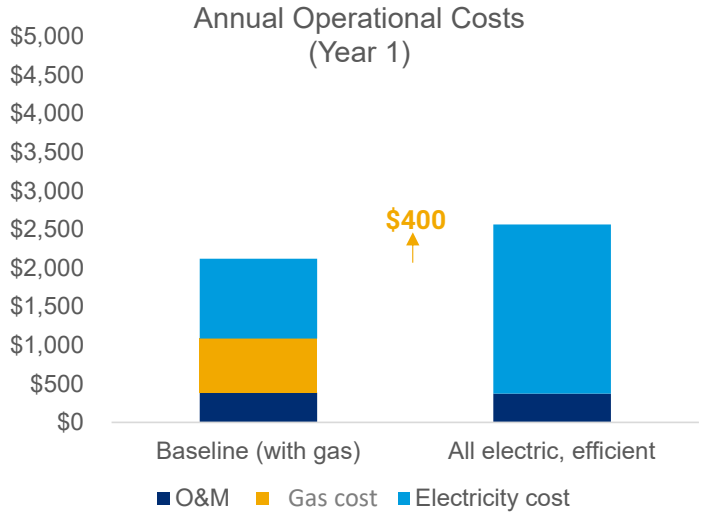
Modeled results do not include technology cost reduction, incentives, tax credits, integrated design, and cost savings due to co-benefits or grid optimization

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Decarbonization retrofits of single-family homes with gas heat may increase both upfront and operating costs, highlighting the need to reduce project installation costs and account for co-benefits

Retrofit of pre-1980 home with ducted ccASHP plus HPWH with comfort shell upgrade in Climate Zone 6A, Upstate NY





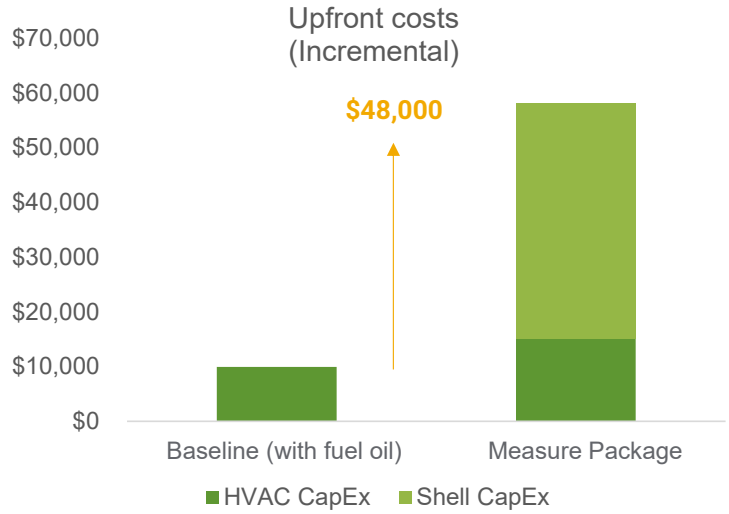
- **Electrification of the home improves indoor air quality and reduces risk of fire and burns**

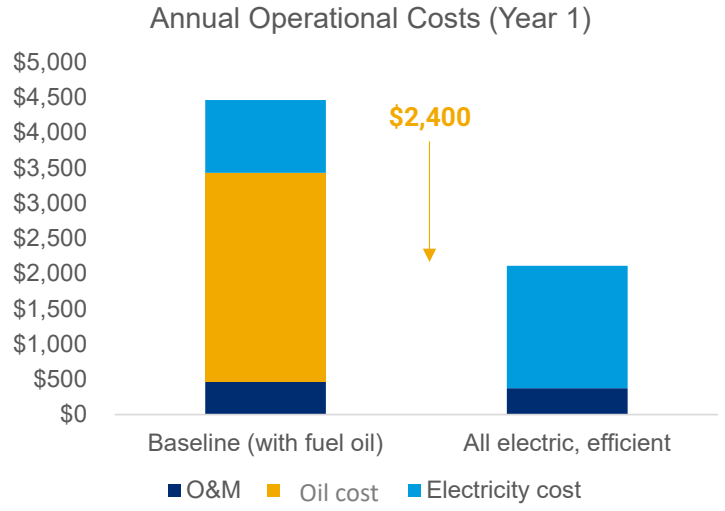
Modeled results do not include technology cost reduction, incentives, tax credits, integrated design, and cost savings due to co-benefits or grid optimization

NEW YORK STATE OF OPPORTUNITY. NYSERDA

Even with longer paybacks, home comfort and resiliency are improved by high performance building shell

Retrofit of pre-1980 home with a ducted ccASHP plus HPWH with upgrade to a code compliant shell in Climate Zone 6A, Upstate NY





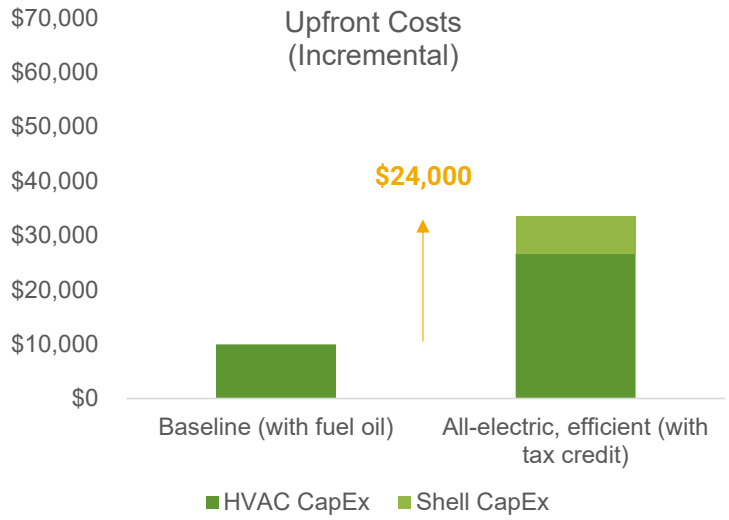
- **Coupled with electrification, code compliant shell upgrades save $500/yr more than comfort shell upgrades (if switching from fuel oil) but have a significantly longer payback**
- **Code compliant shells provide comfort benefits as well, and significantly reduce grid impacts**

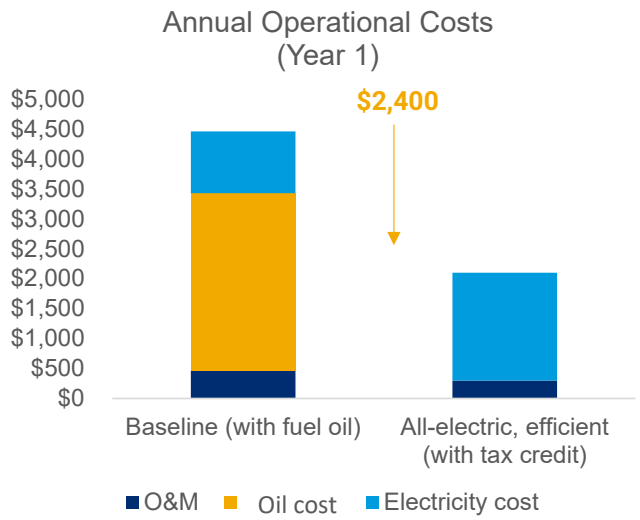
Modeled results do not include technology cost reduction, incentives, tax credits, integrated design, and cost savings due to co-benefits or grid optimization

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Ground-source heat pump retrofits after tax credits can have a comparable payback to air source heat pumps in homes with existing ducts

Retrofit of pre-1980 home with GSHP (provides space heating and cooling and hot water) with comfort shell upgrade in Climate Zone 6A, Upstate NY, with tax credit





- **Ground-source heat pump systems coupled with comfort shell upgrades show a 10-year simple payback when switching from oil heat that can use existing ducts; after federal tax credits, but not including incentives**

Modeled results do not include technology cost reduction, incentives, integrated design, and cost savings due to co-benefits or grid optimization

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Single Family Homes → Carbon Neutrality

Benefits

- Improved health for occupants due to better indoor air quality
- Improved comfort due to better shell
- Improved passive survivability due to better shell
- Reduced fire and/or burn risk due to induction stove tops
- Annual utility bill savings (for oil baseline) with shell upgrades

Challenges

- Market fragmentation due to diverse housing stock
- Huge volume of homes that need to be retrofitted (>200,000 per year)
- Contractors lack familiarity and direct experience with all-electric products and high performance building shell retrofits
- Remediation of pre-existing conditions may add additional costs
- Low relative cost of gas compared to electricity (the economics for oil to heat pump conversion are better than for a gas baseline)

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Office
Solution Sets

- The solution set applies to both owner-occupied and leased buildings
- Office buildings are generally cooling dominated; only 10-20% of the load in office buildings is space heating, and water heating loads are minimal
- Building upgrades contribute to improved health and productivity for occupants due to better indoor air quality

Example Modeled Scenarios:

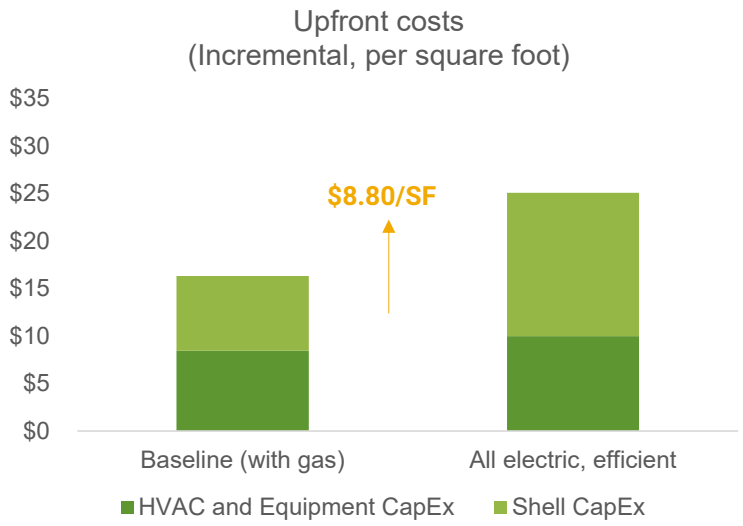
	All-Electric Retrofit with Code Compliant Shell	Passive House Inspired Retrofit
Load reduction strategies	▪ Code compliant walls, roof* ▪ Double-pane windows ▪ LED lighting ▪ Smart appliances ▪ Low-flow water fixtures	▪ Passive House levels of walls/roof ▪ Triple-pane windows ▪ LED lighting ▪ Smart appliances ▪ Low-flow water fixtures ▪ Heat recovery
Building electrification technology	▪ Cold climate air source heat pumps ▪ Heat pump water heaters with storage tanks	▪ Cold climate air source heat pumps ▪ Heat pump water heaters with storage tanks
Advanced controls	▪ Not modeled	▪ Load flexibility and advanced controls of hot water, space conditioning systems, and smart appliances
Distributed energy resources	▪ Not modeled	▪ Not modeled

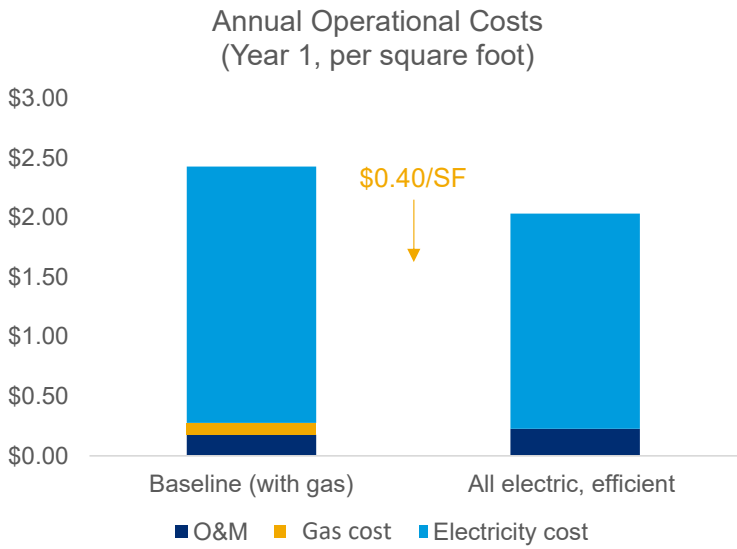
**Per current New York State Energy Conservation Construction Code for new construction*

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Shell upgrades, though costly up front, provide modest operational cost savings

Retrofit of pre-1980, 500,000 SF, 12-Story Office Building in Climate Zone 4A, Downstate NY, with an all-electric ccASHP system, HPWH, a code compliant shell, LED lighting, and smart appliances



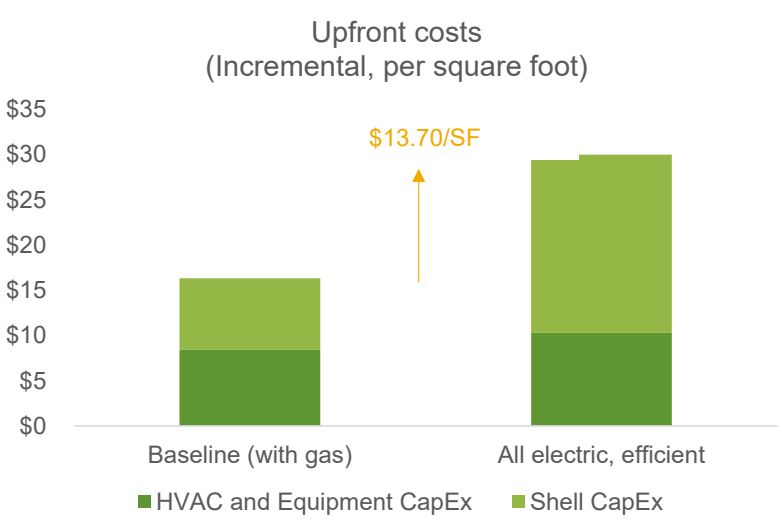


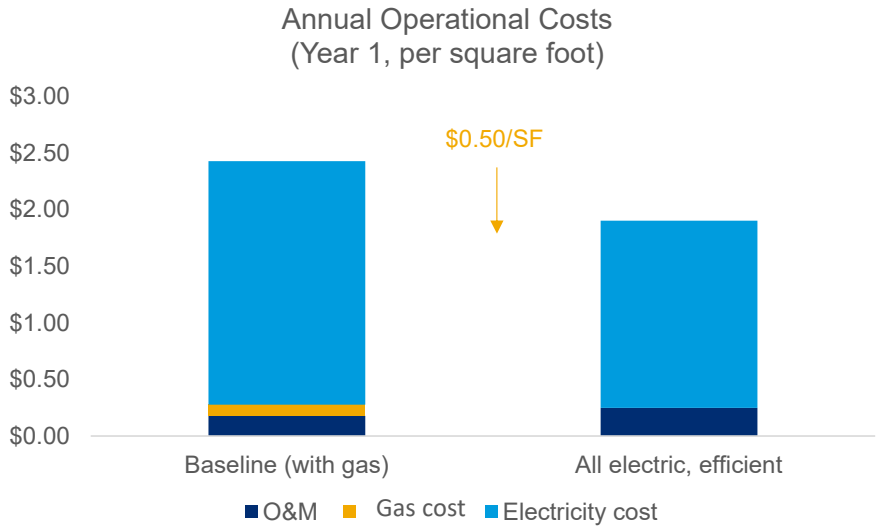
- **Because gas use is usually a smaller share of operational costs for offices, the cost savings due to electrification are smaller relative to residential**

