

Energy Efficiency and Housing Advisory Panel

Panel Meeting 8
February 10, 2021

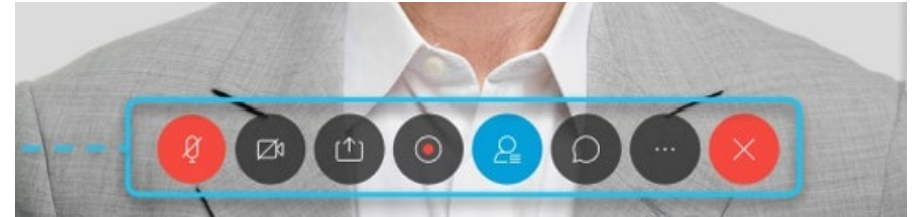


**Climate Action
Council**

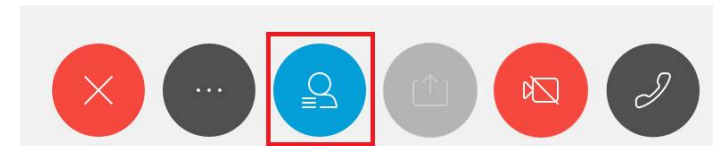
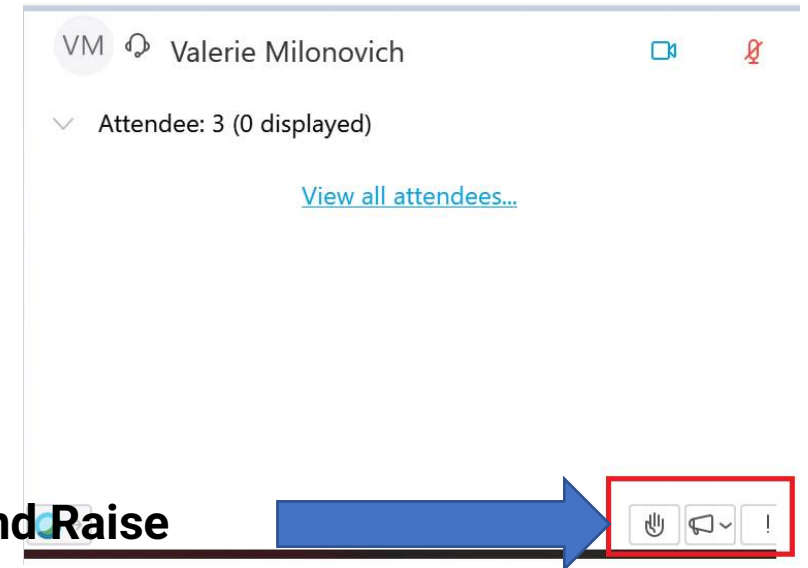
Meeting Procedures

Before beginning, a few reminders to ensure a smooth discussion:

- > Panel members should be on mute if not speaking.
 - > If using phone for audio, please tap the phone mute button.
 - > If using computer for audio, please click the mute button on the computer screen (1st visual).
- > Video is encouraged for Panel members, in particular when speaking.
- > In the event of a question or comment, please use the hand raise function (2nd visual). You can get to the hand raise button by clicking the participant panel button (3rd visual). The chair will call on members individually, at which time please unmute.
- > If technical problems arise, please contact Edward Galvin at Edward.Galvin@cadmusgroup.com



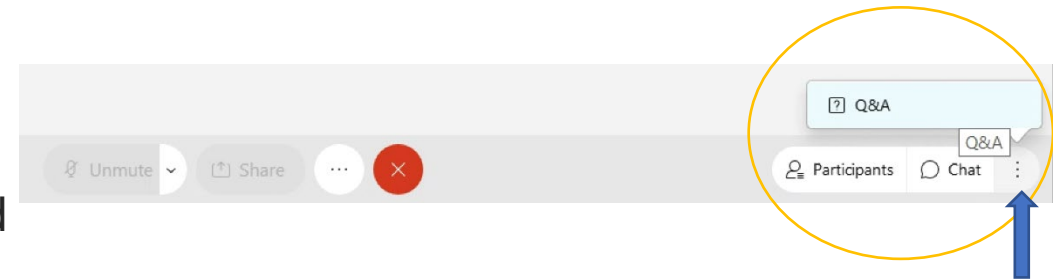
You'll see  when your microphone is muted



Procedure for Public Input

The Advisory Panel welcomes public comments and questions both during and in between its meetings

- > To submit feedback to Panel Members and agency staff during the meeting, members of the public can use the WebEx Q&A function located in the right bottom corner.
 - Comments and questions submitted through WebEx will be aggregated and submitted to panel members to be included in deliberations.
- > To submit feedback between Advisory Panel meetings, please email eehpanel@nyserda.ny.gov



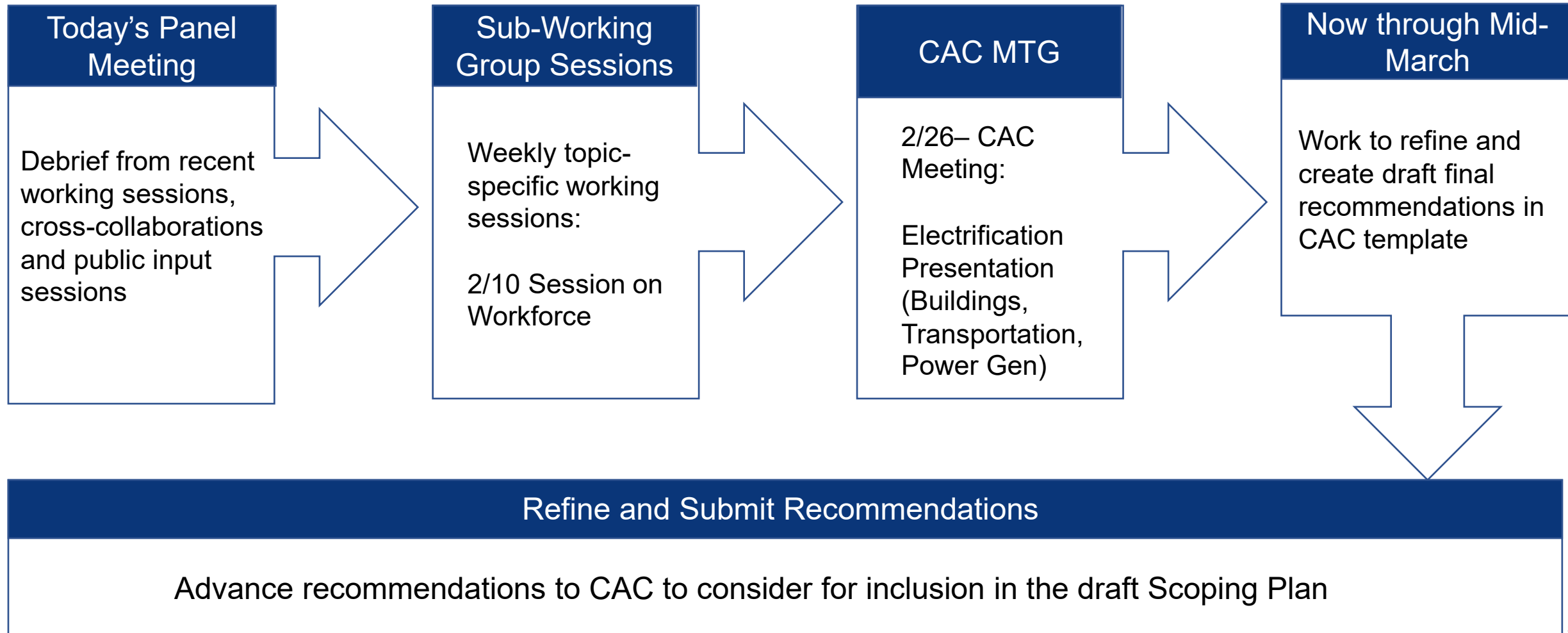
Agenda

Overall Objective: Prepare to provide recommendations by Mid March

Agenda

- > Welcome and Overview (5 min)
- > Building Decarbonization Policies: Preliminary Findings on Impacts and Costs (60 min)
- > Speed Round Recap (20 min)
 - Public input session
 - Cross-panel discussion with Power Generation
 - Just Transition Working Group Principles
- > Discussion: Recent input, ideas and opportunities to refine preliminary recommendations (30 min)
- > Next Steps and Wrap Up (5 min)

Overview



Upcoming CAC

Next Climate Action Council meeting:

- **February 26th at 3pm**
- **Electrification presentation – Buildings, Transportation & Power Gen**
- **Building Electrification portion of presentation (~15 min) will:**
 - Recap electrification as a central pillar of building decarbonization – in conjunction with energy efficiency and flexible building loads
 - Share strategies under consideration by the EE&H Panel to address barriers to electrification, advance equity, and enable market scale and cost reduction:
 - Regulations to phase out fossil fuel use in buildings
 - Scale up public education/outreach, technical assistance
 - Workforce development and training
 - Low-cost financing and incentives (priority on LMI/disadvantaged communities, incl. for retrofit- and electrification-readiness work)
 - Support for R&D, demonstrations
 - Managed, just transition from reliance on gas to clean energy

Climate Act **Advisory Panels** **New York Climate Action Council** **Climate Justice Working Group** **Resources** **Events**

Get Involved. Stay Involved.
Sign up to be Among the First to Learn of New York State Climate News and Developments

Climate change is a reality. New York is fighting it.
Our future is at stake. That's why New York State is committed to the most aggressive clean energy and climate agenda in the country. In 2019, we passed the nation-leading Climate Leadership and Community Protection Act (Climate Act) to empower every New Yorker to fight climate change at home, at work, and in their communities.

New York's Climate Act builds on almost a decade of climate leadership by Governor Andrew M. Cuomo. Based on the latest climate science, the Climate Act's targets are among the most rigorous of any major economy in the world. Every New Yorker will play a key role in protecting our communities and ensuring a sustainable future. Together, we will transform New York's economy, create new jobs, and stimulate industry and innovation, while building more resilient communities to benefit, and protect, all New Yorkers.

[View the Climate Act Fact Sheet \(PDF\)](#)

New York's Nation-Leading Climate Targets

- 85% Reduction in GHG Emissions by 2050
- 100% Zero-emission Electricity by 2040
- 70% Renewable Energy by 2030
- 9,000 MW of Offshore Wind by 2035
- 3,000 MW of Energy Storage by 2030
- 6,000 MW of Solar by 2025
- 22 Million Tons of Carbon Reduction through Energy Efficiency and Electrification

Climate Action Council to Lead the Transition
The [New York State Climate Action Council](#) (Council) is a 22-member committee that will prepare a Scoping Plan to achieve the State's bold clean energy and climate agenda. The Council will also oversee the establishment of sector-specific advisory panels and working groups and will work in consultation with the [Climate Justice Working Group](#) and the Environmental Justice Advisory Group.

The next meeting of the Climate Action Council will be held on Tuesday, January 19, 2021 at 3:00 p.m.

In keeping with measures designed to limit the spread of COVID-19, the meeting will be held via teleconference. To observe the meeting, please use the WebEx information below. A recording of the meeting will be posted on the Climate Act website within three days of the meeting, or as soon as practicable.

[Meeting Agenda \(PDF\)](#)
[View Meeting#](#)

Event Number: 145 880 6755
Event Password: climate
Phone Number: 1-415-655-0003
Access Code: 145 880 6755

Building Decarbonization Policies - Preliminary Findings on Impacts and Costs

See slides 24 - 61

Debrief from Public Input Session

Public input session

Held February 4, 3-5pm – over 300 attendees

Staff are continuing to work on synthesis of comments

Themes of Comments Provided

- > Broad support for building electrification and energy efficiency
- > Greater specificity on timelines, need a date certain
- > Education and outreach – campaign to get the word out to the public
- > Workforce and integration with training – invest in green jobs, diversify the workforce
- > Affordable transition is critical
- > Resilience of (all-electric) buildings is critical

Public input session (cont'd)

Themes of Comments Provided (cont'd)

- > Housing and developers – gain additional input
- > Biodiesel and biofuels should be explored
- > Low global warming potential refrigerants and HFC management should be addressed
- > Align current state programs
- > Consider enforcement – already code enforcement challenges
- > Commit to public Panel meetings and public participation
- > Support for Climate and Community Investment Act (CCIA)

Condo / Coop Input

Feedback from Property Managers and Owners:

- > Concerned about construction feasibility, resident disruption, environmental remediation required to retrofit and electrify old buildings
- > Lack of information on viable technical solutions and cost impacts for their buildings
- > Reluctant to electrify without greater certainty on future electricity pricing, grid readiness to support increased loads, and downstate grid's progress toward carbon-free electric generation.
- > COVID has exacerbated buildings' financial stability
- > Recommendations need to allow for full depreciation of installed equipment.
- > Need for coordination between State and NYC (e.g. interaction with NYC's LL97; State and City licensing requirements)

Recap: Housing Roundtables Input (from Nov 2020)

Identified Barriers

- > Insufficient access to low-interest financing and to incentives that are needed to cover high upfront costs
- > Older housing stock needs pre-electrification improvements (e.g. health, weatherization, electrical service)
- > Rate disparity between electric and gas makes gas more attractive
- > Lack of skilled workforce for both installation and operations & maintenance

Policy Actions to Consider

- > Incentives with long-term certainty that help make building decarbonization both accessible and affordable
 - Particular focus on disadvantaged communities and LMI households
- > Changes to electric rates and to policy for gas hook ups
- > Extensive workforce development
- > Education and awareness campaigns for general public to drive consumer demand and for contractors/installers

Debrief:

**Cross-Panel Collaboration with EE&H
and Power Generation Panel**

Cross-Panel Discussion with Power Gen

High Points

- > Consultant findings on building electrification - peak demand impacts and building-level investment decisions:
 - Cost premiums for electrification are lower for new construction (nearing cost parity) than for building retrofits. No one-size-fits-all solution for retrofits
 - Inclusion of basic shell upgrades with electrification is cost effective, reducing grid impact at minimal/no additional cost premium
 - Ground source heat pumps paired with a basic shell upgrade – where technically feasible – can offer greater grid benefits than air source heat pumps paired with deeper shell measures
- > Peak demand impacts and load flexibility
 - Challenging period is very cold week in winter; by 2040 NYS system will be winter-peaking
 - No clear solution yet, but several under development including use of controls, long-range storage, hydrogen
- > Gas transition
 - Comprehensive planning needed, incl. to converge utility long-term planning with building codes
 - Ensure most vulnerable ratepayers aren't the last ones on the system (e.g. LMI, restaurants) – understand tipping point when gas network is no longer affordable for remaining customers
 - Business models of gas utilities will need to evolve
 - Regulatory solutions needed to facilitate transition: amend to public service law, depreciation, cost-benefit analysis
 - Need for coordinated utility response, esp. for customers who've been waiting for gas service

Cross-Panel Discussion with Power Gen (cont.)