Modeled results do not include technology cost reduction, incentives, tax credits, integrated design, and cost savings due to co-benefits or grid optimization

A Passive House shell is not yet financially attractive in an office retrofit scenario; However, it may be desired for productivity, health, comfort, and resilience benefits

Retrofit of pre-1980, 500,000 SF, 12-Story Office Building in Climate Zone 4A, Downstate NY, with an all-electric ccASHP system, HPWH and a Passive House-inspired shell, with heat recovery, advanced controls, LED lighting and smart appliances





- **The upfront cost of the shell (windows in particular) is not made up by energy savings; Office buildings often have high window-to-wall ratios, which results in more glazing area to replace**
- **Office buildings are internal-load driven, so less influenced by a high-performance envelope**

Modeled results do not include technology cost reduction, incentives, tax credits, integrated design, and cost savings due to co-benefits or grid optimization

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Office Buildings → Carbon Neutrality

Benefits

- Improved health and productivity for occupants due to better indoor air quality
- Improved comfort, particularly in perimeter offices, due to better shell
- Improved net operating income
- Improved passive survivability due to better shell
- Annual utility bill savings

Challenges

- Project complexity and lack of streamlined capital improvement planning
- Access to capital
- Split incentive, tenant disruption and intervention points that are dependent on tenant turnover and/or lease structures
- Remediation of existing conditions may add additional costs
- Low relative cost of gas compared to electricity (the economics for oil-to-heat pump conversion are better than for a gas baseline)

Higher Education
Solution Sets

- Many college and university campuses in New York State use central plants for steam, chilled water and electricity
- There is an opportunity to maximize investment impacts by making coordinated upgrades to campus portfolios
- A critical feature to consider is campus-wide ability to manage loads and mitigate peaks

Example Modeled Scenarios:

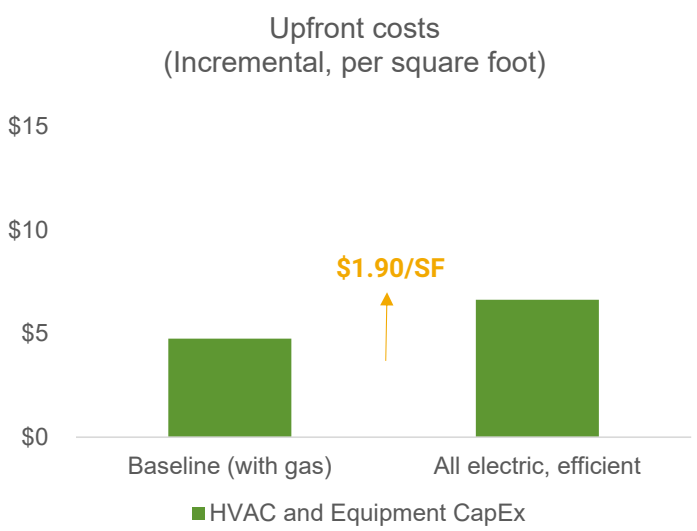
	All-Electric New Construction with Code Compliant Shell	Passive House-Inspired New Construction
Load reduction strategies	▪ Code compliant walls, roof* ▪ Double-pane windows ▪ LED lighting ▪ Smart appliances ▪ Low-flow water fixtures ▪ Heat recovery	▪ Passive House levels of walls, roof ▪ Triple-pane windows ▪ LED lighting ▪ Smart appliances ▪ Low-flow water fixtures ▪ Improved heat recovery
Building electrification technology	▪ Cold climate air-source heat pumps ▪ Heat pump water heaters with storage tanks	▪ Cold climate air-source heat pumps ▪ Heat pump water heaters with storage tanks
Advanced controls	▪ Not modeled	▪ Load flexibility and advanced controls of hot water, space conditioning systems, and smart appliances
Distributed energy resources	▪ Not modeled	▪ Not modeled

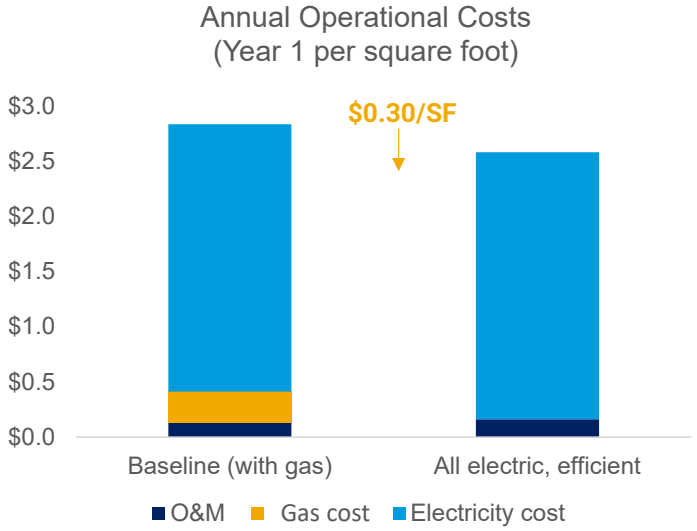
**Per current New York State Energy Conservation Construction Code for new construction*

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

All-electric new construction has minimal incremental upfront costs and less than a 7-year payback

12 Story, 500,000 SF Classroom Building, New Construction with an all-electric central air source heat pump system, HPWH, heat recovery, LED lighting and smart appliances, in Climate Zone 6A, Upstate NY



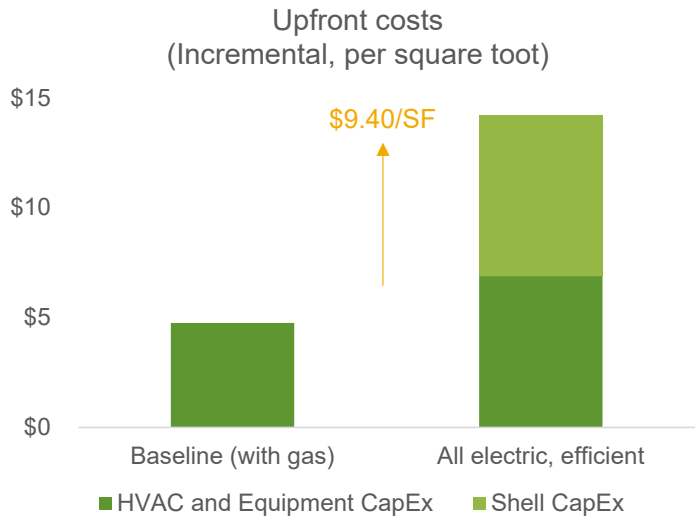


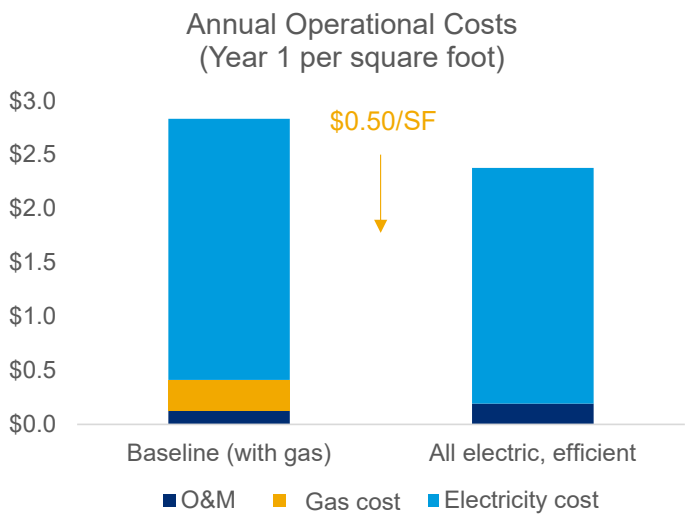
- **The upfront cost premium is less than 1% of total construction costs for the building**

Modeled results do not include technology cost reduction, incentives, tax credits, integrated design, and cost savings due to co-benefits or grid optimization

For Passive House-inspired new construction, the upfront premium is less than 2% of total construction costs before incentives and tax credits

12-Story, 500,000 SF Classroom Building, New Construction with an all-electric central ASHP, HPWH, Passive House-inspired shell, advanced controls, improved heat recovery, LED lighting and smart appliances in Climate Zone 6A, Upstate NY





- **Passive House-inspired new construction results in a longer payback but is still much shorter than the average higher education building lifespan and will provide superior health, productivity, comfort and resiliency**

Modeled results do not include technology cost reduction, incentives, tax credits, integrated design, and cost savings due to co-benefits or grid optimization

Higher Education Buildings → Carbon Neutrality

Benefits

- Improved health and productivity for occupants due to better indoor air quality
- Educational value to students
- Improved comfort due to better shell
- Improved passive survivability due to better shell
- Annual utility bill savings

Challenges

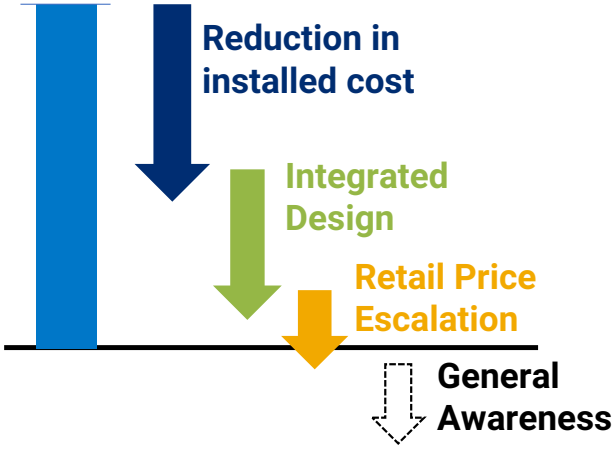
- Project complexity and lack of streamlined capital improvement planning
- Access to capital
- Retrofitting campus central energy plants is costly and creates technical challenges to reuse distribution system
- Occupant disruption and intervention points that are dependent on academic calendars
- Remediation of pre-existing conditions may add additional costs
- Low relative cost of gas compared to electricity (the economics for oil to heat pump conversion are better than for a gas baseline)

The economics and value will improve due to:

- Reduced technology and installed cost premiums through hard and soft cost reduction
- Improved quantification and understanding of non-energy benefits
- Reduced upfront costs through integrated design (particularly in new construction and gut rehab)
- Increased cost savings, as retail energy prices escalate
- Increased general awareness about technology performance will reduce risk and increase demand

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Reducing New Construction Net Present Cost Premium



Chs. 8&9: The Economics, Benefits and Challenges for Building Solution Sets

Additional opportunities to enhance value proposition

1

Financing options and emerging business models

2

Quantifying and monetizing the co-benefits and societal cost of carbon

3

Minimizing liability and future proofing buildings

4

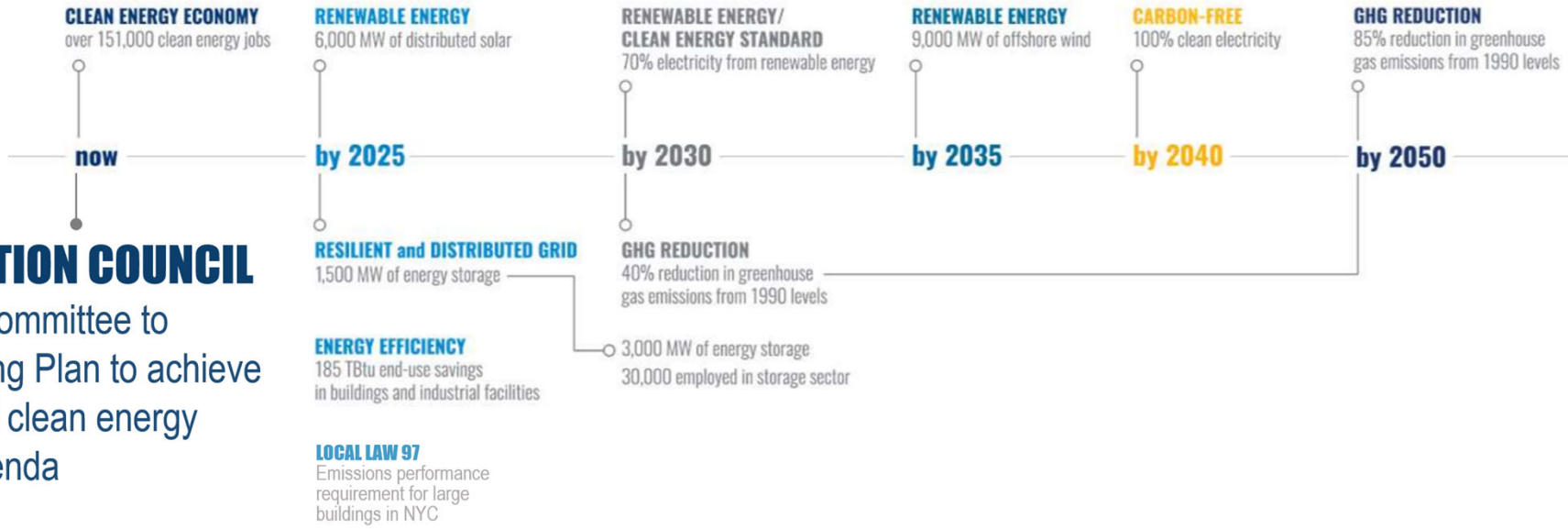
Leveraging the grid benefits of carbon neutral buildings