> Electric rates

- Cost of Service rate-making requires funds collected through rates to equal costs
- Subsidized electric rate would have to have funding shortfall made-up through revenue collected from other ratepayers in same class
- DPS exploring demand-based rates for cost recovery vs volumetric rates used now to recover fixed costs
- As electrification increases with current load shape, almost all components of electric rates will evolve

> Better understanding needed of

- How to approach hard-to-electrify buildings
- Sensitivity analysis for grid-side vs building-side investments
- Strategies to reduce peak (storage, pricing)
- Rate making options to address increasing electrification, including demand-based pricing across customer classes

Just Transition Working Group: Principles

Principles: Background

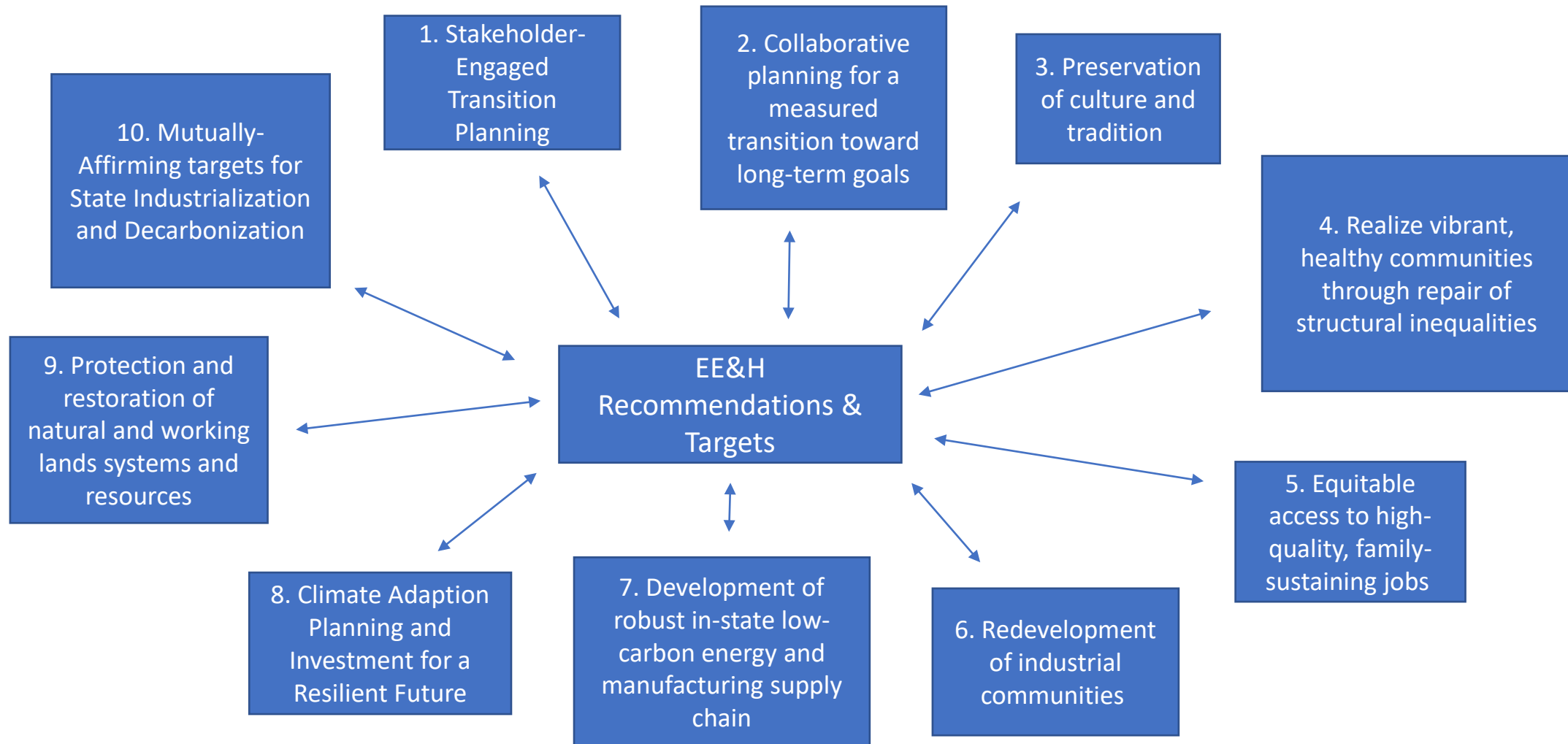
> Developed to:

"support a fair and equitable movement from fossil fuel-based economies toward the achievement of the carbon neutral future envisioned by the CLCPA"

> Guide Advisory Panel recommendations

> Each may have different applicability depending on economic sector

Principles



Group Discussion

Group Discussion

- > Cost and Impact Analysis
- > Public Input Session
- > Cross-Panel Discussion with Power Gen
- > JTWG Principles

Wrap Up

Next Steps and Reminders

- > Climate Action Council– 2/26 at 3pm – Please note Electrification Presentation on Buildings; Transportation and Power Generation
- > Mid March – Finalize Recommendations

Thank you!

Building Decarbonization Policies - Preliminary Findings on Impacts and Costs (slides)



New York State
Carbon Neutral Buildings



Building Decarbonization Policies Preliminary Findings on Impacts and Costs

Date: February 10, 2021

Produced by: RMI, E3, Arup, NBI and NYSERDA



ARUP

Overview

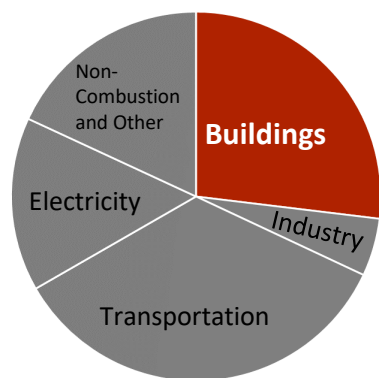
1. Analysis Purpose and Context
2. Preliminary Findings:
 - a. Emissions and cost impact of building decarbonization policies
 - b. Electricity system capacity implications
 - c. Building-level project cost examples
 - d. Cost compression and factors that influence project economics
3. Areas Requiring Additional Research and Analysis
4. Appendix

Analysis Purpose and Context

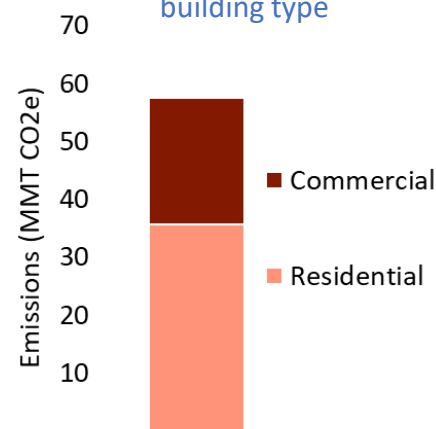
Residential and Commercial Buildings Emissions

- Direct GHG emissions in residential and commercial buildings are dominated by space heating, water heating, cooking appliances, clothes dryers, and other (e.g., fireplaces, secondary heating).
 - Although there is a significant amount of fuel oil used in residential space heating today, the majority of site-based emissions are from natural gas use.

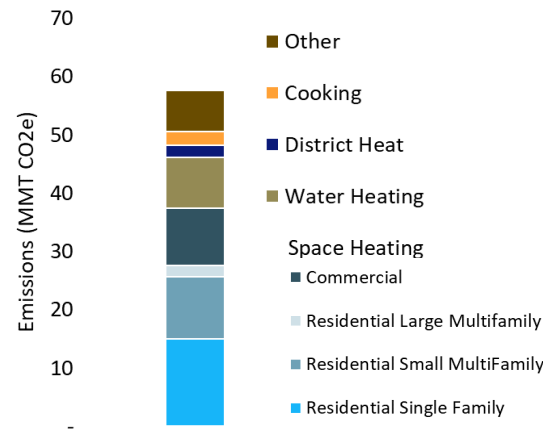
Economy-wide emissions in 2016



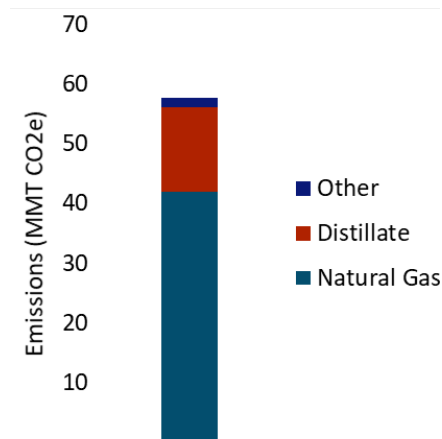
Buildings emissions by building type



Buildings emissions by subsector



Buildings emissions by fuel



Notes:

1. Emissions accounting subject to refinement under CLCPA accounting framework with sectoral targets. CLCPA directs New York State to adopt a 20-year global warming potential and incorporate upstream emissions associated with fossil fuels into its GHG emissions accounting framework. Under this new emissions accounting framework, fossil fuel use, as well as all sources of short-lived climate pollutants, which include methane and HFCs, will carry a higher GHG impact on a tons of carbon dioxide equivalent basis than in the current accounting framework used in this analysis. Work to develop this emissions accounting framework is underway.
2. Emissions associated with electricity consumption is currently tracked in the electricity generation sector.

Analysis Overview

This study assesses the contribution of four building sector policies and performs an analysis of residential, building-level project economics for building decarbonization in support of CLCPA goals. The analytical work began under the Carbon Neutral Buildings Roadmap and generally aligns with several of the recommendations of the Energy Efficiency and Housing Advisory Panel; further analysis would be needed to align more directly with the Panel’s forthcoming set of recommendations.