Chapter 10:
Policy Options

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

A legacy of policies that got us here

Climate Leadership and Community Protection Act (Climate Act) requires 35% with a goal of 40% of the benefits from clean energy investment to flow to disadvantaged communities



CLIMATE ACTION COUNCIL

A 22-member committee to deliver a Scoping Plan to achieve the State's bold clean energy and climate agenda

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

The scale of the solution demands new resources

- Eliminating GHG emissions from New York's building stock by 2050 will require broad, systemic changes
- An equitable transformation at this scale requires new resources

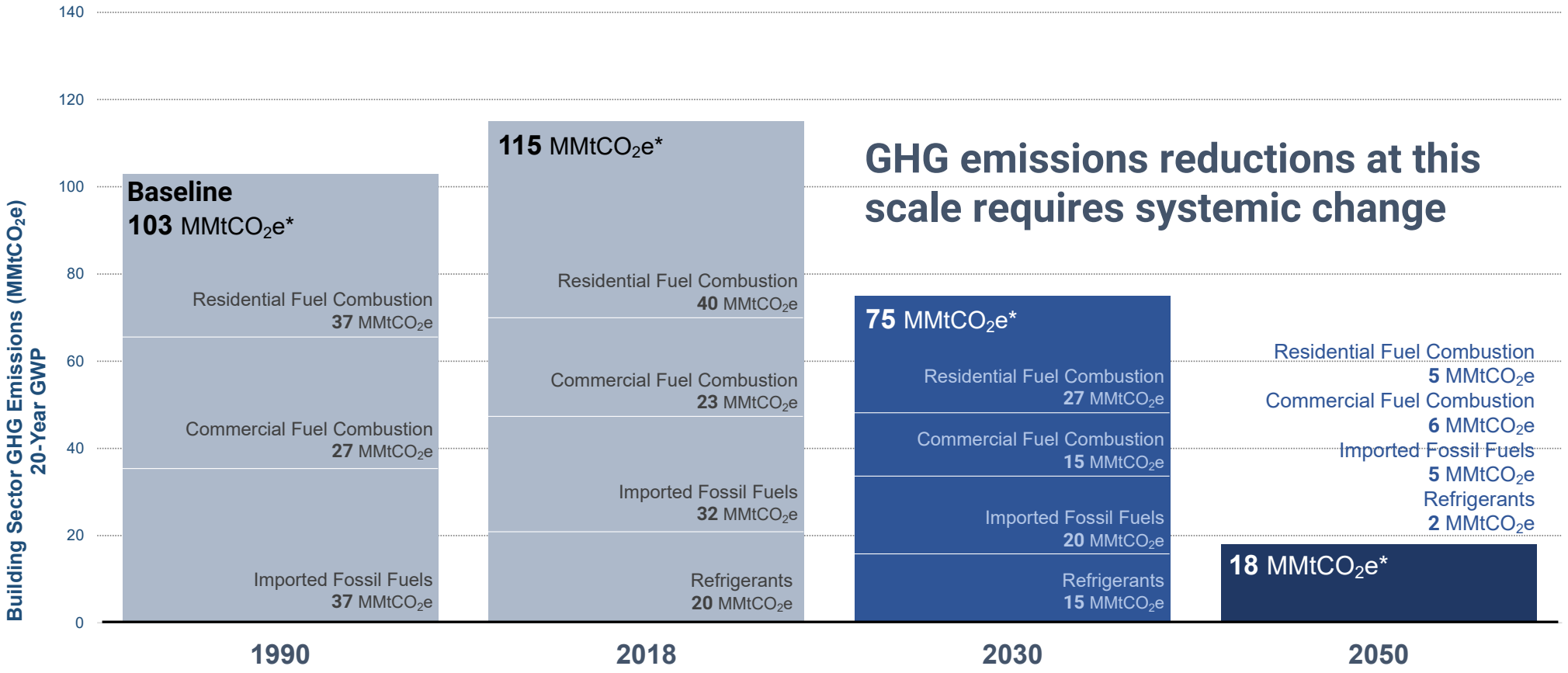
NEW YORK STATE OF OPPORTUNITY. | NYSERDA

And targeted, ambitious policy solutions

Mitigation strategies and enabling initiatives to achieve 2050 goal:

- Regulations and codes to phase out fossil fuel use in buildings
- Incentives, financing and other market development investments to facilitate the transition from fossil fuels

Potential GHG Emissions Impact of Policies



GHG emissions reductions at this scale requires systemic change

* million metric tons carbon dioxide equivalent

Draft values subject to public review process for annual emissions accounting

Advanced Codes for new construction built to a resilient and highly efficient, zero emission standard

- **ASAP:** Adopt highly efficient State Energy Code for all new construction in next code cycle

  Scale up building decarbonization requirements in affordable housing and state supported economic development projects

- **2023:** State building code requires solar PV, electrification-readiness, grid-interactive capability, battery readiness, and electric vehicle readiness

- **2025:** Adopt all-electric (and highly efficient) State code for homes and low-rise residential

- **2030:** Adopt all-electric (and highly efficient) State code for multifamily and commercial

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Prohibit replacement of fossil-fuel heating and hot water equipment; phased out at the end-of-useful life

- **2030:** Zero emission standards prohibiting gas/oil replacements of heating, cooling and domestic hot water equipment in homes
- **2035:** Zero emission standards prohibiting gas/oil replacements of heating, cooling and domestic hot water equipment in multifamily and commercial buildings

  Zero emission standards prohibiting replacement of gas cooking and dryers in residential buildings

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Benchmarking and disclosure of energy performance

- **2023:** Statewide benchmarking and disclosure of energy use, emissions, and water use for buildings larger than 10,000 sf
- **2025:** Public disclosure, as part of sale or lease listing, of the energy consumption or energy rating for large buildings

  Energy/emissions audits required for buildings larger than 25,000 sf
- **2027:** Energy performance grades required for homes at point-of-sale

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Performance requirements for existing buildings to improve energy efficiency

- Consider building performance requirements at point-of-sale or -lease for all buildings

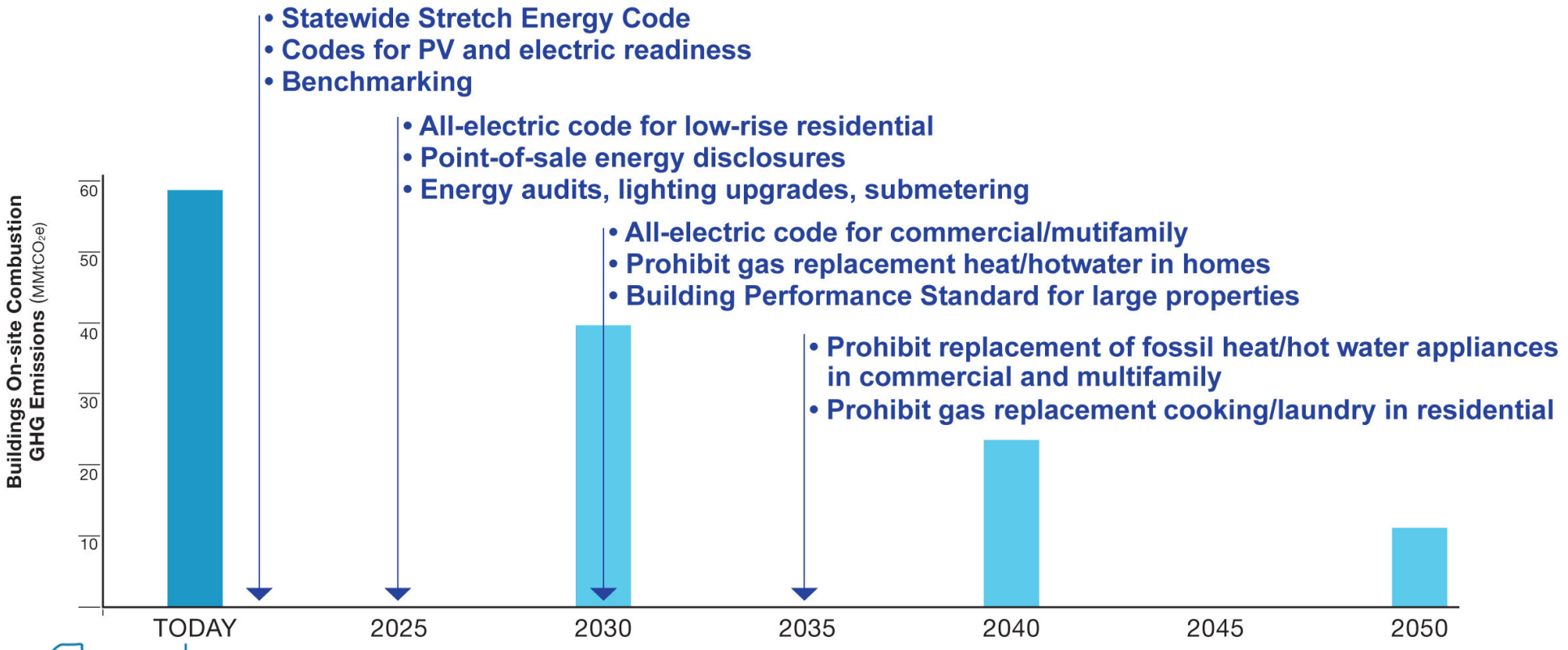
ASAP: Adopt energy efficiency standard for appliances outside Federal preemption

2025: Required lighting upgrades to current Energy Code standards and submetering of tenants in large commercial buildings

2030: Building performance standards for existing large buildings regulating energy efficiency

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Regulations with dates certain send clear market signals



NEW YORK STATE OF OPPORTUNITY. | NYSERDA

A managed, phased, and just transition from reliance on fossil gas and the gas distribution system to a clean energy system

- A planning study to manage a just transition to clean energy, preserving safety, equitable access, reliability, and affordability of service
- Utility proposals to meet emissions reduction goals and alternative models for gas utilities in the long-term
- An equitable transition plan for the gas industry workforce
- A comprehensive equity strategy to incorporate the needs of low-income households and disadvantaged communities

A managed, phased, and just transition to a clean energy system

- Stop utilities advertising fossil gas as “clean”
- Level the playing field for adoption of clean heating solutions by eliminating the “100-foot rule”
- Phase-out incentives and rebates for fossil gas equipment offered by utilities and NYSERDA
- Analysis, planning, and information sharing for electric grid-readiness for electrification of buildings
- Undertake analysis and planning for decarbonization of ConEd district steam system

Transition from hydrofluorocarbons (HFCs) used as refrigerants and in all products used in construction

- Update NYS codes to allow low-GWP refrigerants and to improve leak detection and control
- RD&D investment to increase availability and efficacy of ultra-low GWP refrigerants
- Require reclamation or destruction of refrigerants from appliances at end-of-life
- Workforce training, education, and demonstration projects for low-GWP refrigerants and technologies
- NYS Significant New Alternatives Policy (SNAP) Rule over certain HFCs in refrigerator/freezers, chillers, commercial refrigeration, and aerosols/foams/solvents

- Expand incentives for efficiency, electrification, and grid integration with focus on low-income housing and disadvantaged communities
- Direct cash incentives for electrical service upgrades
- Appropriately size and better target incentives to accelerate efficiency, electrification, renewables, and resilience retrofits
- Create a “Retrofit and Electrification Readiness Fund” for low-income consumers to cover non-energy costs related to an efficiency retrofit

Incentives that speed uptake, transforming the market for building energy efficiency, electrification, and decarbonization

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Low-cost financing for efficiency, electrification, solar, grid integration, and related improvements

- Underwriting to energy performance standards and emissions regulations
- Expand access to low-cost financing for disadvantaged communities and low-income households
- Create a revolving loan fund for building decarbonization
- Expanded performance contracting for State-funded buildings

Erie Basin Marina, Buffalo, NY

Develop a workforce to deliver low-carbon buildings, increase clean energy job placement in disadvantaged communities, and advance industry diversity

- Scale up training for incumbent and new clean energy workers and adjacent industries
- Prioritize disadvantaged communities and low-income residents
- Increase participation of minority and women-owned business enterprises and service-disabled veteran owned businesses
- Require decarbonization curricula in state education for middle/HS and higher education, and in continuing education for licensed professionals

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Partnerships with trusted community leaders on public outreach to increase market demand for energy efficient, all-electric buildings

- Prioritize disadvantaged communities
- Scale up multilingual public and consumer education efforts
- Provide technical assistance, resource toolkits, and best practices
- “One-stop-shop” website for building decarbonization programs
- Develop educational curricula for K-12 and higher education

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

RD&D and business development for more companies and manufacturers to innovate

- Fund RD&D for building envelope, grid interactivity, resiliency, next-generation HVAC, and other strategic solutions
- Fund pilots and demonstrations to inform rulemaking and ratemaking
- Advocate for, and leverage, Federal and National Laboratory resources and RD&D investment

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

New York City, NY

State leads by example to create literacy in embodied carbon of building materials

- Identify incentives and building codes to encourage building reuse
- Lower-carbon specifications for state-funded projects, setting embodied carbon reduction targets
- Leads to codified specifications (based on Environmental Product Declarations) for low-embodied carbon materials
- Assistance to expand in-state manufacturing of products lower in embodied carbon
- Support RD&D, demonstration projects, and technology transfer/commercialization

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Erastus Corning Tower, Albany, NY

Economy-wide solutions to bring systemic change

- Identify and remove regulatory barriers
- PSC rate design and utility regulations for gas, electricity, and load flexibility
- Advocate for Federal resources and policy support
- Enhance building-level resilience and electric grid reliability and resilience
- Viable solutions for hard-to-electrify buildings, including some use of low-carbon fuels