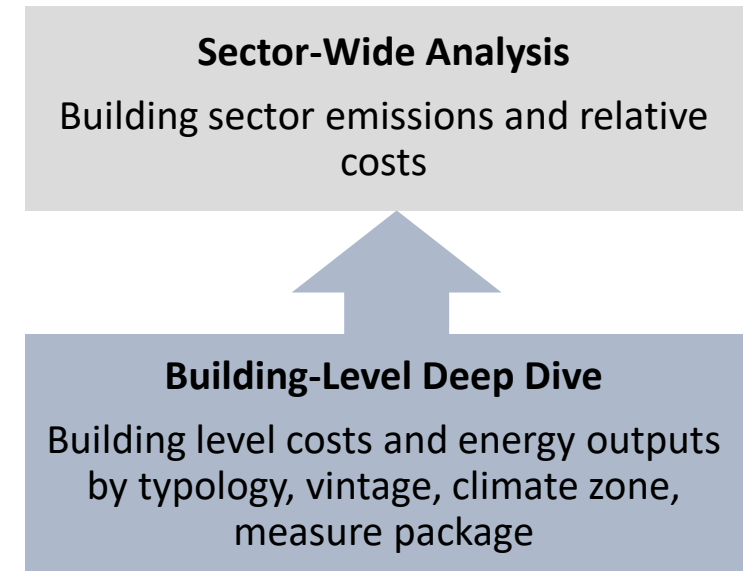


Notes:

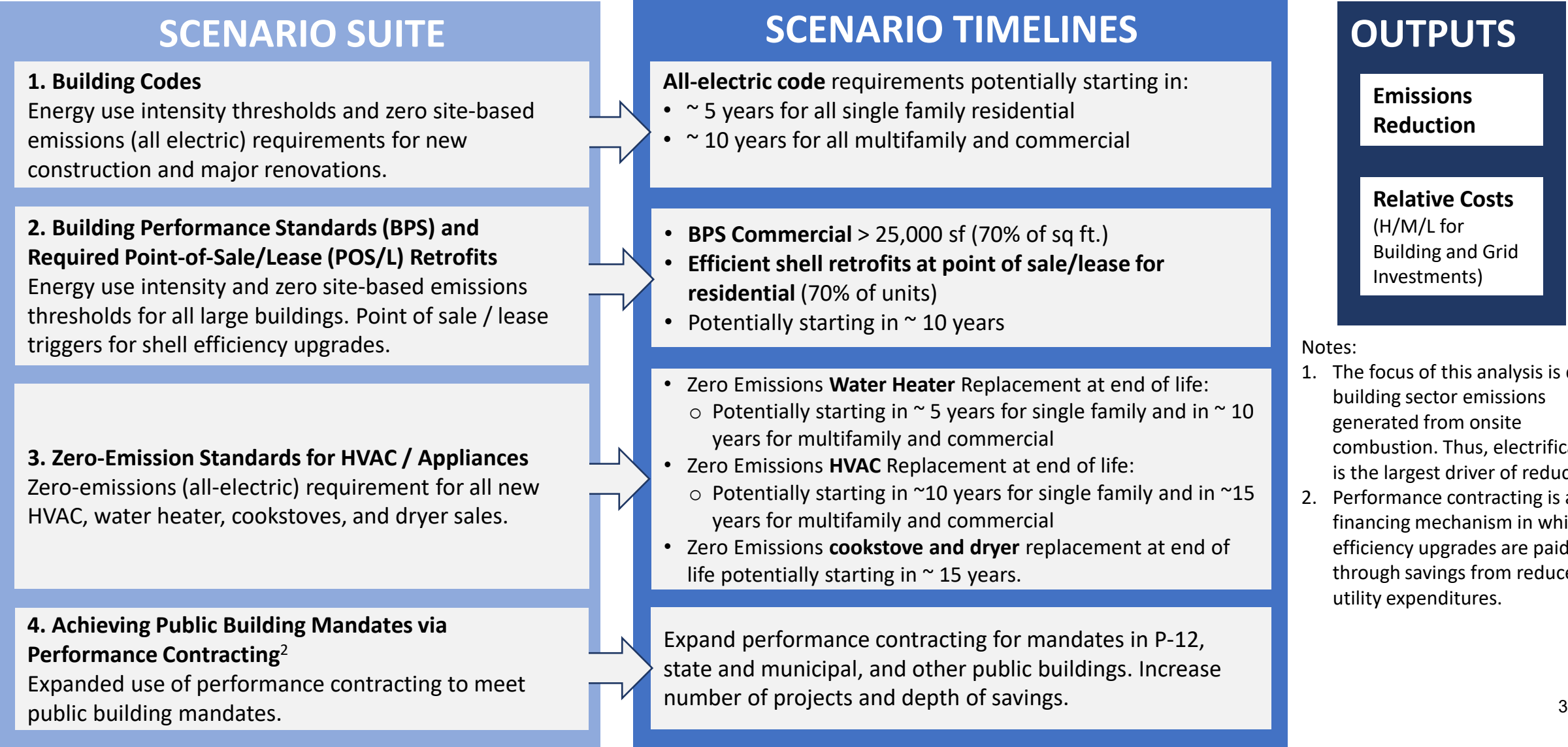
1. Subject to refinement under forthcoming CLCPA accounting framework with sectoral targets. Pathways analysis suggests that the building sector may need to reduce by more than 40% by 2030 and 85% by 2050 economy-wide goal under CLCPA to make up for harder-to-abate sectors.

Framing and Boundaries of Analyses

- The focus of this analysis is **direct, building sector emissions generated from onsite combustion**, including gas and fuel oil; electric grid emissions are attributable to the electricity sector, consistent with economy wide Pathways modeling.
- The decarbonization pathway modeled includes energy efficiency investments that reduce the magnitude of investments required in the state's electricity system. **With less energy efficiency, building upgrade costs would be lower and electric system costs would be higher. Demand flexibility is also an important and not yet quantified factor.** The specific tradeoffs warrant future study.
- **There are many other co-benefits (not quantified in this analysis) such as reduced healthcare costs, increased jobs, and the social cost of carbon.** These savings are significant and could exceed the total direct costs presented here.
- Analysis does not attribute who would bear the costs and does not provide specific design of policies, codes, rates, incentives, etc.
- **Out of Scope:**
 - Embodied carbon (not in core CLCPA emissions accounting framework)
 - Refrigerant emissions (leakage risk varies significantly depending on HVAC system and is not combustion driven)
 - Natural gas upstream and distribution system emissions (methane leakage)
 - District steam costs and impacts
 - Deferred maintenance costs (e.g., repairs, mold remediation, asbestos removal)

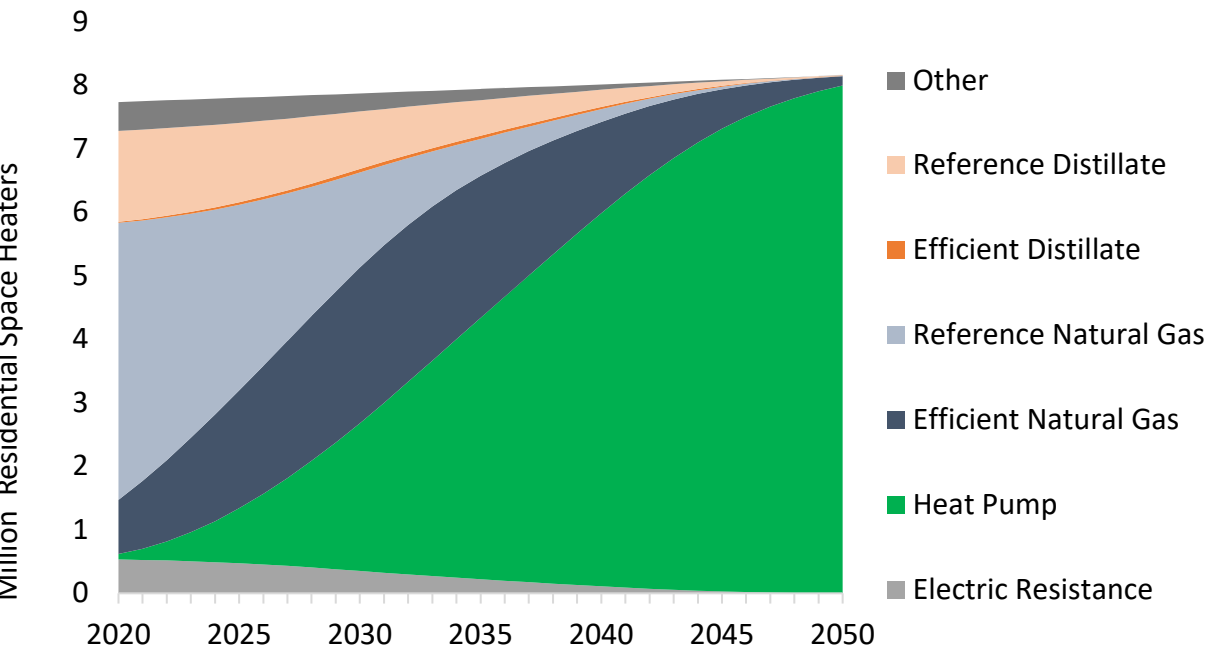


Scenario Analysis – Policy Implementation – Timeline and Typologies Impacted

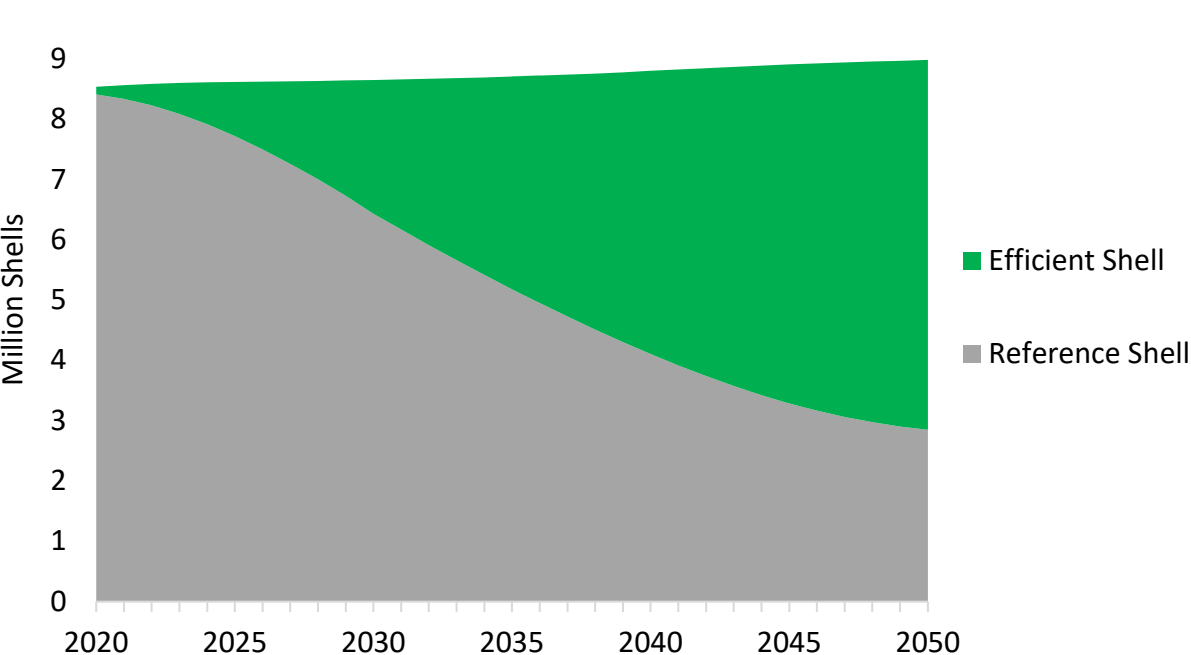


Increasing market adoption followed by policy mandates results in majority of buildings upgraded to electric appliances and efficient shells by 2050

Residential Space Heating



Residential Building Shell



- Programs, incentives, and other enabling factors are assumed to take place prior to mandates, creating a smooth trajectory in measure adoption. This assumption is particularly significant for meeting 2030 targets.
- Residential heat pumps increase in sales share until they hit 100% of new sales in 2030, due to mandates; heat pump water heater sales increase until they hit 100% of new sales in 2025 (not shown).
- By 2050, nearly all buildings have electrified space and water heating. (In practice, solutions remain to be developed for some hard-to-electrify building typologies.)
- Efficient shells gradually make up a larger share, comprising roughly 75 percent of building shells by 2050.

Preliminary Findings Summary

Preliminary Findings: Building Decarbonization Policies

Policy Scenario Analysis: GHG Emissions and Cost

- Combined policy scenario suite meets CLCPA building sector emissions reduction targets.
- *Building Performance Standards & Point of Sale/Lease Retrofits* (Policy 2) results in the highest incremental building cost since it requires deep shell upgrades in the majority of existing buildings.
- *Zero-Emission HVAC/Appliance Standards* (Policy 3) results in the highest emissions reduction and also the highest incremental grid cost, because it requires electrification of heating and cooking across all building typologies (new construction and retrofit targeting end of life replacement) without efficiency measures to reduce grid impact.
- In practice, recommendations should consider how to optimize policies to mitigate grid impact - e.g., shell upgrades, demand flexibility – which requires further scenario analysis.

Building Costs

- Decarbonization packages currently have a cost premium compared to fossil fuel baseline packages.
- Deep shell measures incur the highest cost premiums.
- Cost premiums can be mitigated through cost compression, integrative design, and other influencing factors.

Managing Grid Impacts

- Pairing electrification with basic shell upgrades is cost effective and reduces grid peak.
- Ground source heat pumps (GSHPs) can offer additional grid benefits, often at a lower cost than air source heat pumps (ASHPs) paired with deeper shell measures.

Preliminary Findings:
Individual policy emissions and
relative costs

Summary of Cost and Emissions Findings

Policy Scenario	Emissions Impact (Interim 1990 baseline)	Total Cost (30-Year Net Present Cost)	
		Buildings	Grid
1. Building Codes	Low/Medium	Low	Low
2. Building Performance Standards and Required Point-of-Sale/Lease Retrofits	Medium	High	Low
3. Zero-Emission HVAC / Appliance Standards	High	Medium	High
4. Achieving Public Mandates via Performance Contracting	Low	Low	Very Low
Combined Policy Scenario Suite (1-4)	High	~70%	~30%

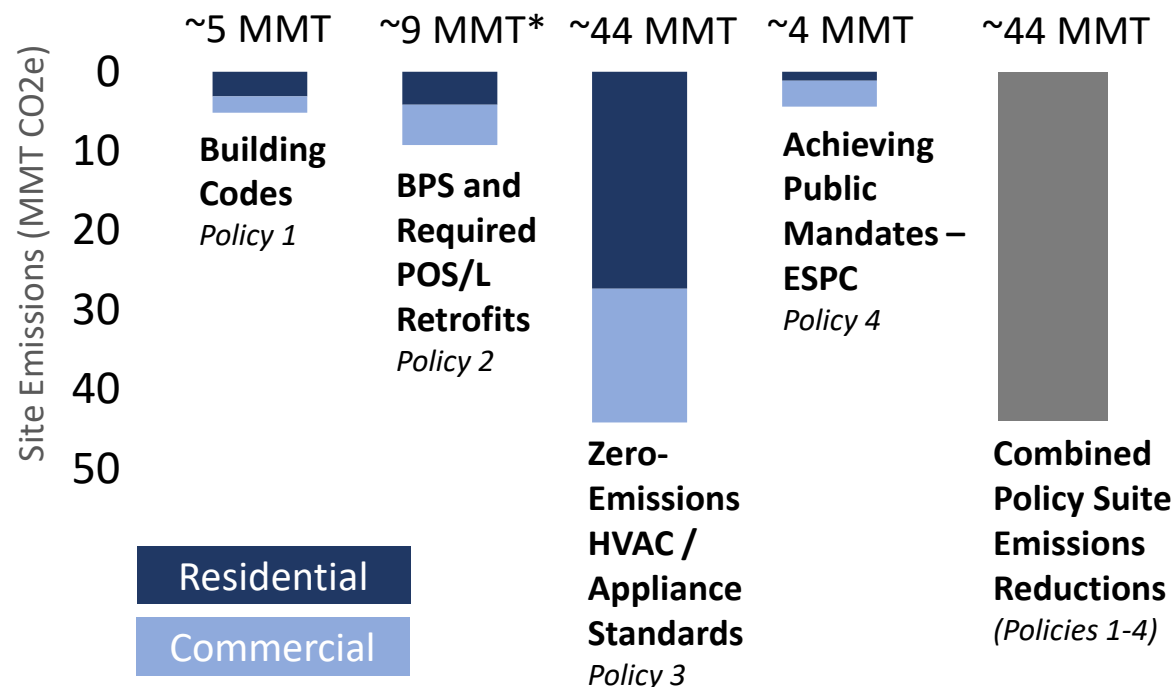
Notes:

1. The High, Medium, Low rankings for cost are an estimated comparison of the costs of each individual policy and are sensitive to detailed cost parameters for building and grid impacts.
2. Percentages represent the proportional costs between buildings and the grid for the total costs of the combined policy scenario suite.

Individual Policy Contributions toward 2050 Annual Emissions Target

The graph below shows the annual emissions reductions in 2050 for scenario analysis of each individual policy and the total reduction if applied together.

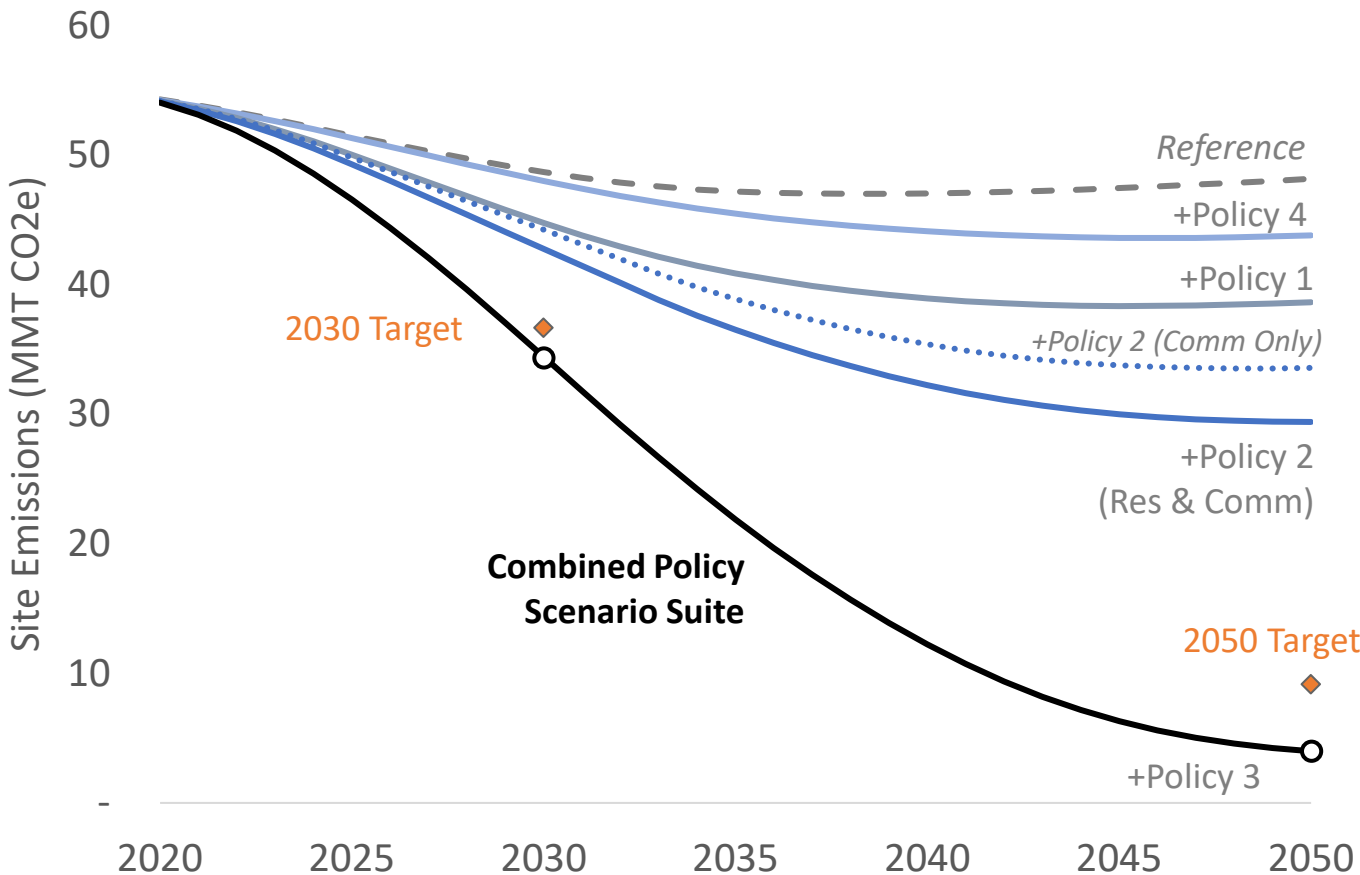
Annual Emissions Reductions from Reference Case in 2050



- Policies overlap when bundled – Combined emissions reduction is not equal to the sum of the individual policies due to overlapping impact.
- Individually, Zero-Emission HVAC / Appliance Standards result in the greatest onsite carbon reduction because this policy affects appliances in all typologies
- Zero-Emission HVAC / Appliance Standards without energy efficiency would lead to increased grid costs
- Achieving mandated levels of measure adoption will require an enabled workforce and supply chain and other policy actions such as programs and incentives

*Rough split ~5 MMT for Building Performance Standards, ~4 MMT for Point-of-Sale/Lease Retrofits

Combined Policy Scenario Suite Meets 2030 and 2050 Emissions Reduction Targets



- Chart shows the emissions reduction when layering in individual policies – not reductions from each policy individually.
- Analysis assumes signals from these policies are coupled with complementary actions (e.g., incentives, consumer awareness, etc.) that drive adoption, resulting in smooth trajectories over time rather than stepwise changes when policies take effect. This assumption is particularly significant for meeting 2030 targets.
- Emissions accounting subject to refinement under CLCPA accounting framework.

Notes:

1. Policies are layered on top of each other. **Policy 4 (Performance Contracting)** allows public buildings to lead and affects a relatively small portion of the building stock. **Policy 1 (Building Codes)** is applied next because it affects new buildings and major renovations. **Policy 2 (Building Performance Standards and Point-of-Sale/Lease Retrofits)** affects existing buildings which comprise the bulk of the building stock. **Policy 3 (Zero-Emission Appliance Standards)** requires end-of-life appliance replacement and ensures electrification in buildings not covered by other policies.
2. Target emissions are 36.6 MMT CO₂e by 2030 (40% reduction from 1990) and 9.2 MMT CO₂e by 2050 (85% reduction from 1990). Modeled market adoption rates and combined policy suite result in 34.4 MMT CO₂e (44% reduction) by 2030 and 3.9 MMT CO₂e (94% reduction) by 2050.

Summary of Qualitative Findings

Policy Scenario	Ease of Implementation <i>Ability to execute and enforce policy, incl. stakeholder views</i>	Benefits to Disadvantaged Communities <i>Equity impacts on disadv. communities</i>	Health and Co-Benefits <i>Occupant and public health, productivity, comfort, resiliency, etc.</i>
1. Building Codes	Medium	Good	Medium
2. Building Performance Standards and Required Point-of-Sale/Lease Retrofits	Hard	Moderate	Medium
3. Zero-Emission HVAC / Appliance Standards	Hard	Moderate	High
4. Achieve Public Mandates via Performance Contracting	Easy	Moderate	Medium

Less Desirable Outcome

More Desirable Outcome

See Appendix for more on Co-benefits

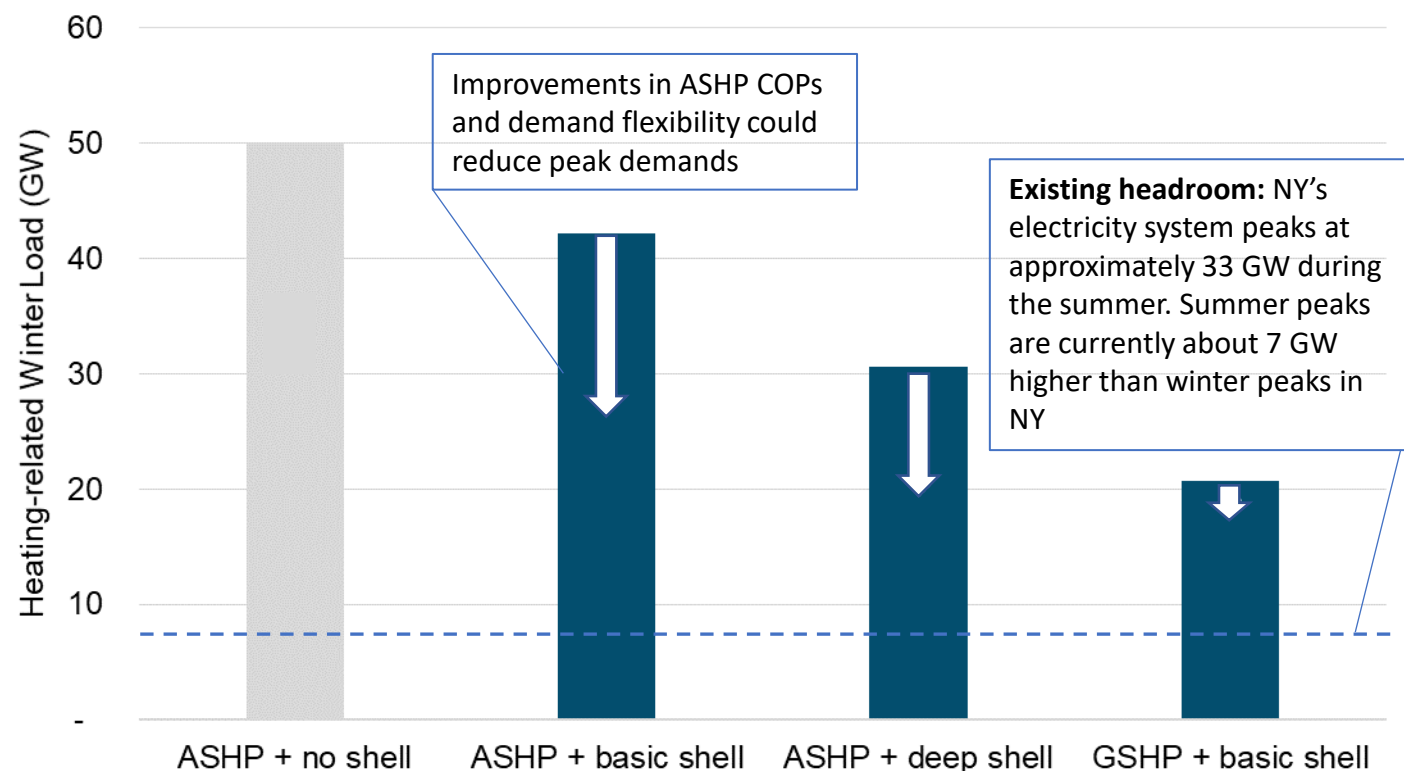
Notes:

1. Qualitative summaries reflect opinions of the consultant team.
2. Benefits to Disadvantaged Communities includes considerations such as health or economic benefits with disproportionate impacts on disadvantaged communities and engagement opportunities with community leaders. The CLCPA process includes ongoing efforts to define disadvantaged communities and assess impacts of policies on these groups.

Preliminary Findings: Electricity System Capacity Implications

Electrification will add new winter demands to NY's electricity system. The magnitude of those peaks depends on what measures are implemented in buildings.