Flatiron Building, New York City, NY

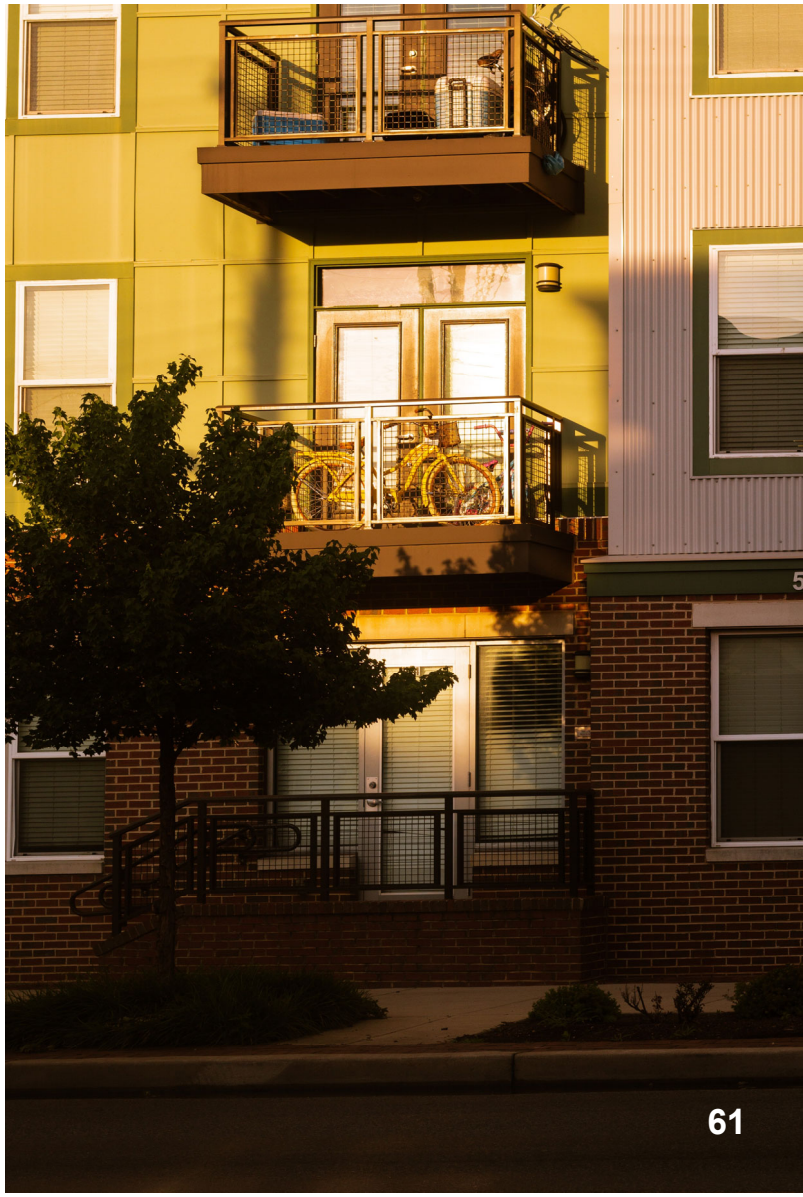
Impacts on commercial buildings

- Advanced codes and a Building Performance Standard would drive improvements to the State's building stock, with an early focus on the most underperforming buildings
- Appliance and building upgrades can increase asset value and provide operational cost savings
- Low-cost financing and emerging business models are needed to support a strong business case

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Impacts on residential buildings

- All-electric, energy-efficient, grid-integrated upgrades as required through a Building Performance Standard will save energy expenses, increase asset value, and reduce air pollutants resulting in significant health benefits
- Any policy requiring retrofits in low-income households and disadvantaged communities must also mitigate costs and threats to affordability



NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Achieving carbon neutral buildings statewide requires New York State policy intervention to send clear market signals, public subsidies for low-income households and disadvantaged communities, and business development assistance to reduce costs and advance technologies

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Chapter 11:
Disadvantaged Communities and Low-Income Households

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Ensuring equitable access to benefits

Climate Act requires 35% with a goal of **40% of all benefits from clean energy investment** to flow to disadvantaged communities.

48% of New York's households are LMI

- Households with annual incomes at or below 80% of the Area Median Income
- Climate change heightens the vulnerabilities of low-income neighborhoods and communities of color
- Lower-income households have a higher energy burden

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Source: NYSERDA Low-to-Moderate Income Market Characterization Report, 2/2017

Ensuring an equitable transition

- Strategies to **achieve an equitable transition** must be calibrated to the primary building types in disadvantaged communities with flexible solutions that evolve over time.
- Many low-income households are **renters in older vintage homes** that have a higher likelihood to need remediation of issues such as:
  - Electrical panel upgrades
  - Mold and moisture
  - Lead paint
  - Structural deficiencies

Four-part approach to support disadvantaged communities

Electrification while preserving affordability

Efforts to decarbonize buildings in low-income housing and disadvantaged communities must prioritize efficiency and be designed so to not increase residents' economic burdens

Address diverse low-income housing types

Address specific barriers by housing type with matching regulatory, policy, and financial remedies that recognize “one size does not fit all”

Community-led strategic initiatives

Empower impacted communities to take part in the decision-making process so that decarbonization of these communities is done together and works for the residents

Holistic approaches to low-income and disadvantaged communities

Will support equitable transition and bring benefits to all New Yorkers that include health and safety improvements, job creation, and reduced energy burden

Scaling the market for an equitable transition

- Remove barriers as part of early-stage market development
- Develop pilot programs and demonstrate a market to electrify low-income housing
- Facilitate private capital investment in highly efficient, all-electric affordable housing
- Public investments and incentives in building efficiency and electrification in public housing and disadvantaged communities
- Ensure households heating with gas are not left paying for stranded assets from the gas transition

Economic benefits to disadvantaged communities

Reduced energy cost burden through investment in home upgrades and bill assistance

Improved housing that provides better comfort and value

Clean energy workforce and entrepreneurial opportunities

Increased investment (and wealth creation/ asset building) in disadvantaged, underinvested communities

Additional benefits to disadvantaged communities

Improved health and safety outcomes with better indoor and outdoor air quality, and new cooling capacity (in units with no A/C)

Improved mental health, productivity, and cognitive outcomes with improved thermal comfort, lower noise levels and reduced energy burden

Better resilience for vulnerable populations with passive and active building strategies

Engagement of disadvantaged communities to self-determine how they will participate so that programs create local benefits and local jobs

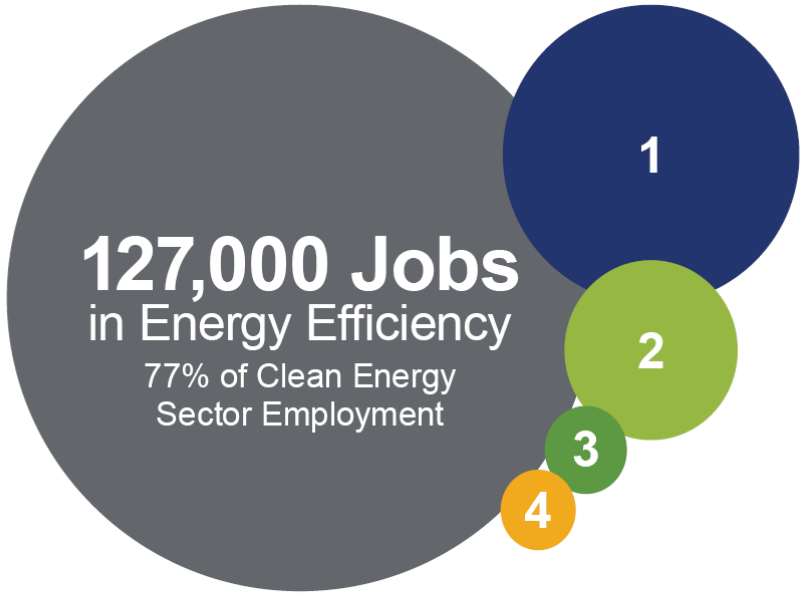
Chapter 12:
Workforce Development and Just Transition

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Decarbonizing New York's building stock will deliver significant job growth and economic opportunity in every region of the State

- New York's energy efficiency industry employs the largest share of clean energy workers
- 77% of clean energy sector employment and 88% of industry establishments are in energy efficiency
- Over half the sector's employment are installers of high-efficiency HVAC equipment and heat pumps

New York Clean Energy Industry Report, 2019 data



1	2	3	4
24,000 Jobs	8,600 Jobs	2,600 Jobs	2,200 Jobs
in Renewable Electrical Power Generation	in Clean and Alternative Transportation	in Renewable Fuels	in Grid Modernization and Energy Storage

Ch. 12 Workforce Development and Just Transition

A blueprint for transitioning to a stronger, greener workforce

Invest in education and training

Training new and existing clean energy workers so they are prepared to manage and adapt to technological changes over the next 5, 10 and 20 years to ensure long-term success

Build trust with the market

Ensure quality service and installations for consumers and businesses with high standards and quality control delivered by providers and trainers

Ongoing stakeholder engagement

Facilitate communication to identify demand and ensure training investments are driven by employer and market needs.

Clean energy industries are poised for significant growth

Build career interest

Expand awareness through local outreach and seed interest early. Focus on creating more opportunities for youth, women, and people of color

Empower communities

Utilize resources provided through New York's Clean Energy Hubs and coordinate public and private partners' efforts on current workforce development programs

Invest in innovation

Investment in innovation and anchoring an in-state supply chain of growing businesses and manufacturing will achieve climate goals while also attracting new investments and jobs

Approaches for workforce development

- Identify workforce gaps to increase industry capacity and focus on skilled labor and accessibility to training
- Develop contractor partnerships to connect design teams with trained labor
- Raise consumer awareness and demand
- Financial resources should target labor and wage discrepancies
- Elevate disadvantaged communities, minority and women-owned business enterprises, NY-based companies, cooperatives, B corps, and service-disabled veteran-owned businesses
- Give attention to transitional industries

Top reasons for hiring difficulty among heat pump employers

(for key occupations)

	Technical skills	Relevant work experience
Licensed HVAC installer	76%	70%
HVAC supervisor	67%	77%
Plumber	88%	88%
Plumbing supervisor	83%	92%
Electrician	88%	100%
Owner/senior management	76%	76%
Construction/ installation helper or apprentice	76%	85%

Source: New York Clean Energy Industry Report, 2019

Addressing transitional industries

Prioritize those working in industries such as fossil fuel where jobs will be impacted

Additional training or retraining for workers affected by the clean energy transition

Ensure jobs are available for transition industry professionals

Give attention to current industries' wage, labor and hiring practices

Provide **access to additional services** for those who need new career training and familial support during transition

Scaling workforce development efforts by collaboration

- Community-based outreach and engagement through NYSERDA's Clean Energy Hubs
- Leverage existing relationships in supply chain
- Collaborate with local governments and other State agencies including those focused on affordable housing
- Foster relationships with utilities and NYISO
- Adapt middle/high school and higher education clean energy curricula to integrate with market and industry needs
- Partnerships with labor unions and trade associations

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Chapter 13:
Stakeholder Engagement

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Technical advisory group

18 advisors representing diverse technical and market perspectives met for three workshop-style working sessions to form recommendations for critical aspects of the Roadmap

Engineering, Design, & Innovation
Pasquale Strocchia, Integral Building and Design, Inc.
Jeff Perlman, Bright Power, Inc.
Scott Frank, Jaros, Baum, & Bolles
Marc Zuluaga, Steven Winter Associates, Inc.

Research & Federal Government
Lieko Earle, National Renewable Energy Labs (NREL)

Higher Education
Nina Sharifi, Syracuse University
Cecil Scheib, P.E., New York University (NYU)
Karren Bee-Donohoe, SUNY System Administration

Local Government
Ross MacWhinney & Lindsey Hirsch, New York City Mayor's Office of Climate and Sustainability

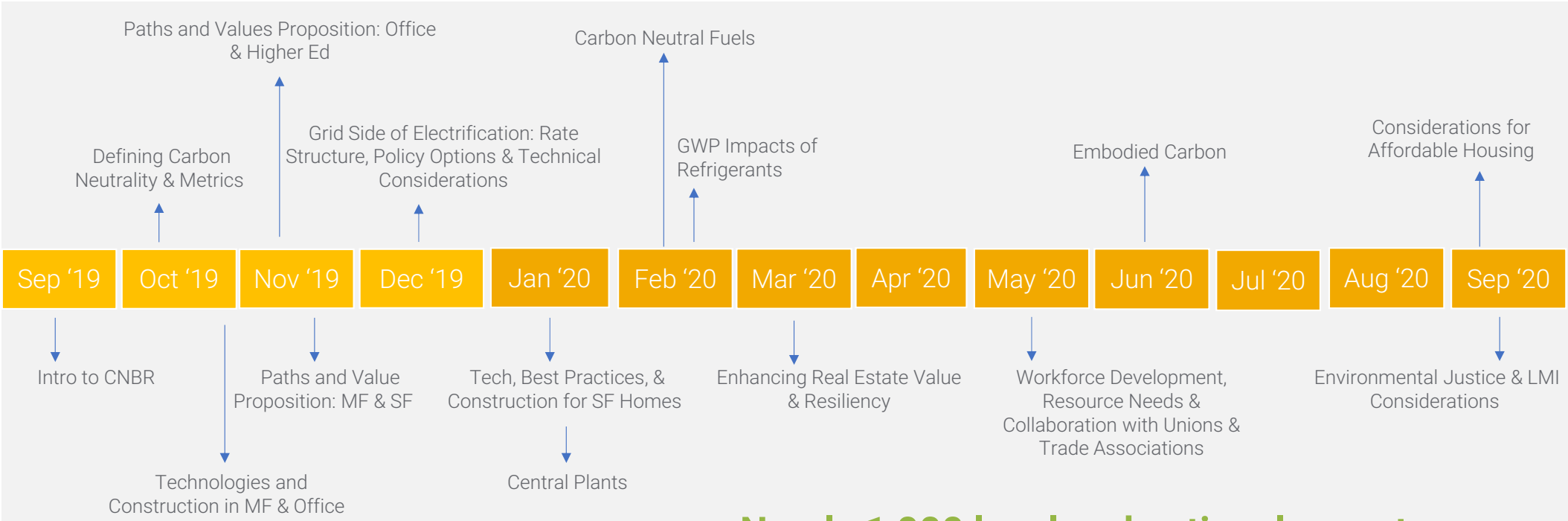
Community, Financing, & Affordability
Sadie McKeown, Community Preservation Corporation
Lauren Westmoreland, Enterprise Community Partners, Inc.

Housing & Real Estate
Zachary Steinberg, Real Estate Board of New York
Linda Wigington, Thousand Home Challenge
Christoph Stump, Trinity Financial, Inc.

Energy and Carbon Advocacy
Panama Bartholomy, Building Decarbonization Coalition
Donna Decostanzo, Natural Resources Defense Council
Adam Hinge, Sustainable Energy Partnerships

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

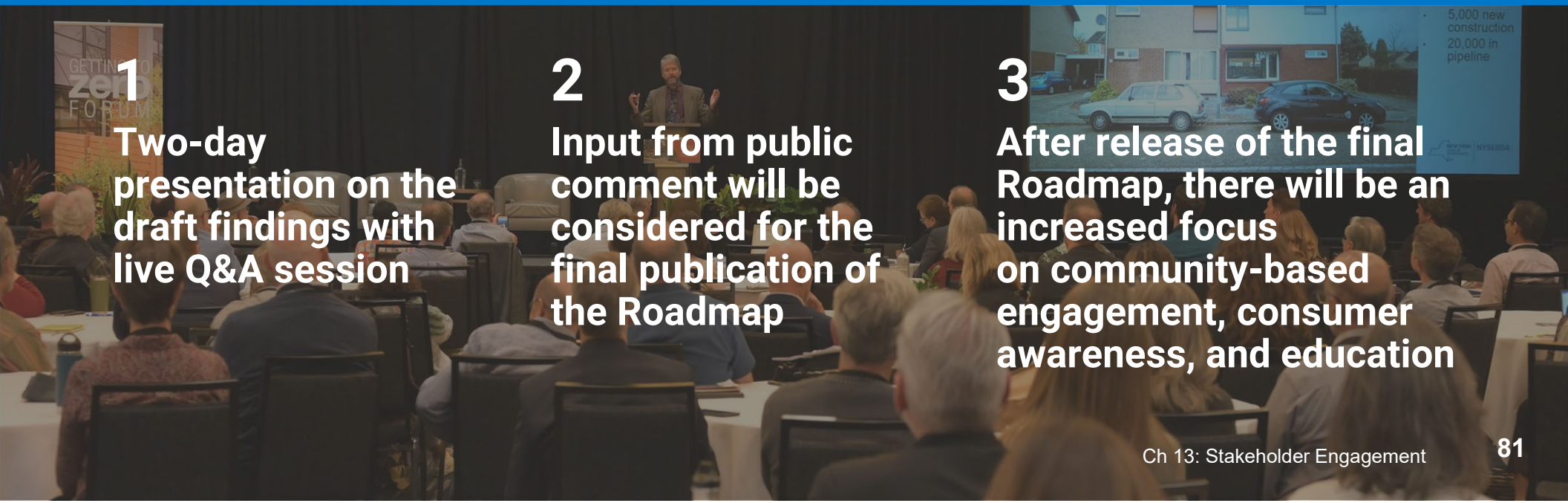
Engaging stakeholders through numerous information-gathering roundtables



Nearly 1,000 local and national experts participated in these meetings

Public input and statewide awareness building

These two days, we've introduced you to the Roadmap and are calling for feedback from the public on these preliminary findings



1
Two-day presentation on the draft findings with live Q&A session

2
Input from public comment will be considered for the final publication of the Roadmap

3
After release of the final Roadmap, there will be an increased focus on community-based engagement, consumer awareness, and education

Work with us to realize New York's vision

The Roadmap lays out a plan to decarbonize New York's buildings by 2050 and every New Yorker has a role to play in making that happen.

We want to hear from you and how this plan can work in and for your community.

Learn more and submit comments at:
nyserda.ny.gov/Carbon-Neutral-Buildings

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Chapter 14: Conclusion to the Carbon Neutral Buildings Roadmap

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

New York State's no regrets climate commitment

Implementation of the Climate Act must drive forward policies and solution sets that focus on building decarbonization, prioritizing cost reduction strategies and equitable benefits for all New Yorkers

New construction is easier to manage cost, but market-ready technology applications and design strategies are available for both new and existing buildings

Additional outcomes of building decarbonization

Co-benefits of better health, improved comfort, productivity and resiliency in homes, workplaces, schools and other building types

Equitable opportunities will be provided for disadvantaged communities with enhanced outreach to support delivery

Economic growth for manufacturers providing equipment, infrastructure investment in communities and neighborhoods as well as training and skill development for New York's workforce

Managing the cost

- Distributed energy resources and controls that enable flexibility and grid interactivity are often already cost effective
- Electrification is already cost effective in new construction and is on a trajectory to become cost effective with policy support in retrofits
- Envelope efficiency strategies are largely cost effective in new construction but will require technology advancement and policy support to be more economical in retrofits

Economically Viable Projects Exist Today

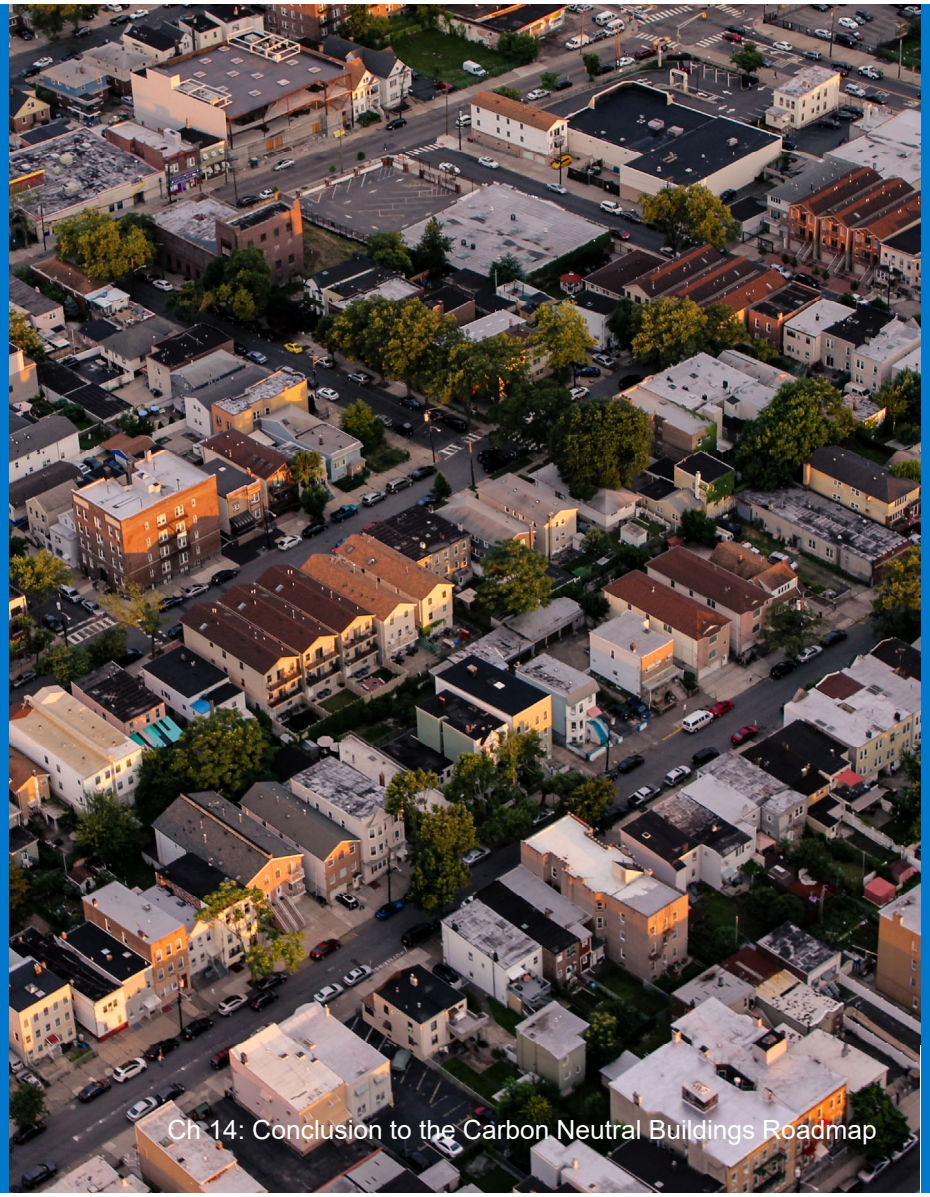
- Homes with oil heat, and particularly those with ducted distribution systems
- New construction using integrated design and avoiding gas infrastructure needs
- Commercial buildings with heat recovery and advanced controls
- Home and building owners who have greater health or resiliency needs

Technology-ready and viable RD&D

- Cost reduction strategies will help bring down the upfront cost of technologies
- Some technologies are currently commercially available but need ongoing development to improve performance and lower operation cost
- Focus on technologies that allow for retrofits without occupant displacement
- Refrigerants and embodied carbon are critical areas of focus in addition to the operational carbon of buildings

Strong policies are crucial to meeting New York's climate goals

- Policies that enable carbon neutrality also benefit New Yorkers by creating energy savings, resilience, and health benefits
- Extending and expanding existing policies is essential to enable cost reduction and economies of scale, especially in existing buildings
- Decarbonization policies can catalyze workforce development programs and create good-paying jobs for New Yorkers



Buffalo, NY

Prioritizing disadvantaged communities and creating jobs

- Goal of 40% benefits from clean energy investment to go to disadvantaged communities
- Investments will be made in the areas of housing, solar and other distributed energy resources, pollution reduction, low-income energy assistance, power generation, transportation, and economic development
- Workforce development is a driver of cost reduction across technologies and will stimulate job growth
- Equitable access and implementation of these technologies and workforce development options are a priority

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Making demand flexibility inherent

- Reduces and manages peak demand, thereby saving system cost, lowering peaker plant operation, and improving health
- Helps reduce the grid impacts of electrification
- Supports grid decarbonization by balancing the use of variable renewable generation sources
- Provides cost-effective alternatives that could help building owners meet legislative mandates

Next phase of Roadmap development

This 30-year plan will continue to be developed to address other aspects of building decarbonization.

Embodied carbon

Low greenhouse warming potential (GWP) refrigerants

Additional building types in the next iteration(s) of Roadmap will include:

- K-12 Schools
- Big Box Retail
- Warehouses
- Hotels and Hospitals

Building types that may require additional analysis include:

- Skyscraper (commercial & residential)
- Restaurants and commercial kitchens
- Grocery Stores

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

RESIDENTIAL

Net Zero Energy Historic Gut Rehab

- Ground-source heat pumps with variable speed air handler
- Energy recovery ventilation
- Spray foam insulation
- ENERGY STAR® appliances with induction Stove
- Solar thermal hot water
- Photovoltaics
- Electric vehicle charging station

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

RESIDENTIAL

1840's Farmhouse

Clifton Park, NY

Image Source: https://www.energysage.com/project/4463/paul-joanne-coons-clifton-park-ny-solar-hot-water/

CASE STUDY: **Single family home retrofit, upstate**

Retrofit Measures

- Ground-source heat pump with variable speed air handler
- Rooftop energy recovery ventilation
- All-electric ENERGY STAR® Appliances
- Solar thermal hot water system
- Solar electric panels with EV hook-up
- Spray foam insulation

Business Case

- 1840s farmhouse in the Capital Region invested in a fossil-fuel free, deep energy retrofit that resulted in a comfortable home that produces more electricity than it uses
- The homeowners participated in NYSERDA's Green Home Program, which provided financial rebates for the solar electric panels and solar hot water systems
- The owners also leveraged tax credits to offset the upfront installation costs

Results

- Post-retrofit, the monthly utility bills average $18[1] paying only for the cost of connection to the grid
- The owner's return on investment for the solar electric panels and solar hot water system was 16.1%,[2] and the geothermal system achieved a return on investment of 10.9%[3]

Sources:

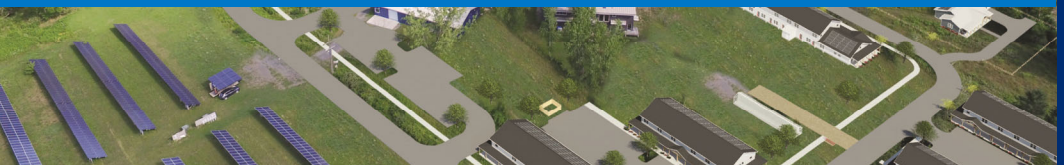
1. https://www.nyserda.ny.gov/All-Programs/Programs/Low-Rise-Residential/Low-Rise-Net-Zero-Energy-Housing/Resources#NetZeroNatalieVideo
2. https://www.energysage.com/project/4463/paul-joanne-coons-clifton-park-ny-solar-hot-water/
3. https://www.energysage.com/project/4464/paul-joanne-coons-clifton-park-ny-geothermal/

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

RESIDENTIAL

Geneva Solar Village

Geneva, NY



Early Design
$1,000,000 Award

The Solar Village Company
Sustainable Comfort

Solar Pods are the continuation of the modular, net-zero model of buildings first seen at the development of a high performance, net-zero modular community in Geneva, NY called the Lake Tunnel Solar Village. Building upon the efforts of the single-family home community, Solar Pods looks to take the lessons learned from Lake Tunnel Solar Homes to reach full net-zero energy and drive the cost effectiveness of a high-performance building. The project will push the market forward by sharing operational financials and energy performance of the project to show the transition to high performance buildings is possible.

# of Dwellings	# of Buildings	# of stories	New or Gut Rehab	Total SF	Residential SF	Electric Utility	Gas Utility	REDC	DEC Env. Justice	Downtown Revitalization Initiative
72	6	3	New	69600	69600	NYSEG	NA	Central NY	No	No

Space Conditioning	Ventilation	DHW	Building Envelope	All Electric	Urban or Suburban	Net Zero	Mixed Use	Performance Path	Other 3rd party certs.	Occupancy
Minisplit - ASHP	ERV	ASHP	Panelized	Yes	Urban	Yes	No	ERI	EPA ENERGY STAR	LMI

Technical attribute summary: Modular, Solar photovoltaics (PV), unique integration of air source heat pump (ASHP) to support space conditioning energy recovery ventilation (ERV), ASHP pre-heat of domestic hot water, induction cooktop, heat pump clothes dryer, Smart buildings monitoring & controls.

MULTIFAMILY

Colonial II Apartments Revitalization

Rome, NY

Early Design
$1,000,000 Award

Beacon Communities Development, LLC.
New Ecology, Inc.

Proposer's summary: Beacon is proposing to redevelop the Colonial II building, with plans which surpass the standards for carbon reduction and energy efficiency set by the first project and push the building towards net zero energy and net zero carbon. Like Colonial I, this gut renovation project will involve establishment of a tighter thermal envelope, addition of LED light fixtures, installation of high-efficiency equipment, and thermostat upgrades in each apartment. The renovated of Colonial II will also feature heating and cooling service from on-site geothermal wells connected to individual ground source heat pumps, individual energy recovery ventilators to provide fresh air and exhaust stale air, central heat pump hot water heaters with a recirculation loop, and a vast solar photovoltaic array to cover 98% of the annual electricity production in the building.