2050 NY Electric Building Heating Peak Demand Scenarios



- Analysis explores impact of air source and ground source heat pumps and shell measures on NY's electric system. In practice, a mix of technology adoption will occur.
- Electrification without shell measures is projected to result in an undesirably high level of peak increase.
- Basic shell measures (together with demand-side interventions like flexible loads, and improvements in heat pump performance) achieve a substantial reduction.
- Further reduction of peak demand could be achieved through either GSHP instead of ASHP or deep instead of basic shell, but those options should be weighed against higher measure costs

Notes:

1. ASHPs modelled are assumed to be "cold climate" heat pumps, with a system coefficient of performance (COP) of 1.75 during the coldest hour modelled. The white arrows show the reduced peak demand impacts if COPs increase to 2.5 in the coldest hour and 2 GW of dependable space- and water-heating load flexibility is available. The US DOE Building Technologies Office has set a target of ASHPs achieving a COP of 3 at -13F.
2. Deep shell scenario assumes single family buildings upgraded to a code compliant building shell and multifamily and commercial buildings upgraded to a Passive House inspired shell.

Preliminary Findings: Building Level Project Examples

Use Case Economics: Example Graphic

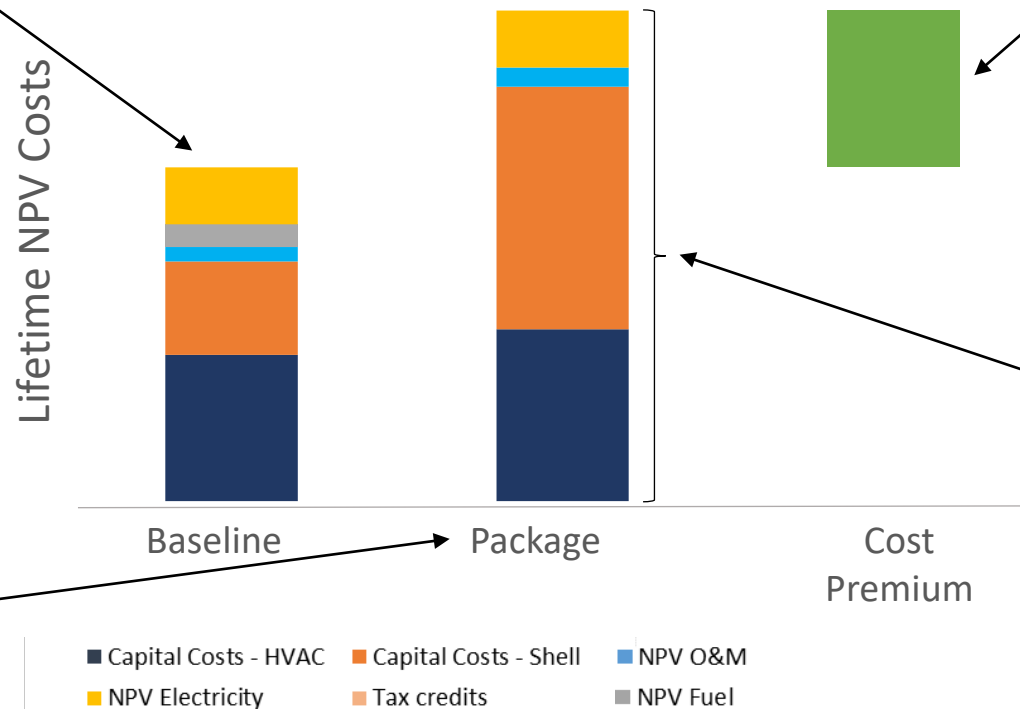
1. Baseline Retrofit or Construction Package:

Includes fossil fuel heating equipment in a typical new building (with code-level shell) or retrofit package (baseline shell varies by building typology and vintage).

2. Decarbonization Measure Package:

Decarbonized building including electric HVAC equipment and in some use cases include higher performance envelope and induction range.

Example graphic to illustrate use case economics



4. Cost Premium

- Difference in Net Present Cost between Baseline and Measure Package, over the package lifetimes.
- A cost premium exists if the Net Present Cost of the Measure Package is greater than the Net Present Cost of the Baseline Package.
- If the Net Present Cost of the Measure Package is lower than that of the Baseline Package, then there will be no cost premium.

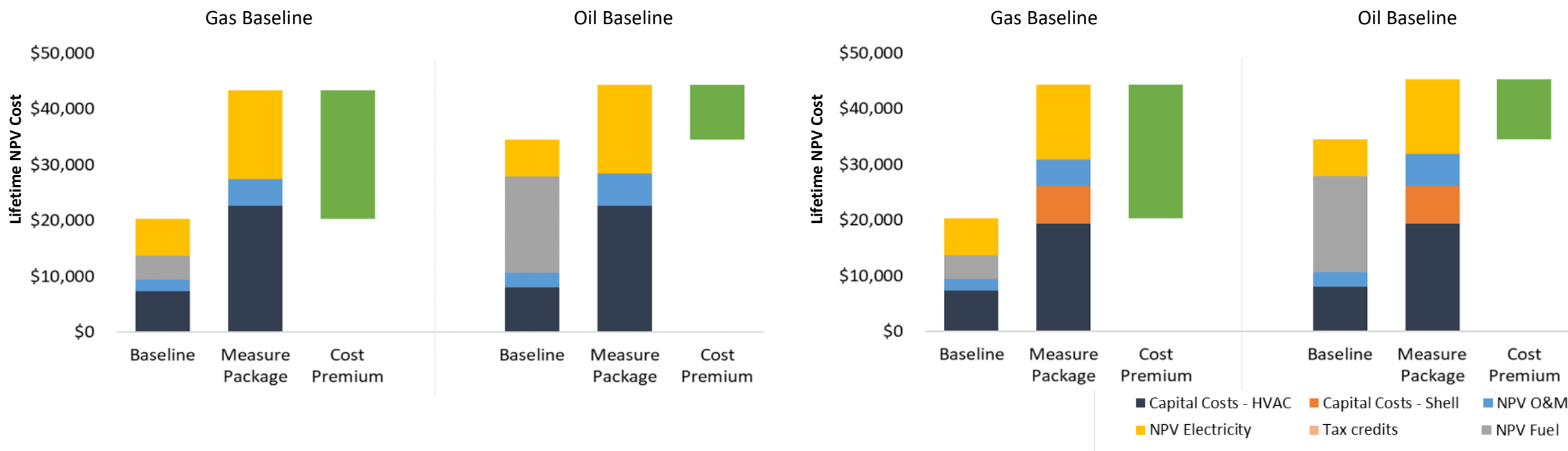
3. Net Present Cost

- Sum of Capital Costs and Net Present Value of Operations and Maintenance (O&M), Fuel, and Electricity Costs over 20 years (25 years for GSHP), using a 16% discount rate.
- Capital costs assume 2020 installed costs (no cost compression).
- A 16% discount rate represents a typical residential building decision-maker aiming for a ~6-year simple payback period on any building investments.

SINGLE FAMILY RETROFIT: The addition of basic shell to electrification measures increases the cost premium minimally but delivers important benefits including comfort and reduced grid impacts.

Single Family Detached Home, Pre-1980, Climate Zone 6A, Upstate NY: Ducted ccASHP plus HPWH retrofit (no shell upgrade)

Single Family, Pre-1980, Climate Zone 6A, Upstate NY: Ducted ccASHP plus HPWH retrofit with basic shell upgrade (air sealing and attic insulation)

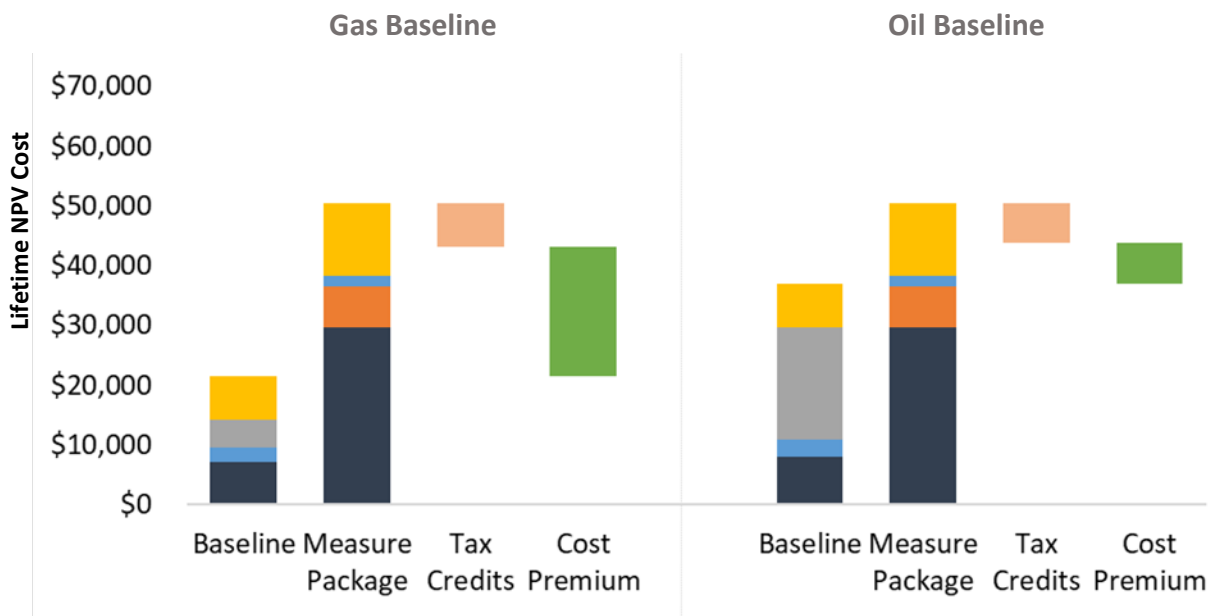


- Combined with a heat pump retrofit, a basic shell upgrade (almost) pays for itself through additional energy bill savings and reduced heat pump sizing; and offers benefits of home comfort and reducing grid impact. **This suggests encouraging basic shell is highly attractive.** At present, no NYS incentive framework (equivalent to NYS Clean Heat for heat pumps) exists for shell measures.

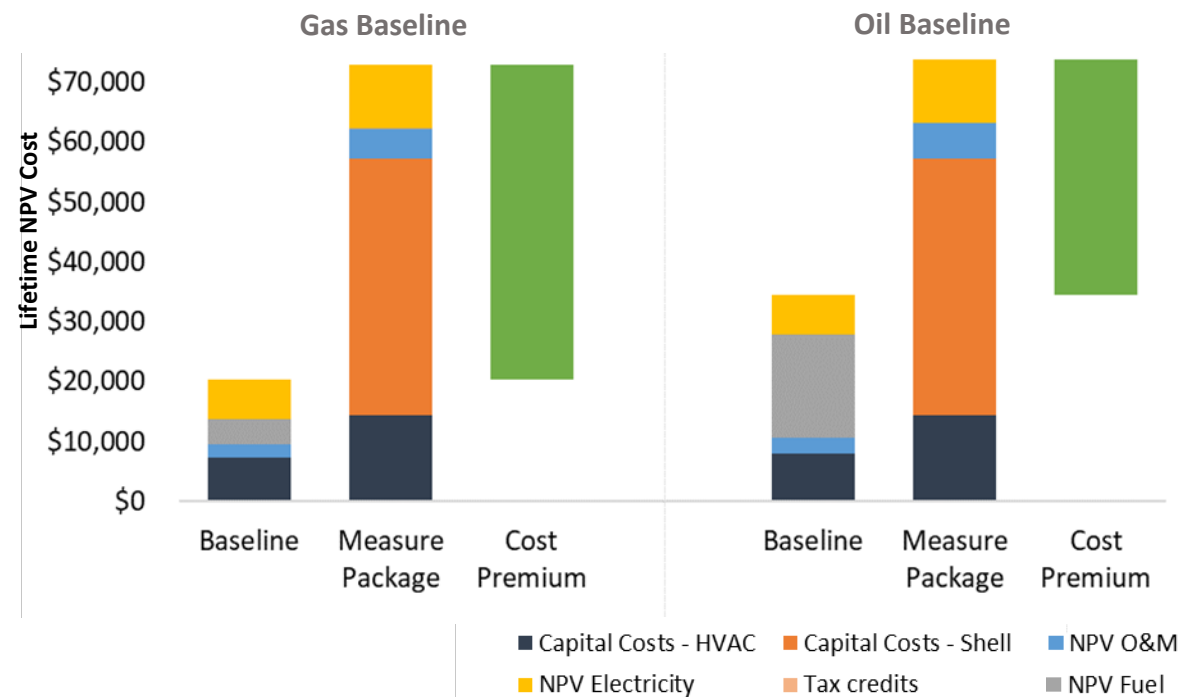
Note: Analysis of the cost premium assumes a 16% discount rate is applied to future energy and O&M costs (savings). A 16% discount rate represents a typical residential building decision-maker aiming for a ~6-year simple payback period on any building investments.

SINGLE FAMILY RETROFIT: Replacing a basic shell with a code-compliant shell upgrade or replacing a ccASHP with a GSHP can provide additional grid benefits. In existing ducted buildings, the cost premium for a GSHP can be similar to a ccASHP, but the code-compliant shell upgrade is much more expensive.