# of Dwellings	# of Buildings	# of stories	New or Gut Rehab	Total SF	Residential SF	Electric Utility	Gas Utility	REDC	DEC Env. Justice	Downtown Revitalization Initiative
99	1	7	Gut Rehab	66,525	66,525	Nat'l Grid	Nat'l Grid	Mohawk Valley	No	TBD

Space Conditioning	Ventilation	DHW	Building Envelope	All Electric	Urban or Suburban	Net Zero	Mixed Use	Performance Path	Other 3rd party certs.	Occupancy
GSHP	ERV	CO2 HP	Re-use of existing bldg structure, panelized wall assembly	Yes	Urban	Possibly	No	ASHRAE	National Green Bldg. Standard v2020 Silver (committed) & Gold, possibly Emerald expected; ENERGY STAR MFNC	LMI

Technical attribute summary: Gut rehab, ground source heat pump, Solar photovoltaics (PV) meeting 98% of annual energy use, energy recovery ventilation (ERV), CO2 heat pump domestic hot water, electric ENERGY STAR appliances.

MULTIFAMILY

NYCHA NZE
Retrofit Pilot

Building Profile

- Construction Material: concrete frame with block and brick infill
- Exterior Finish: Brick
- Floors: 6
- Dwelling Units: 48
- Vintage: 1951
- Current MEP Systems:
- Central steam/boiler plant for heating and hot water. No cooling
- Exhaust ventilation through single 4” bathroom grill

Cycle Architecture + Planning
Brooklyn Navy Yard 141 Flushing Ave,
Building 77
Suite 1122 Brooklyn, NY 11215
646.308.1603

MULTIFAMILY

NYCHA NZE Retrofit Pilot

Anticipated Retrofit Strategy

Envelope Treatment

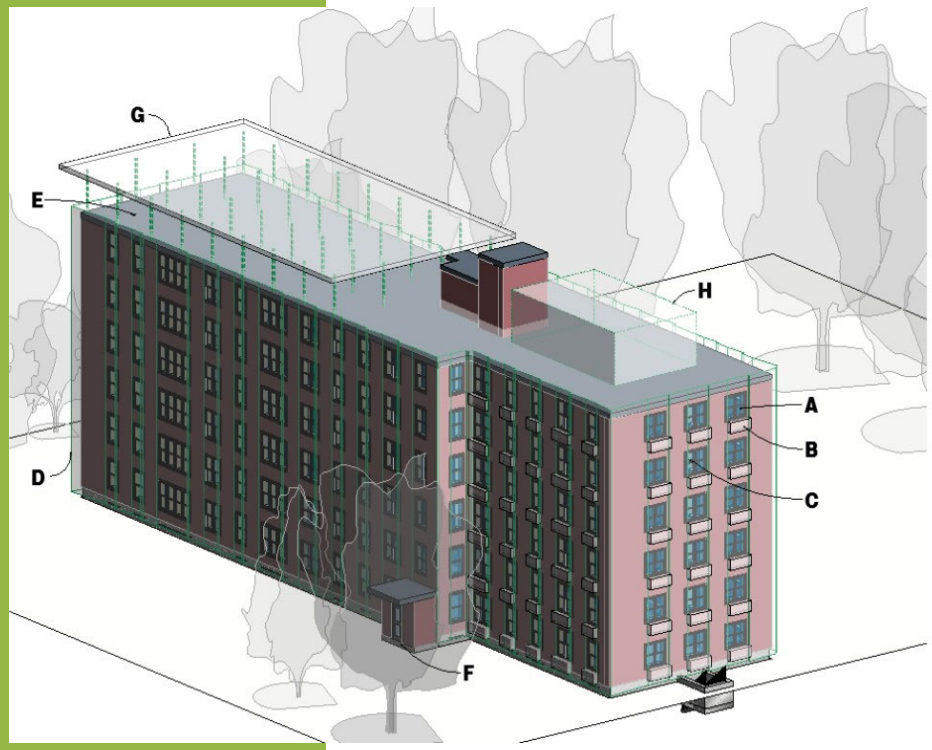
Pre-fabricated Panels:
- Airtight
- Well insulated
- New windows
- Additional insulation at roof

MEP Systems

In process:
- Packaged heat pump
- Split system / VRF
- Air to water heat pump

Onsite renewables

In process:
- Solar Canopy
- Battery Storage



BUILDING 12 RETROFIT

A ENERGY EFFICIENT WINDOWS
New energy-efficient windows will be provided, reducing drafts and noise from outside.

B NEW HEATING AND COOLING EQUIPMENT
Apartments will receive new heating and cooling. Residents will have full control over temperatures in each room of their apartment. NYCHA will provide cooling to all apartments in each room, eliminating window ACs

C NEW LIGHTING AND APPLIANCES
New energy efficient appliances and lighting within apartments and energy efficient lighting in hallways and public areas.

D NEW INSULATED EXTERIOR WALLS
New exterior wall panels will improve the building's insulation and the appearance of the building.

E NEW INSULATED ROOF
New well-insulated roof will improve comfort for residents as well as eliminate leaks

F NEW FRONT ENTRANCE DOOR
New entry doors will improve security for residents and reduce drafts from outside.

G SOLAR CANOPY:
Solar panels will produce carbon free electricity for use at Ravenswood.

H ROOFTOP MECHANICAL ROOM
Energy efficient mechanical equipment would be placed on the rooftop.

Cycle Architecture + Planning
Brooklyn Navy Yard 141 Flushing Ave,
Building 77
Suite 1122 Brooklyn, NY 11215
646.308.1603

MULTIFAMILY MIXED USE

The Seventy-Six Building C

Albany, NY

Credit: Garrison Architects

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

NEW YORK STATE OF OPPORTUNITY. Buildings of Excellence Award Winner

BLUE RIBBON FOR DESIGN Excellence

Building C, a 77,609-square-foot, seven-floor mixed-use structure with 69 dwelling units, including studio, one-, two-, and three-bedroom units, duplexes, and adaptive re-configuration design.

The majority of units (>60%) will be designated affordable housing. Building C is part of a four-building masterplan for this block. The project brings triple net zero sustainability, resiliency, and beauty to the deserving South End community.

As a proof of concept, this project demonstrates that conscious buildings can be regenerative, creative, healthy, integrated, and inspiring. By pushing the envelope of what a building can be and the purpose it can serve, The Seventy-Six Complex adds high-performance affordable housing and mixed-use community resources in a replicable, quickly delivered model.

MULTIFAMILY MIXED USE

The Seventy-Six, Building C

Albany, NY

Early Design
$1,000,000 Award

South End Development
Garrison-Architects

Proposer's summary: The Seventy-Six Complex, in the early stage of Schematic Design, has been a dream of the South End Development (SED) team for decades. This proposal addresses Building C, a 77,609 gross square foot seven-floor mixed-use structure with 89% residential program and 69 dwelling units including studio, one- two- and three-bedroom units, duplexes, and adaptive re-configuration design to provide flexibility for future uses. The majority of units (>60%) will be designated affordable housing. Building C is part of a four-building masterplan for this block, bounded by 2nd Avenue & Krank Street. The project brings ground-breaking triple net zero sustainability, resiliency, and beauty to the deserving South End community. As a proof of concept, this project demonstrates that conscious building can be regenerative, creative, healthy, integrated, and inspiring. By pushing the envelope of what a building can be and the purpose it can serve, The Seventy-Six Complex adds high-performance affordable housing and mixed-use community resources in a replicable and quickly delivered model.

# of Dwellings	# of Buildings	# of stories	New or GutRehab	Total SF	Residential SF	Electric Utility	Gas Utility	REDC	DEC Env.Justice	Downtown Revitalization Initiative
69	1	7	New	77,609	68,769	Nat'l Grid	Nat'l Grid	Capital Region	Yes	TBD

Space Conditioning	Ventilation	DHW	Building Envelope	All Electric	Urban or Suburban	Net Zero	Mixed Use	Performance Path	Other 3rd party certs.	Occupancy
GSHP	ERV	Solar Thermal	Fully modular, triple net zero	Yes	Urban	Yes	Yes	PHIUS+ 2018	PHIUS+ 2018, Living Building Challenge (LBC) Water Petal; International Living Futures Institute (ILFI) Zero Energy.	LMI

Technical attribute summary: Modular, ground source heat pump (GSHP), solar thermal domestic hot water, energy recovery ventilation (ERV), Solar PV, Wind Turbines, induction cooktops, heat pump clothes dryers, ENERGY STAR appliances. 'Triple Net Zero' (net zero energy, water and waste), energy management system.

MULTIFAMILY MIXED USE

Zer0Place

New Paltz, NY
Net Zero Energy Apartment Building

Image Source: https://zeroplace.com/

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

CASE STUDY: **Multifamily low-rise, new construction, upstate**

Retrofit Measures	▪ Geothermal system for heating, cooling, and hot water ▪ High-performance building envelope—insulated-concrete form (ICF) walls, triple-paned fenestration, high-R slab and roof assemblies, and thermal bridging reduction ▪ 246kW solar system
Business Case	▪ Tenants will pay zero dollars in monthly electricity costs ▪ All-electric—avoided gas line installation, reduced heating/cooling costs
Results (*ongoing construction)	▪ Projected energy savings of 20-25% over NY ECC-code buildings ▪ Estimated payback of 8-10 years (insulation, geothermal and solar)

Sources:

1. https://zeroplace.com/
2. https://www.contractormag.com/green/geothermal/article/21144562/zero-place-and-the-future-of-geothermal

COMMERCIAL

Court Square

45–01 23rd Street, Long Island City, NY

Credit: MY Architect PC

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

NEW YORK STATE OF OPPORTUNITY. | Buildings of Excellence
Award Winner

Court Square is a “super-tall” mixed-use building containing thirty-eight floors of luxury condominium dwelling units, nine floors of core and shell office space, a future city library, and future retail space.

The project embodies sustainable luxury reimagined to meet today’s energy and climate-based challenges and serves a leading example of how this type of design can be realized seamlessly together.

Court Square will fully electrify its HVAC and DHW systems. The project will certify as LEED Gold and incorporate induction cooktops, heat pump dryers and smart-learning thermostats in all residential units. The project is actively evaluating additional cutting-edge measures to optimize energy performance.

MULTIFAMILY

Casa Pasiva

New York City, NY
Retrofit NY Spotlight

Credit: x

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

RetrofitNY

- Revolutionizing how affordable multifamily buildings are renovated
- Innovative solutions to decarbonize buildings while limiting disruption for residents
- Increasing the comfort and health of residents

Casa Pasiva – low-carbon affordable housing retrofit in Brooklyn, NY

Owner: RiseBoro
Design and construction: Chris Benedict, R.A.

- 60-80% total energy reduction
- Improved resilience during utility outages
- Energy efficient heat pump heating and cooling
- Improved indoor air quality and comfort with active ventilation system
- Very high efficiency windows and added insulation on the exterior of the building

COMMERCIAL

NRDC Net Positive Study

New York, NY

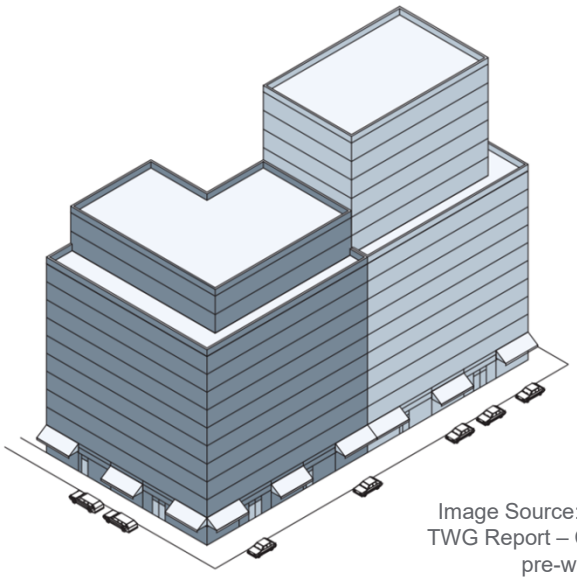


Image Source: NYC 80x50 TWG Report – Commercial, pre-war 7+ stories

CASE STUDY: **Office, hi-rise, retrofit, downstate**

Retrofit Measures

- Remote net metering solar array
- Energy efficient boiler
- Controllable plugs – 90.1 plug load control
- Thermal-paned windows, improved insulation, and tight air sealing
- 90.1 lighting control w/ daylight integrated dimming and occupancy sensors

Business Case

- Use of New York State's NY-Sun Program for remote net metering solar array
- NRDC sought to model pathways to net-zero of their head quarters without the ability to install PV system
- Improved natural light & comfort for employees.
- Use 1/3 of the energy of a conventional office

Results

- All measures - $34,000 to $43,000 annual savings on a total investment of $87k. (~2-year simple payback period, with an IRR of 36%)
- Non-controls ECMs that required investment - $17k - $18k annual savings. (~4.5-year simple payback period, with an IRR of 7%)

Sources:

1. https://www.nrdcnetpositivestudy.org
2. https://www.nrdc.org/experts/maria-mccain/nrdcs-headquarters-achieves-net-zero-energy
3. https://www.nrdc.org/resources/nrdc-new-york-headquarters

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

COMMERCIAL

Net Zero Energy Building HOLT Architects HQ

Ithaca, NY

Image Source:
https://www.holt.com/case-study-net-zero-energy-building/

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

CASE STUDY: **Small office, retrofit, upstate**

Retrofit Measures	▪ PV solar arrays ▪ Building envelope—continuous insulation inside of block & in study cavity replaced uninsulated concrete masonry unit (CMU) block walls ▪ Natural light was maximized via skylights & clerestory windows ▪ LEDs + expansive lighting controls ▪ Plug load controls ▪ Mechanical System—all-electric, distributed air-to-air heat pumps with advanced refrigeration cycle ▪ Natural light was maximized via skylights & clerestory windows
Business Case	▪ Use of New York State's NY-Sun Program for remote net metering solar array ▪ NRDC sought to model pathways to net-zero of their head quarters w/o the ability to install PV system ▪ Improved natural light & comfort for employees ▪ Use 1/3 of the energy of conventional office
Results	▪ All measures—$34,000 to $43,000 annual savings on a total investment of $87k. (~2-year simple payback period, with an IRR of 36%) ▪ Non-controls ECMs that required investment—$17k - $18k annual savings. (~4.5-year simple payback period, with an IRR of 7%)