*Single Family Detached Home, Pre-1980, Climate Zone 6A, Upstate NY:
GSHP plus HPWH with basic shell upgrade*



*Single Family Detached Home, Pre-1980, Climate Zone 6A, Upstate NY:
Ducted ccASHP plus HPWH with upgrade to a code-compliant shell upgrade*



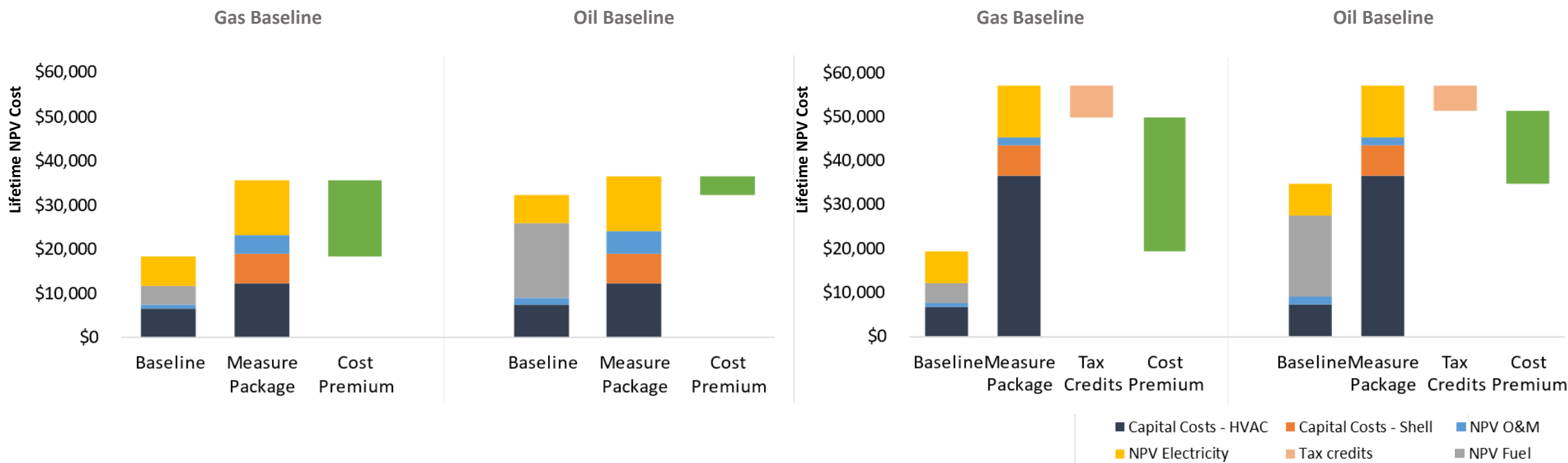
- Compared to the cost premium for ducted ASHP (previous slide), GSHP looks like an attractive option at ducted sites, incurring a similar cost premium but unlocking significant additional grid impact benefits.
- This finding is different at radiator sites (where GSHP are more expensive, see next slide), and depends on the availability of federal tax credits for GSHP.
- By contrast, a deeper shell retrofit to current Code levels incurs a very significant additional cost premium.

Note: Analysis of the cost premium assumes a 16% discount rate is applied to future energy and O&M costs (savings). A 16% discount rate represents a typical residential building decision-maker aiming for a ~6-year simple payback period on any building investments.

SINGLE FAMILY RETROFIT: While GSHP and ASHP have similar cost premiums at sites with existing ducts, at sites with existing radiators, ductless ccASHP have a significant cost advantage over GSHP.

Single Family Detached Home, Pre-1980, Radiator Heating, Climate Zone 6A, Upstate NY: Ductless ccASHP plus HPWH with basic shell upgrade

Single Family Detached Home, Pre-1980, Radiator Heating, Climate Zone 6A, Upstate NY: GSHP plus integrated HPWH with basic shell upgrade

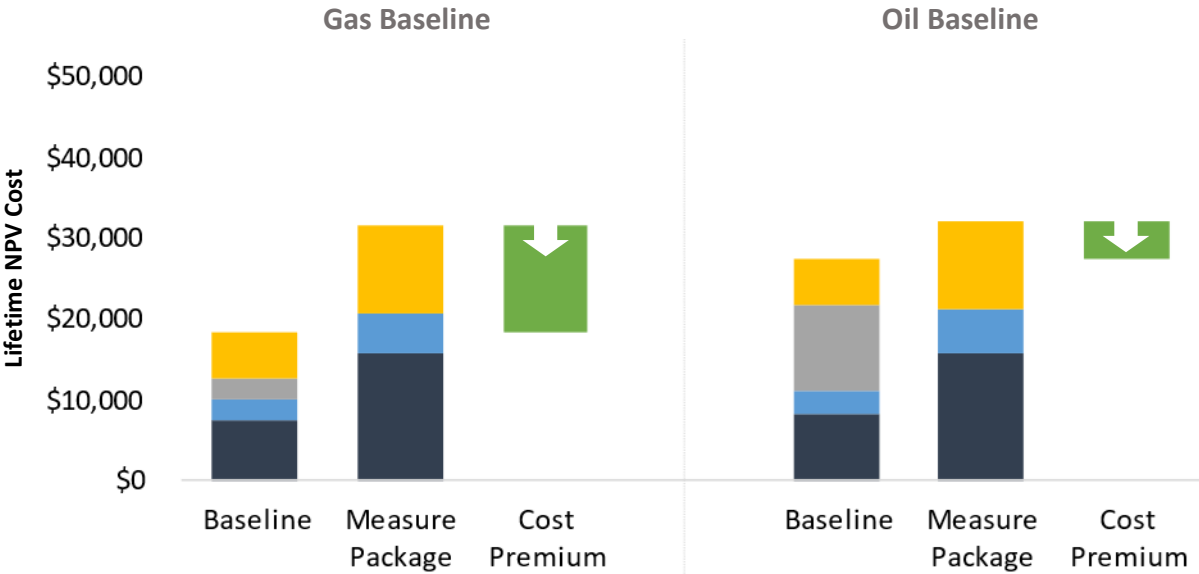


- At a radiator site, the typical expected ccASHP variant would be ductless ASHP, which is cheaper than ducted ASHP.
- GSHP at radiator sites are more expensive than at ducted sites (requiring installation of an air handler and partial ductwork).
- Accordingly, based only on cost premium, ductless ASHP appear more attractive than GSHP at radiator sites.**
- When considering either GSHP or deep shell as options to reduce grid impacts, the higher GSHP cost at radiator sites still results in a lower cost premium than a deeper shell upgrade.

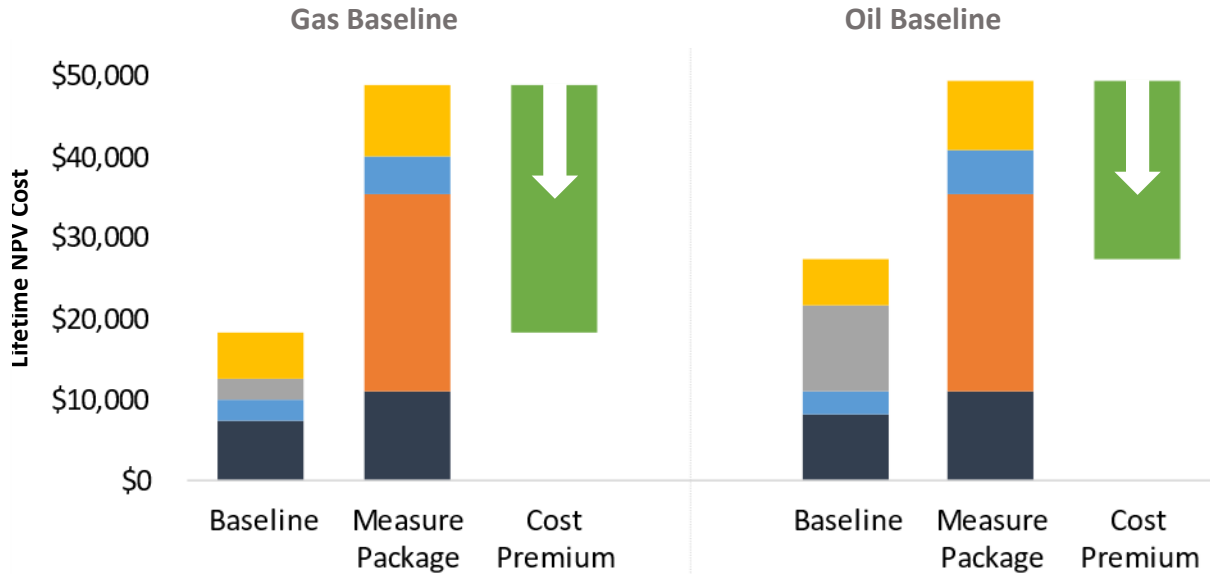
Note: Analysis of the cost premium assumes a 16% discount rate is applied to future energy and O&M costs (savings). A 16% discount rate represents a typical residential building decision-maker aiming for a ~6-year simple payback period on any building investments.

SINGLE FAMILY NEW CONSTRUCTION: Electrification with a code-compliant shell is nearing cost parity with conventional fossil fuel construction. Cost premiums overall are lower in new construction than in retrofits.

Single Family Detached Home, **New Construction**, Climate Zone 6A, Upstate NY: Ducted ccASHP plus HPWH



Single Family Detached Home, **New Construction**, Climate Zone 6A, Upstate NY: Ducted ccASHP plus HPWH with passive house-inspired shell

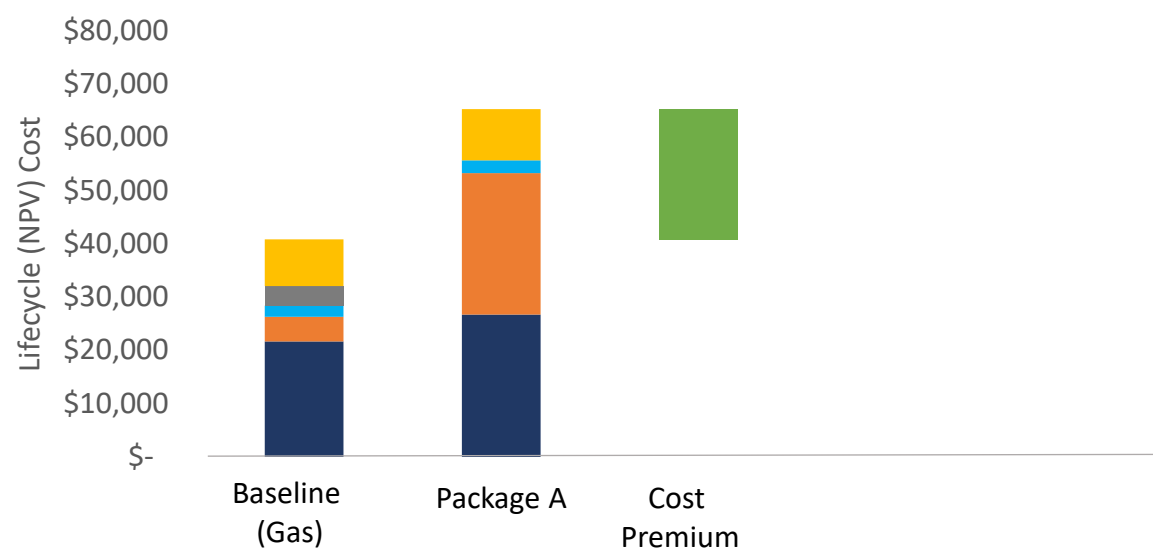


- **The cost premium for electrification in new construction is lower than in retrofit** due to smaller heat pump sizes needed in new construction and because the customer avoids all gas charges.
- Ratepayers also experience the benefit of avoided customer gas connection costs. New home gas connections can range from ~\$3,500 - \$20,000+, varying widely on the extent of infrastructure upgrade required.
- The most ambitious shell interventions show a significant cost premium, though likely with more potential for cost reduction in new construction.
- The arrows indicate potential decreases in the cost premium as a result of integrative design which could reduce costs by up to 50% in new construction.

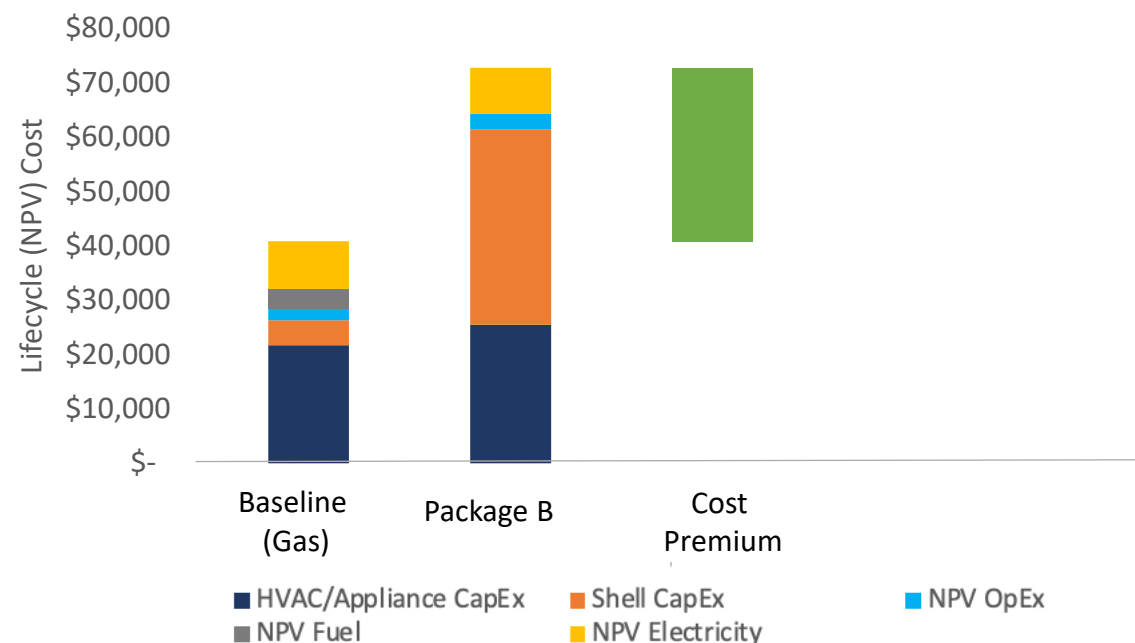
Note: Analysis of the cost premium assumes a 16% discount rate is applied to future energy and O&M costs (savings).

MULTIFAMILY RETROFIT: The shell costs are a bigger driver of project economics than the electrification costs.

7-Story Multifamily, Pre 1980, Cost Per Unit, Climate Zone 4A, NYC: with upgrade to distributed ccASHP, code-compliant shell, HPWH and induction range (Package A)



7-Story Multifamily, Pre 1980, Cost Per Unit, Climate Zone 4A, NYC: with upgrade to Central ccASHP, passive house-inspired shell, HPWH and induction range (Package B)

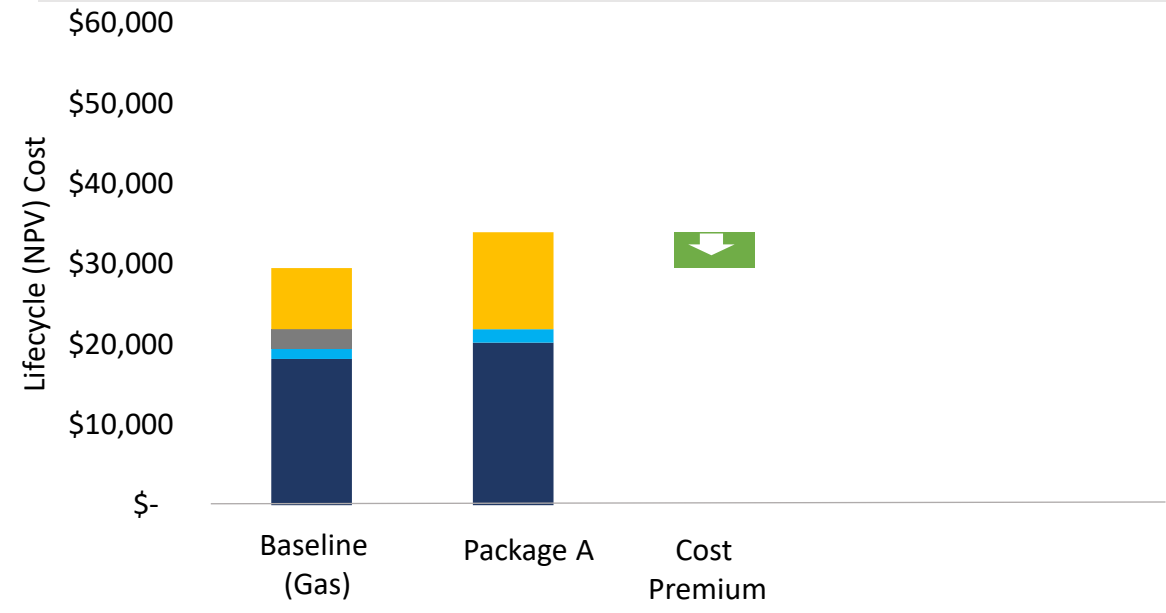


- Improving the shell reduces heating energy use, offsetting some of the more expensive fuel cost of electricity relative to gas.
- An upgrade to a passive house-inspired shell over a code-compliant shell decreases energy costs but still increases the cost premium. However, a code-compliant shell increases grid benefits.**
- Cost compression can play a big role to reduce capital costs. Integrative design does as well, but to a lesser extent in retrofits.

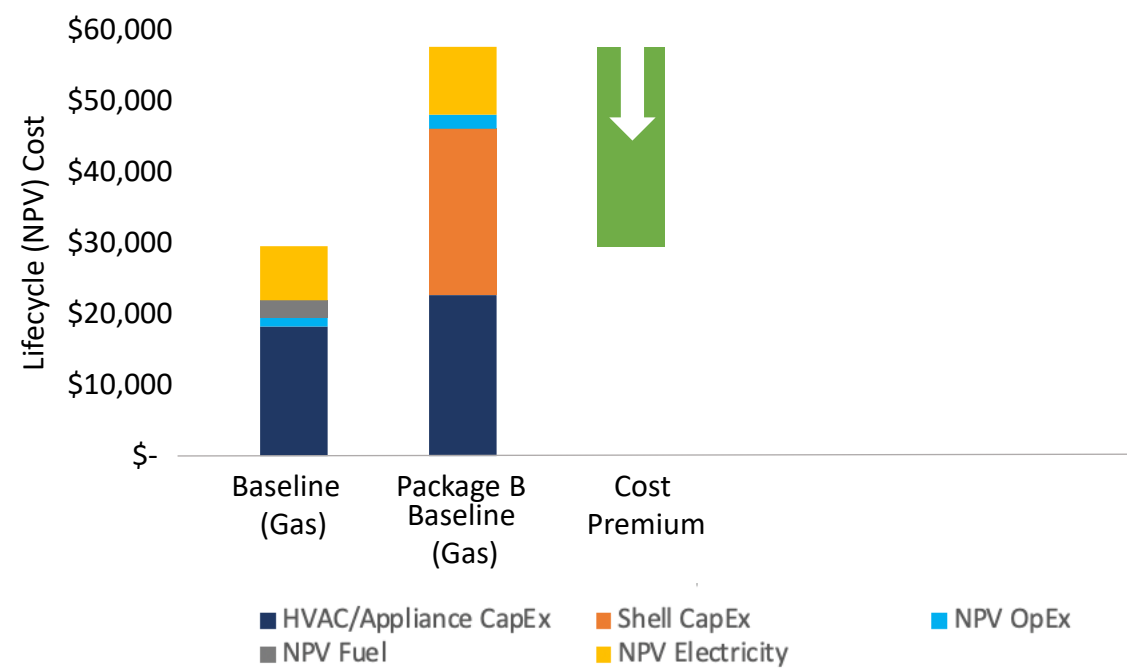
Note: Analysis of the cost premium assumes a 16% discount rate is applied to future energy and O&M costs (savings). A 16% discount rate represents a typical residential building decision-maker aiming for a ~6-year simple payback period on any building investments.

MULTIFAMILY NEW CONSTRUCTION: Electrification with a code-compliant shell is nearing cost parity with conventional gas construction. Cost premiums overall are lower in new construction than in retrofits.

7-story Multifamily, **New Construction**, Cost Per Unit, Climate Zone 4A, NYC: Distributed (ductless) ccASHP with code-compliant shell, HPWH, Induction range, (Package A)



7-story Multifamily, **New Construction**, Cost Per Unit, Climate Zone 4A, NYC: Central ccASHP with passive house-inspired shell, HPWH, induction range, (Package B)



- The primary driver of the Package A cost premium is the higher cost of electricity compared to gas.
- Cost premiums for Package B are in a similar range with data from Buildings of Excellence (BOE), a NYSERDA program that stimulates the design, construction, and operation of very low- or carbon neutral buildings. The average first cost premium for BOE projects is approximately 7% of total construction cost without incentives and 2% of total construction costs with incentives; several reported no first cost premium. Cost premiums decrease as developers gain experience.
- For Package B, prefabrication can drive up to a 30% decrease in total incremental cost, with further cost compression potential in the future.
- The arrows indicate potential decreases in the cost premium as a result of integrative design which could reduce costs by up to 50% in new construction.

Note: Analysis of the cost premium assumes a 16% discount rate is applied to future energy and O&M costs (savings).

Preliminary Findings: Grid Peaks and Building Costs

- Electrification of space and water heating drive building sector decarbonization.
- Building shell upgrades, demand flexibility, and high-efficiency heat pumps (including GSHP) reduce incremental expansion of grid capacity and resulting grid upgrade costs.

Managing Grid Impacts

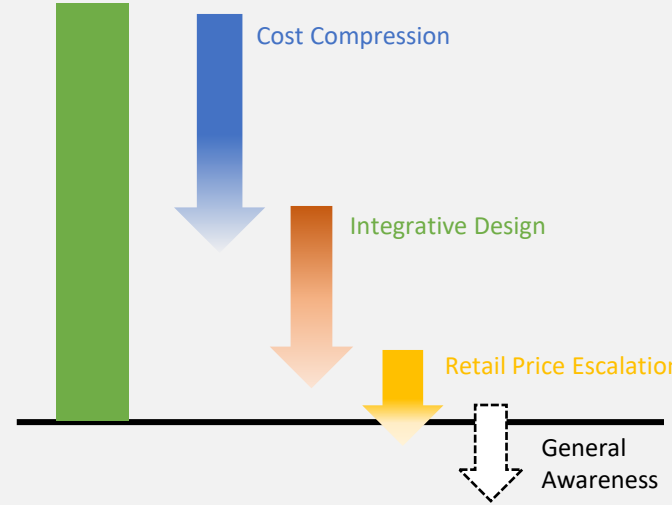
- The inclusion of basic shell upgrades with electrification is cost effective, offering a significant reduction in grid peak increase at minimal/no additional cost premium compared to electrification only.
- Ground source heat pumps (GSHPs) – where technically feasible – can offer greater grid benefits when paired with a basic shell than air source heat pumps (ASHPs) paired with deeper shell measures.

Building Costs

- Decarbonization packages currently have a cost premium compared to fossil fuel baseline packages, due to both higher upfront costs and higher energy costs in some cases.
- Deep shell measures incur the highest cost premiums; however, there are opportunities to reduce these costs in new construction and multifamily retrofits.
- Cost premiums can be mitigated through cost compression as the market scales, integrative design, and other influencing factors.

Preliminary Findings: Cost Compression and Factors that Influence Project Economics

Key influencing factors can bring 20-year cost to parity with natural gas heating and conventional building systems

Summary of Findings	<ul style="list-style-type: none">Improving cost effectiveness of building decarbonization upgrades for the customer involves addressing both technology first cost and energy/operational lifecycle cost.There is no silver bullet – no individual influencing factor can bring the current 20-year cost premium to cost parity. It will require multiple strategies to reduce cost premium.	<div data-bbox="1793 258 2461 332">Cost Reduction Potential</div> <div data-bbox="1793 332 2461 1039"><p><i>Example Graphic</i></p><p>20-Year Cost Premium</p><p>Key influencing factors can bring 20-year cost to parity with natural gas heating and conventional building systems.</p></div>
20-Year Cost Premium	<ul style="list-style-type: none">The average 20-year cost premium equates to 1-5% of total building cost for all-electric new construction with a code-compliant shell and 2-15% for all-electric new construction with a passive house-inspired shell. Varies per typology, vintage and climate zone.The low relative cost of gas compared to electricity is a major challenge. Some building decarbonization measures result in higher annual energy costs than the natural gas comparison cases.The 20-year cost premiums are higher for upgrades in Climate Zone 4A (New York City) as compared to Climate Zones 5A (Buffalo) and 6A (Massena). This is due to higher electricity costs, labor costs and material costs downstate.In general, residential buildings have a larger cost premium than commercial buildings.Cost compression and integrative design savings are the biggest drivers of cost reduction. Cost compression could provide 15-55% reduction in upfront cost. Integrative design in new construction could reduce costs by up to 50%.	

Drivers of Cost Compression

1. Scale and Supply Chain Innovation

- **Increased demand drives investment in automation and innovation in manufacturing and the supply chain.** Especially for prefabricated panels and high-performance glazing.
- Mandates, HVAC/appliance standards, low interest finance, and performance targets can send positive market signals, reduce risks, generate demand, and increase scale.

2. Designer & Contractor Education

- **Contractor education on right-sizing designs, integrating controls, efficiency measures, and installation best practices reduces costs** for heat pump water heaters and heat pumps, especially for single family homes.
- Vermont, Maine, and Boulder, Colorado, have demonstrated successes.

3. Removing Regulatory Roadblocks and Perceived Technology Risks

- **Streamlined permitting can support greater contractor adoption of technologies that are perceived as higher risk** (e.g. prefab panels, GSHP, and Integrated Mechanical Systems).
- Encouraging streamlining through standard approval processes, appropriate regulation for new and innovative use cases.
- Adoption “playbooks,” and sponsoring data collection to reduce the contractor burden of proof can support reduce de-risk technologies.