Sources:

1. https://www.holt.com/case-study-net-zero-energy-building

COMMERCIAL

Net-Zero Energy Building – United Way LI

Deer Park, NY

Image Source: https://www.unitedwayli.org/news/united-way-long-island-launches-its-net-zero-energy-challenge-earth-day-renewable-energy

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

CASE STUDY: **Small office, retrofit**

Project Scope	▪ 31,000 SF ▪ Existing Office Building
Retrofit Measures	▪ Replacing natural gas HVAC with air source heat pumps ▪ Lighting upgrades and controls ▪ More efficient mechanical and server equipment ▪ Rooftop solar PV system ▪ EV charging Stations ▪ Battery Storage
Business Case	▪ Funding from NYSERDA will allow for a net zero building with increased resiliency and comfort ▪ Largest solar arrays of any not-for-profit commercial building
Results	▪ Offset 100% power usage with renewable solar ▪ Budgeted at $1.8 million ▪ Scale down carbon footprint by nearly 150 tons per year

Sources:

1. https://www.unitedwayli.org/news/united-way-long-island-launches-its-net-zero-energy-challenge-earth-day-renewable-en

HIGHER EDUCATION

RIT-Golisano Institute for Sustainability

Rochester, NY

Image Source: http://www.swbr.com/wp-content/uploads/2014/03/rit-gis-case-study_lo.pdf

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

CASE STUDY: **Academic, new construction, upstate**

Measures	▪ Vertical axis wind turbines ▪ 400kW UTC Fuel Cell ▪ Energy recovery & heat capture ▪ Geothermal and radiant floor system ▪ Continuous R-38 roof, high-performance facade with solar shading controls ▪ Low energy cooling & heating systems ▪ Building microgrid—solar PV system, battery storage system, EV charging stations
Business Case	▪ Establish a LEED-platinum certified research center to provide an example of energy-optimization practices for the students who attend RIT's sustainability institute
Results	▪ 56% more efficient than a ASHRAE 90.1 baseline building and reduced carbon footprint by 61% ▪ Construction costs: ~$40million

Note: This project is not all-electric

Sources:

1. http://www.swbr.com/wp-content/uploads/2014/03/rit-gis-case-study_lo.pdf

HIGHER EDUCATION

New York University

Net Zero Energy for Economic Development

Project

- Greenwich Village, contiguous properties of NYU
- 44 Buildings on Central Plant District System
- 6.9 Million SF
- Residential, dormitory, office, academic, laboratory, performance & library

NZE Master Plan

- Net zero carbon emissions
- Building-level analysis
- Loop infrastructure analysis
- Central plant study
- Renewable energy optimization & procurement
- Study high-intensity process loads

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

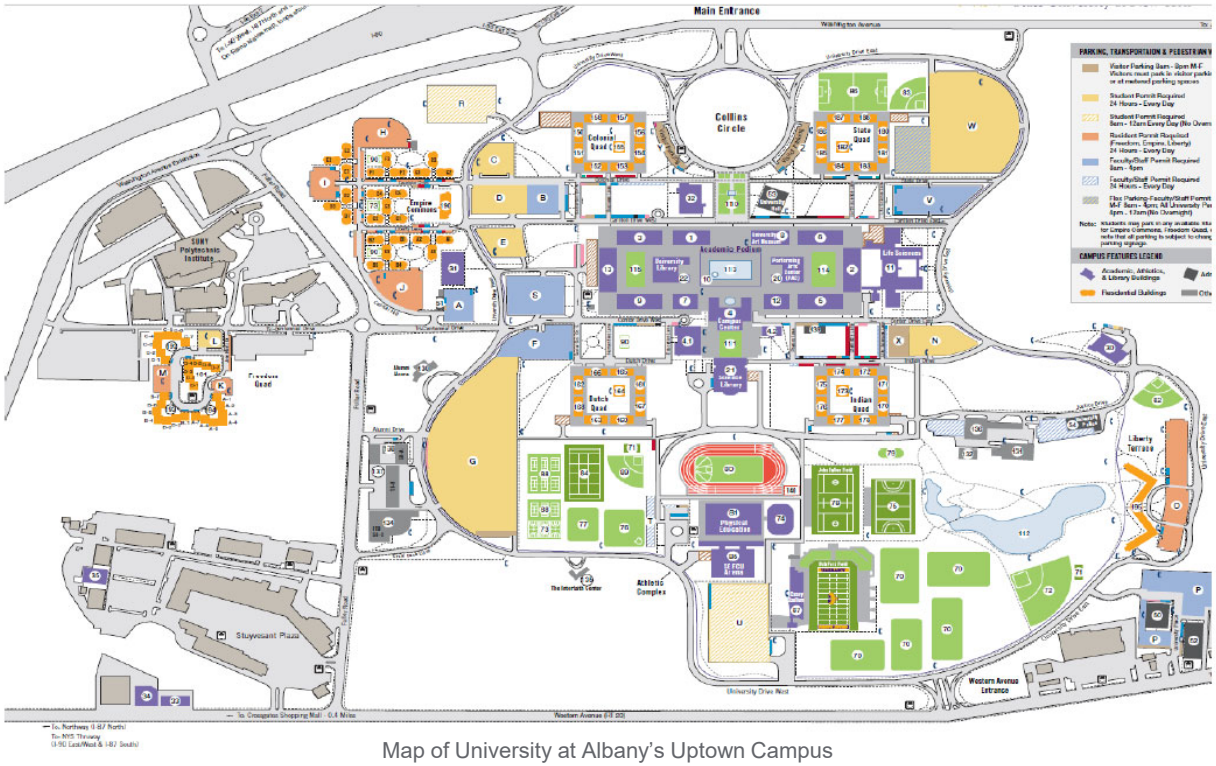
HIGHER EDUCATION

University at Albany-Uptown

Net Zero Energy for Economic Development

Project

- 4.7 Million SF
- 450 Acres
- Residential, dormitories, office, academic, research/laboratories, libraries, athletic, & services



Map of University at Albany's Uptown Campus

NZE Master Plan

- Net zero energy/carbon campus
- Building-level load reduction strategies
- District system improvements
- Human impacts
- Renewable energy installations
- Implementation plan
- Study high-intensity process loads

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

HIGHER EDUCATION

Living Lab at Winding Ridge

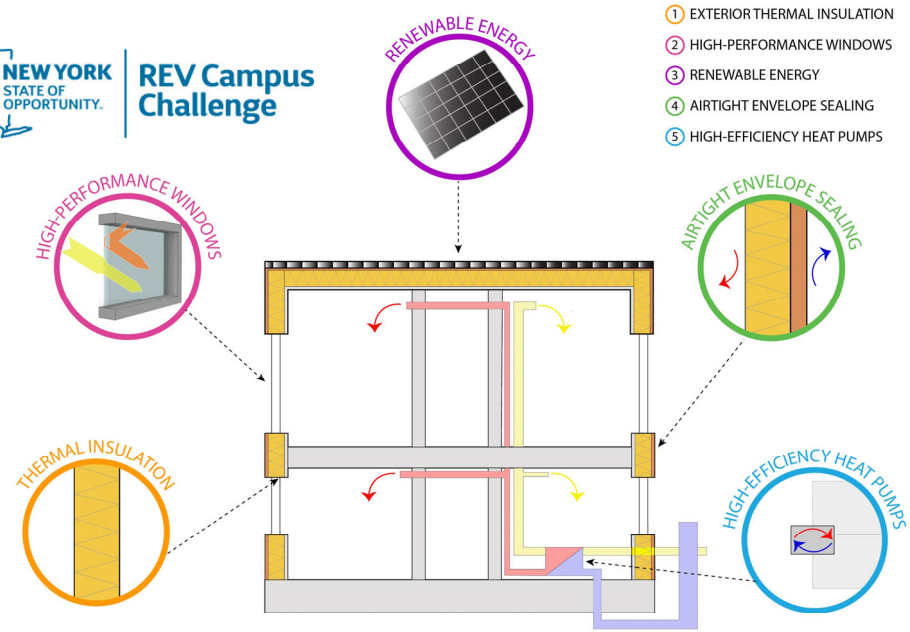
Syracuse University, Syracuse, NY
Net Zero Retrofit

Building Scale Goals

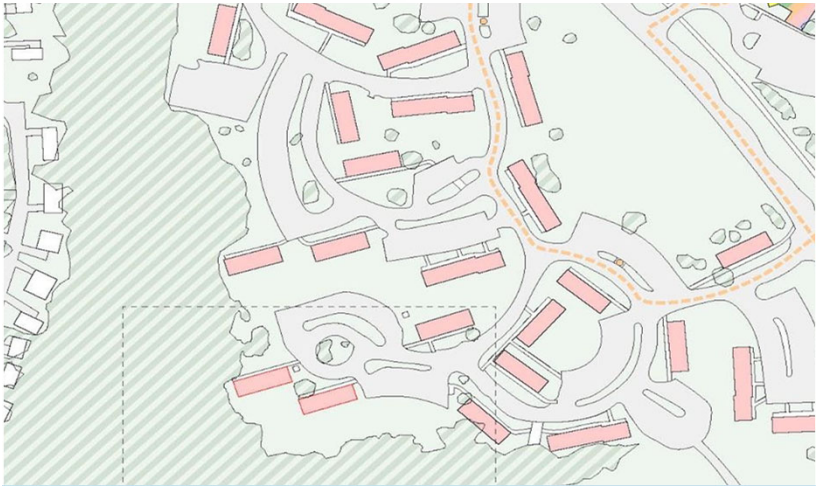
- Test net zero energy + carbon approach on a representative typology
- Develop a replicable model for NY State & other US cold climates

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

NEW YORK STATE OF OPPORTUNITY. | REV Campus Challenge



RETROFIT SYRACUSE UNIVERSITY SOUTH CAMPUS

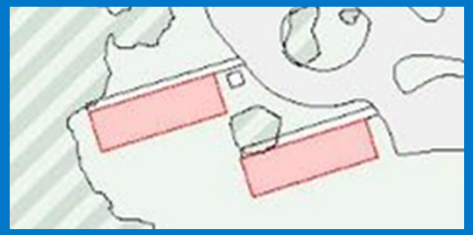


HIGHER EDUCATION

Living Lab at Winding Ridge

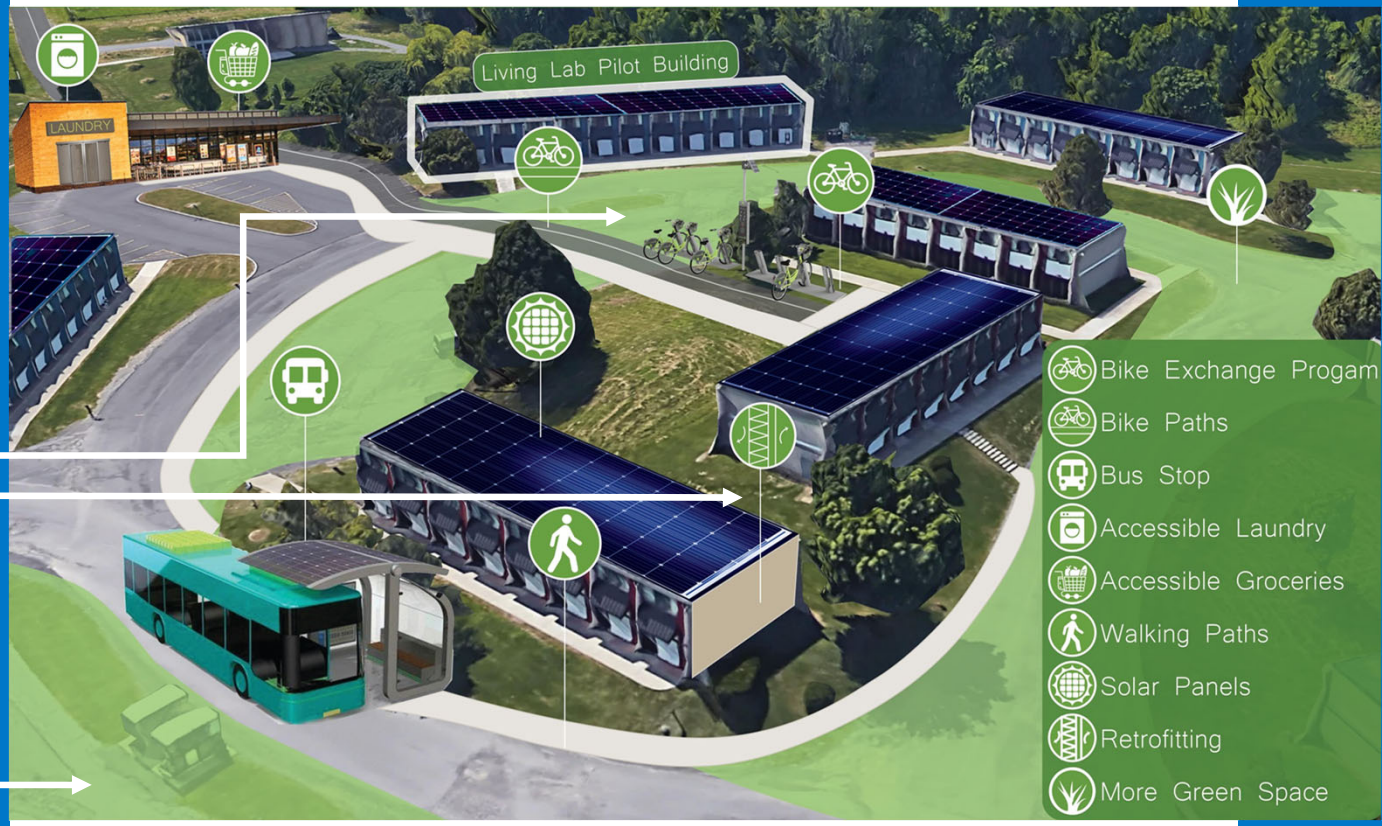
Syracuse University, Syracuse, NY
Net Zero Retrofit

- Net zero energy ready as first step towards a south campus zero carbon sustainable site
- Scale & design optimization of site-wide strategies vs. building-integrated:
- Geothermal – ground loops
- Storage / Microgrid / Energy Sharing
- Water Catchment and Storage



NEW YORK STATE OF OPPORTUNITY. | NYSERDA

NEW YORK STATE OF OPPORTUNITY. | REV Campus Challenge



We need to hear from you!

All New Yorkers must take a no regrets approach to fighting climate change. Here are actions you can take:

1. Provide feedback via our website at nyserda.ny.gov/Carbon-Neutral-Buildings
2. Sign up to stay informed about new developments on the Roadmap.
3. Share this presentation with colleagues, customers and others in your network.
4. Learn about NYSERDA programs that will help us realize the Roadmap goals www.nyserda.ny.gov/all-programs

Q&A Session

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Thank you!

Please remember to submit comments

nyserda.ny.gov/Carbon-Neutral-Buildings

Appendix: Glossary of Terms

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Affordable: For the purposes of this report, “affordable” is defined as “where the homebuyer has a household income which does not exceed the income limits defined by the State of New York Mortgage Agency (SONYMA) low-interest rate mortgage program in the non-target, one- and two-person household category for the county where such property is located.”1 This specification is equivalent to 100% of state median family income (SMI) or area median family income (AMI) whichever is greater.

All-electric building: No combustion equipment is used as part of the building heating, cooling, hot water, cooking, and laundry.

Baseline Assessment: When appropriate, the baseline measurement to analyze the potential benefits of a home under an Affordable Green Building Program will be a home built in compliance with the current Energy Conservation Construction Code of New York State—2016 (ECCC-NY). This is based on the 2015 International Energy Conservation Code and ASHRAE 90.1-2013, as modified by the State of New York and, the 2017 Uniform Code Supplement for New York State based on the 2015 International Residential Code.

Best Practice: In this report, best practice represents the most effective method acceptable for construction of any given measure or system. It includes construction industry standards that may go beyond code requirements. Best practice may also apply to program or administrative functions.

Building decarbonization: The reduction of carbon emissions (aka GHG emissions), through the conversion of existing equipment and systems powered by combustion processes, to highly efficient equipment and systems powered by emissions-free sources.

Building electrification: The conversion of an existing building's heating, cooling, hot water, cooking, and laundry equipment and systems powered by combustion processes, to highly efficient equipment and systems powered by electricity.

Carbon Coefficient: Carbon coefficient is defined as the quantity of CO2e emissions attributable to a unit of energy consumed. NYC Local Law 97 sets near-term carbon coefficients by energy source (electricity, gas, steam, etc.) that are used to convert energy consumption to emissions impact.

Carbon Emissions Metric: Carbon emissions associated with the different energy sources consumed by the building on an annual basis (lbCO2e/year).

Carbon Footprint: Carbon footprint is defined as the totality of an organization's energy consumption (or activities) and the resulting emissions from that consumption. Emissions are calculated by applying emissions factors to each activity. An emission factor is based on the Global Warming Potential (GWP) of each type of activity.

Carbon Intensity: Please refer to the definition for emissions factor.

Carbon Neutral Building: A building that uses passive design strategies to minimize energy demand, whose systems are highly energy efficient, that meets its energy needs by producing onsite or procuring emissions-free energy, and that is responsive in real time to conditions facing the grid.

Carbon Value: The value of carbon is a monetary estimate of the value associated with small changes in emissions of carbon.

Commercial building: All buildings or facilities that are not included in the definition for "Residential building."

Direct emissions: Onsite fossil fuel combustion from the buildings sector. Direct emissions are dominated by fossil-fuel combustion for space heating and hot water. Electrification is the largest driver of direct emissions reductions.

Disadvantaged communities (interim definition): Properties located in census block groups that are below the HUD 50% Area Median Income threshold and within DEC PEJAs (income + race/ethnicity) or NYS Opportunity Zones.

Electrification: Electrification refers to replacing direct fossil fuel use (e.g., propane, heating oil, gasoline) with electricity [use] in a way that reduces overall emissions and potentially energy costs while lowering other air pollutants. (Source: *Environmental and Energy Study Institute*) In the context of buildings and homes, electrification commonly refers to the practice of replacing fossil fuel-powered measures, such as HVAC and domestic hot water equipment, with electric-powered equivalents.

Electric readiness: The installation of electrical service and panel capacity, conduit, fixtures, and outlets for a future installation of electric equipment for space heating and cooling, hot-water, cooking, and laundry.

Electric vehicle (EV) readiness: The installation of electrical service and panel capacity, conduit, fixtures, and outlets for a future installation of EV chargers.

Embodied carbon: The sum of all GHG emissions resulting from the mining, harvesting, processing, manufacturing, transportation and installation of materials and buildings.

Emissions factor: The emissions factor or carbon intensity of electricity indicates how much GHG emissions are created by all power plants operating at any given moment.

Emissions profile: An emissions profile indicates the amount of GHG emissions created by power plants during the course of an hour, day, month or year.

Energy affordability: A household's energy burden—the percentage of household income spent on energy bills—provides an indication of energy affordability.
Energy efficiency: Minimized consumption of energy required to perform useful work.

Energy storage readiness: The installation of electrical service and panel capacity, conduit, fixtures, and outlets for a future installation of electric batteries.

Environmental justice: Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. (EPA)

Equity: Equity means broadly that assets are distributed fairly and justly for the benefit of the public. (Office of Equity and Access)

Financing: The Public Authorities Law Section 1872-a states that financing can be from NYSERDA or other public or private sources and available to developers, builders, design professionals or potential owners for affordable units.

Future-proof: Many of the potential climate impacts to buildings and their occupants can be reduced through conscious efforts to incorporate resilient design measures—the idea of "future-proof" design that keeps flexibility and system/component service life in mind.

Green building measures: Green Building Measures refers to the green building practices or processes identified in The Public Authorities Law, Section 1872-a. Specifically included are energy cost and consumption savings, healthy indoor living environments, smart growth/smart planning, integrated design, environmentally responsible products, and waste reduction.

Green building standards: Standards that are used to incent green building. Green building can be defined as "the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building." (EPA)

Greenhouse gas intensity (GHGI): GHGI is a metric for commercial buildings. Considers the carbon emissions from the different energy sources consumed by the building on an annual basis in tons of CO_2 per square foot per year.

Grid integrated buildings: An energy-efficient building that uses smart technologies and on-site distributed energy resources (DERs) to provide demand flexibility while co-optimizing for energy cost, grid services, and occupant needs and preferences in a continuous and integrated way.

Hazards: Climate events that cause damage to buildings. For example: hurricanes, tropical storms, flooding, severe storms, winter storms, sea level rise, and heat waves.

HFCs or hydrofluorocarbons: HFC's are greenhouse gases, manufactured for use in refrigeration, air conditioning, foam blowing, aerosols, fire protection and solvents.

High performance: High performance projects received an incentive from NYSERDA because their predicted (modeled) energy consumption was at least 30% below the energy code in effect when the project began. These projects offer additional examples of buildings with low energy targets and outcomes.

Impacts: The potential effects climate change has or could have on buildings or occupants. For example, cladding damage, water damage to building contents, and increased occurrence of asthma are all potential impacts of climate changes on buildings.

Indirect benefits: Indirect benefits accrue from a green building measure or program, but are not immediately observable, secondary to the main focus of the program, and often difficult to calculate with any degree of confidence. For this report, potential indirect benefits are identified but not quantified.

Indirect emissions: Electricity usage accounted in the electricity generation sector.

Integrated design: Integrated design is a process to engage all project team members in the process of discovering synergies between systems, components, and co-creators (design and construction team) to produce much higher levels of building performance, human comfort, and environmental benefits, with less wasted time and resources.

Low-Income and Low- to moderate-income (LMI): Low- and Moderate-Income households in are categorized as the following, based on their annual income.

-Very Low Income: Income less than 130% HHSPG
-Low Income: Income greater than 130% HHSPG but less than the greater of 150% HHSPG vs. 60% SMI for New York
-Moderate Income: Income greater than the greater of 150% HHSPG vs. 60% SMI for New York but less than the greater of 80% SMI for New York vs. 80% PUMA AMI

Multifamily building: A residential building with five or more dwelling units. **Net Energy Use Intensity (Net EUI):** Net EUI is annual energy use minus annual on-site renewable generation, divided by the building's floor area in SF. A building with a measured net EUI (site or source) less than zero has achieved ZE. Some buildings in the ZE Emerging category show a negative net EUI based on modeled or estimated data.

Net Zero Energy (NZE): NZE projects are buildings with significantly reduced energy loads, such that 100% or more of the energy use can be met with on-site renewable energy generation annually. In this list, projects are categorized as NZE Certified, NZE Verified, or NZE Emerging. For simplicity, projects that have set a net zero carbon goal are listed as net zero energy.

Net Zero Energy Certified: Net zero energy certified projects have been awarded Net Zero Energy (or equivalent) certification by a trusted third party such as the International Living Future Institute (ILFI). The certifier has thoroughly reviewed at least one continuous year of energy consumption and generation data to certify zero energy performance.

Net Zero Energy Emerging: Net zero energy emerging buildings have publicly stated goals of reaching NZE. These buildings may be in the planning or design phase, under construction, or have been in operation for fewer than 12 months. Others may have been operating for at least a year, but their measured energy use data either has yet to achieve NZE, or the data to document NZE performance was not available.

Net Zero Energy Verified: Net zero energy verified projects have achieved NZE for at least one full year and NBI has verified the performance data.

NYStretch Energy Code: A model code for voluntary adoption by local jurisdictions in New York State, to be enforced as the local Energy Conservation Construction Code, which sets energy conservation standards more stringent than the NYS Energy Conservation Construction Code.

Owner: For purposes of new construction, owner refers to a person who owns a residential building on the date that a certificate of occupancy. In the instances where the certificate is owned by the builder, it includes the potential owner.

Peak demand: Peak demand refers to times of the highest demand for electricity, which tend to happen during the hottest or the coldest hours of the year, as people turn on the heat or air conditioning in order to stay comfortable when outside temperatures are at their extreme.

Passive design strategies: Passive design strategies, such as reducing the volume of conditioned space, optimizing building orientation, minimizing thermal bridging, and using daylighting, thermal massing, and robust insulation, reduce the building's total energy consumption as well as the rate of energy use at any given time (energy demand).

Passive survivability: Passive survivability is the ability of buildings to maintain safe conditions and a reasonable level of functionality in the event of a power outage.

Residential building: A building where the main or dominant use is to provide complete independent facilities for living, sleeping, eating, cooking, and sanitation including single-family and multifamily but not to include transient uses classified as R-1 in the Building Code of NYS.

Resilience: The capacity to withstand and recover from events that incur stress and damage.

Risk: A product of the probability of a climate hazard occurring, the likelihood of impacts from that hazard, and the magnitude of consequences if that impact occurs. An example of a high-risk scenario is expensive electrical equipment located on the ground floor of a building in a flood plain.

Single-family building: A residential building with one to four dwelling units.

Site Energy Use Intensity (EUI): Site EUI is a metric for commercial buildings. This metric stands for the total gross site-level Energy Use Intensity (EUI), used to measure annual energy use per square foot (SF) of building floor area. Energy use includes consumption from all fuels (grid-delivered and on-site-generated electricity, natural gas, district energy, and delivered fuels) in thousands of British thermal Units (kBtu) per year (yr). That sum is divided by the building's gross size, thus the units are kBtu/SF/yr.

Source Energy Use Intensity (EUI): Source EUI is a metric for commercial buildings. Considers energy losses associated with generating a delivering fuel to the building by applying conversions factors to the fuel consumed onsite on an annual basis. Expressed in kBtu divided by square feet. The metric relies on site energy data and published conversion factors.

Source energy: Source Energy Use is the total amount of raw fuel that is required to operate a property. In addition to what the property consumes on-site, source energy includes losses that take place during generation, transmission, and distribution of the energy, thereby enabling a complete assessment of energy consumption resulting from building operations.

State Energy Code: The NYS Energy Conservation Construction Code promulgated pursuant Article 11 of the Energy Law.

Thermal Energy Demand Intensity (TEDI): TEDI Considers the amount of energy a building requires to maintain an indoor temperature that is comfortable for occupants per square foot of conditioned floor area per year. Expressed as a combination of annual heating and cooling demand.

Total System Performance Ratio (TSPR): TSPR is a relative whole system efficiency metric for HVAC systems based on the ratio of predicted heating, cooling and ventilation load to carbon emissions.

Vulnerability: The degree to which buildings, occupants, and related social systems are susceptible to and unable to cope with the adverse impacts of climate change. An example of increased vulnerability is elderly occupants' susceptibility to injury and death from heat waves relative to that of healthy younger occupants.

Zero Energy Performance Index (zEPI): zEPI is a metric for commercial buildings. The metric considers the energy performance of a building on a scale of 0 to 100 by comparing the modeled or actual performance of a building design against a fixed baseline. Additional terms related to LMI can be found in the LMI Market Characterization Glossary.

Acronyms

CO2e: Carbon Dioxide equivalent
DAC(s): Disadvantaged Communities
EJ: Environmental Justice
EV: Electric Vehicle
GHG: Greenhouse gas
GWP: Global Warming Potential
HFCs: Hydrofluorocarbons
HVAC: Heating, ventilation, and air conditioning
LMI: Low- to moderate-income
MMt: Million Metric Tons
MWBE: Minority/Women-Owned Business Enterprise
PACE: Property Assessed Clean Energy
PV: Photovoltaic
R&D: Research and Development
SDVOB: Service-Disabled Veteran Owned Business
T&D: Transmission and Distribution
VRF: Variable Refrigerant Flow
WAP: Weatherization Assistance Program

Government agencies and authorities

DEC: Department of Environmental Conservation
DASNY: Dormitory Authority of the State of New York
DOH: Department of Health
DOS: Department of State
DOT: Department of Transportation
DOTF: Department of Taxation and Finance
DPS: Department of Public Service
HCR: New York State Homes and Community Renewal
HPD: NYC Dept. of Housing Preservation and Development
HUD: U.S. Department of Housing and Urban Development
NYCHA: NYC Housing Authority
NYPA: New York Power Authority
NYSERDA: New York State Energy Research and Development Authority
PHA: Public Housing Authority
PSC: Public Service Commission
SHPO: State Historic Preservation Office