4. Technology Innovation

- **Improved efficiencies, larger unit sizes for non-residential heat pumps, and real-world testing and refinement of Integrated Mechanical Systems can reduce costs per ton.**
- Challenges (e.g., SunShot or Global Cooling Prize) or creating performance thresholds for incentives will help drive manufacturers to innovate and reduce costs and/or improve efficiencies.

Areas Requiring Additional
Research and Analysis

Areas Requiring Additional Research



What is the optimized distribution of grid sector expansion vs. buildings sector efficiency and behind the meter demand flexibility in terms of costs and benefits?



What is the potential value of the co-benefits of building sector decarbonization (e.g., reduced healthcare costs, increased resilience, benefits to disadvantaged communities, job creation and productivity, and performance benefits)?



What is the right package of mandates and incentives to support decarbonization and equity?

Appendix

Potential co-benefits warrant additional research and quantification as a part of the Climate Action Council process

- In addition to emissions reduction, investment in building decarbonization has many potential co-benefits as indicated by the studies referenced below.
- Future analysis should further explore and quantify these co-benefits for New York State.

Reduced Healthcare Costs	Benefits to Disadvantaged Communities	Resilience	Job Creation	Productivity and Performance
<ul style="list-style-type: none">• Avoided healthcare costs for reducing energy usage by 15% for NYC would be the highest in any city across the US, per ACEEE and NRDC• Decreases in pollution in NY will reduce hospital visits from respiratory related illnesses, according to an NYC Health report.• UCLA projects \$3.5 billion in annual health benefits from outdoor air quality improvements due to residential electrification in CA.	<ul style="list-style-type: none">• Since 35% of benefits will directly be invested into disadvantaged communities, this translates to \$4 billion annual benefits for disadvantaged communities, RMI suggests.• The median energy burden for low-income housing in NYC is 3.3 times higher than non-low income households.• Energy efficiency targeted at these households will help alleviate some of that burden.	<ul style="list-style-type: none">• Investment in upgrading the building stock can improve resiliency.• For example, according to the National Institute of Building Sciences, using federal mitigation grants provided for building improvements yields \$6 in benefits for every \$1 invested.	<ul style="list-style-type: none">• 2025 NENY Target is projected to create up to 50,000 new clean energy jobs.	<ul style="list-style-type: none">• According to RMI, net zero energy commercial buildings can lead to increases of productivity of 6-16%.

Scenario Analysis – Policy Implementation – Buildings Impacted & Measures Required

SCENARIO SUITE

1. Building Codes

Energy use intensity thresholds and zero site-based emissions (all electric) requirements for new construction and major renovations.

2. Building Performance Standards and Required Point-of-Sale/Lease Retrofits

Energy use intensity and zero site-based emissions thresholds for all large buildings. Point of sale / lease triggers for shell efficiency upgrades.

3. Zero-Emission Standards for HVAC / Appliances

Zero-emissions (all-electric) requirement for all new HVAC, water heater, cookstoves, and dryer sales.

4. Achieving Public Building Mandates via Performance Contracting

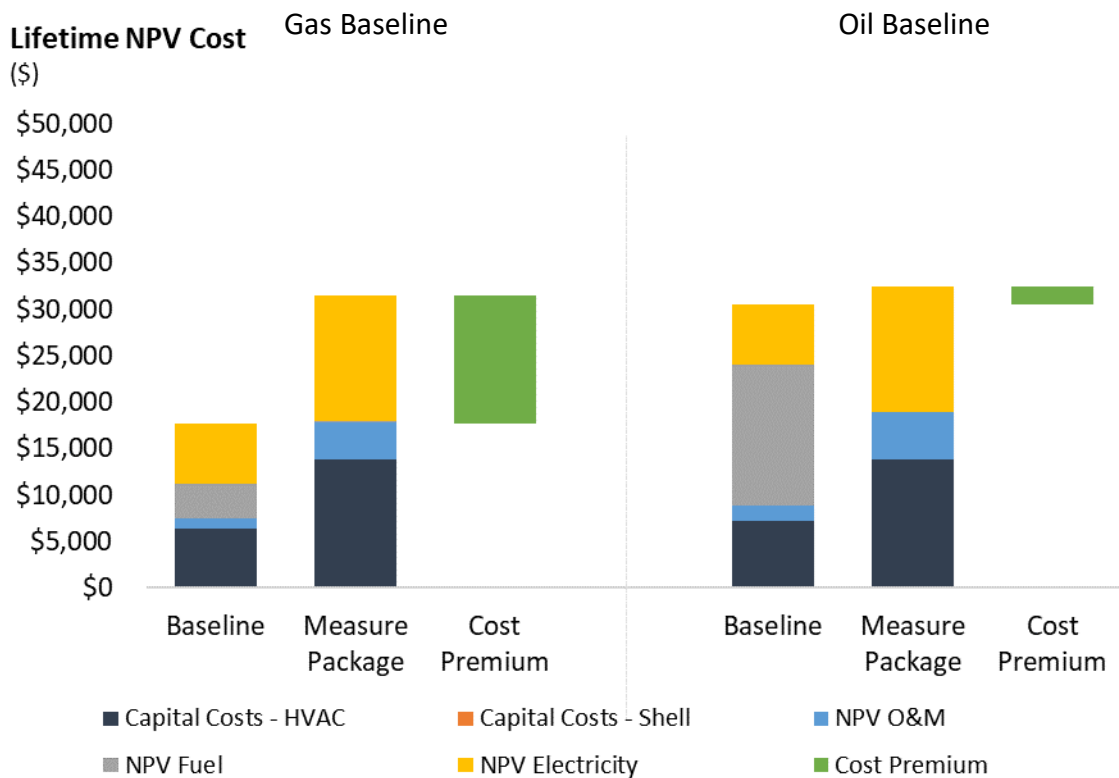
Expanded use of performance contracting to meet public building mandates.

Measures		Building Vintages			Building Sub-Sectors	
Electrification	Energy Efficiency	New Construction and Major Renovation	Existing Buildings Under Natural Replacement Cycle	Existing Buildings Impacted Outside of Natural Stock Rollover	Residential	Commercial
X	X	X			X	X
X	X	X	X	X	X	X
X		X	X		X	X
X	X	/	X	/		X
		(Major Retrofit Only)		(If cost-effective for the site)		

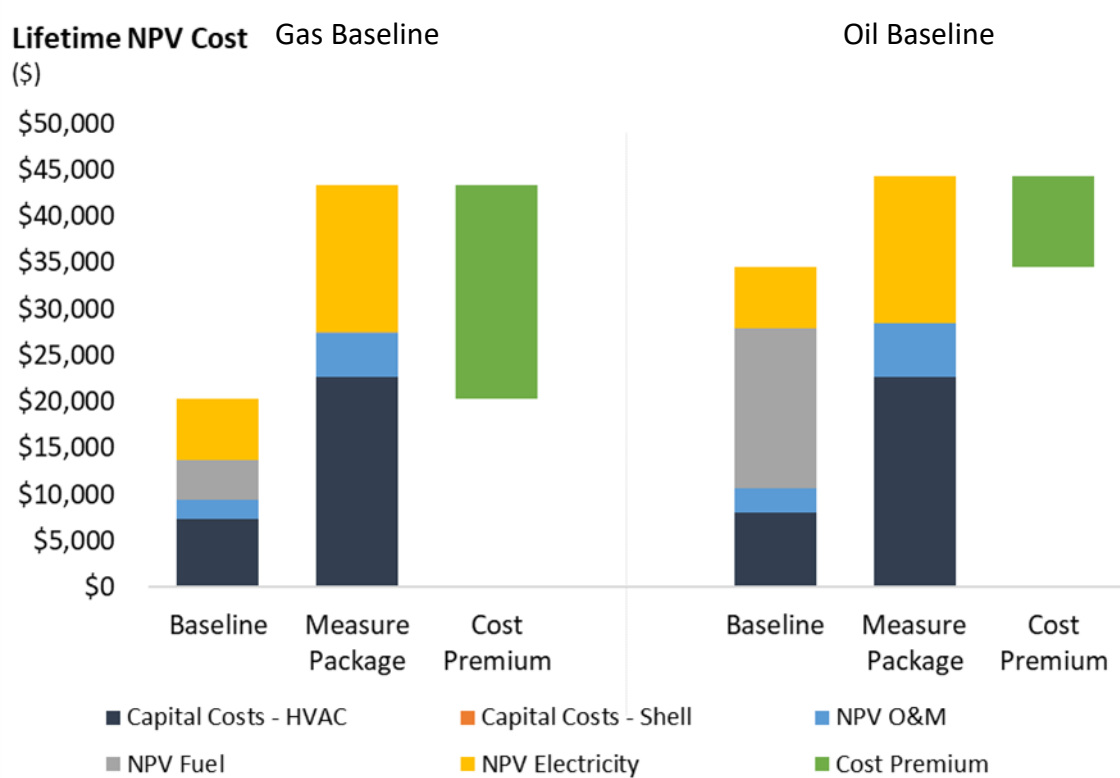
Additional Building Level Project Examples

SINGLE FAMILY RETROFIT: Heat pumps are typically more cost-effective replacing oil than replacing gas. Whole-house ductless ccASHP are typically more cost-effective than ducted ccASHP.

Single Family Detached Home, Pre-1980, Climate Zone 6A, Upstate NYS:
Ductless ccASHP plus HPWH retrofit



Single Family Detached Home, Pre-1980, Climate Zone 6A, Upstate NYS:
Ducted ccASHP plus HPWH retrofit

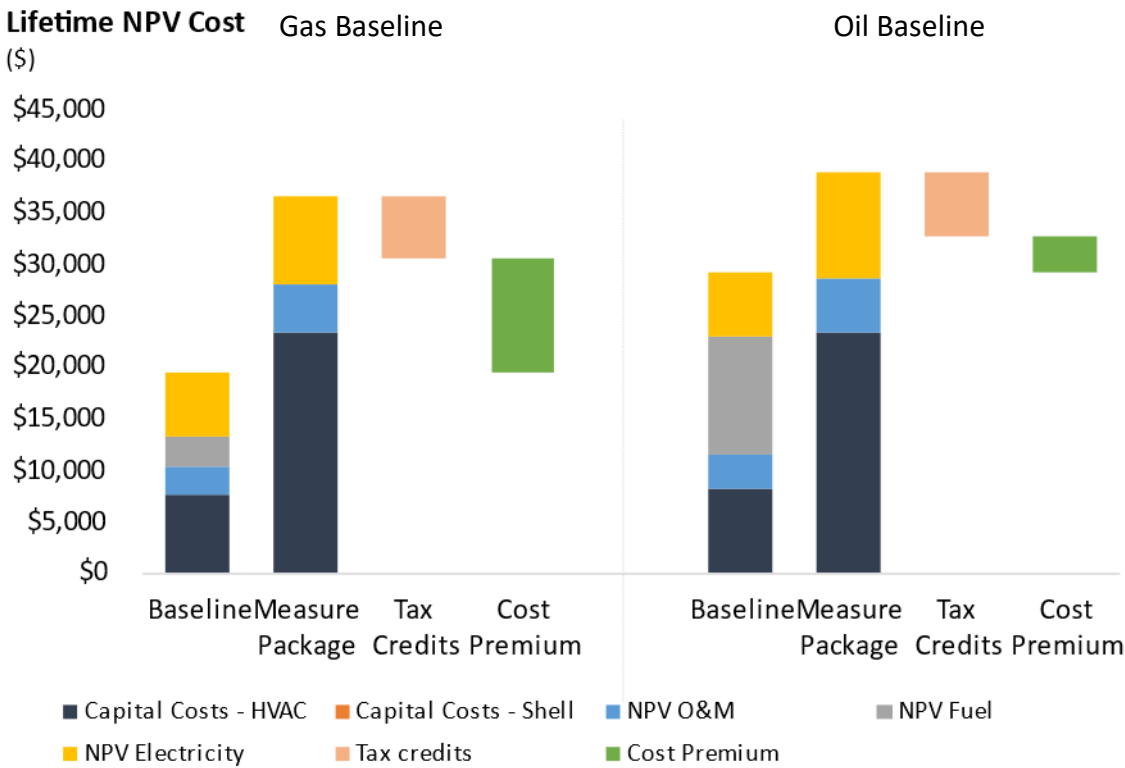


- Low (or negative) bill savings for gas replacements drive higher cost premium
- Higher upfront cost of ducted ccASHP drives higher cost premium

Note: Analysis of the cost premium assumes a 16% discount rate is applied to future energy and O&M costs (savings). A 16% discount rate represents a typical residential building decision-maker aiming for a ~6-year simple payback period on any building investments.

SINGLE FAMILY NEW CONSTRUCTION: Cost premium for GSHP (after federal tax credit) is similar to that of ducted ccASHP.

*Single Family Detached Home, New build, Climate Zone 6A, Upstate NYS:
GSHP (serves heating, cooling and hot water load)*



Note: Analysis of the cost premium assumes a 16% discount rate is applied to future energy and O&M costs (savings). A 16% discount rate represents a typical residential building decision-maker aiming for a ~6-year simple payback period on any building investments.