Carbon Neutral Buildings Roadmap

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

Public Webinars – Day 1
June 15, 2021

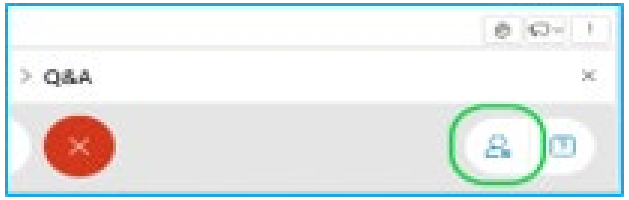
NEW YORK STATE OF OPPORTUNITY. | NYSERDA

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 [icon] when your microphone is muted



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

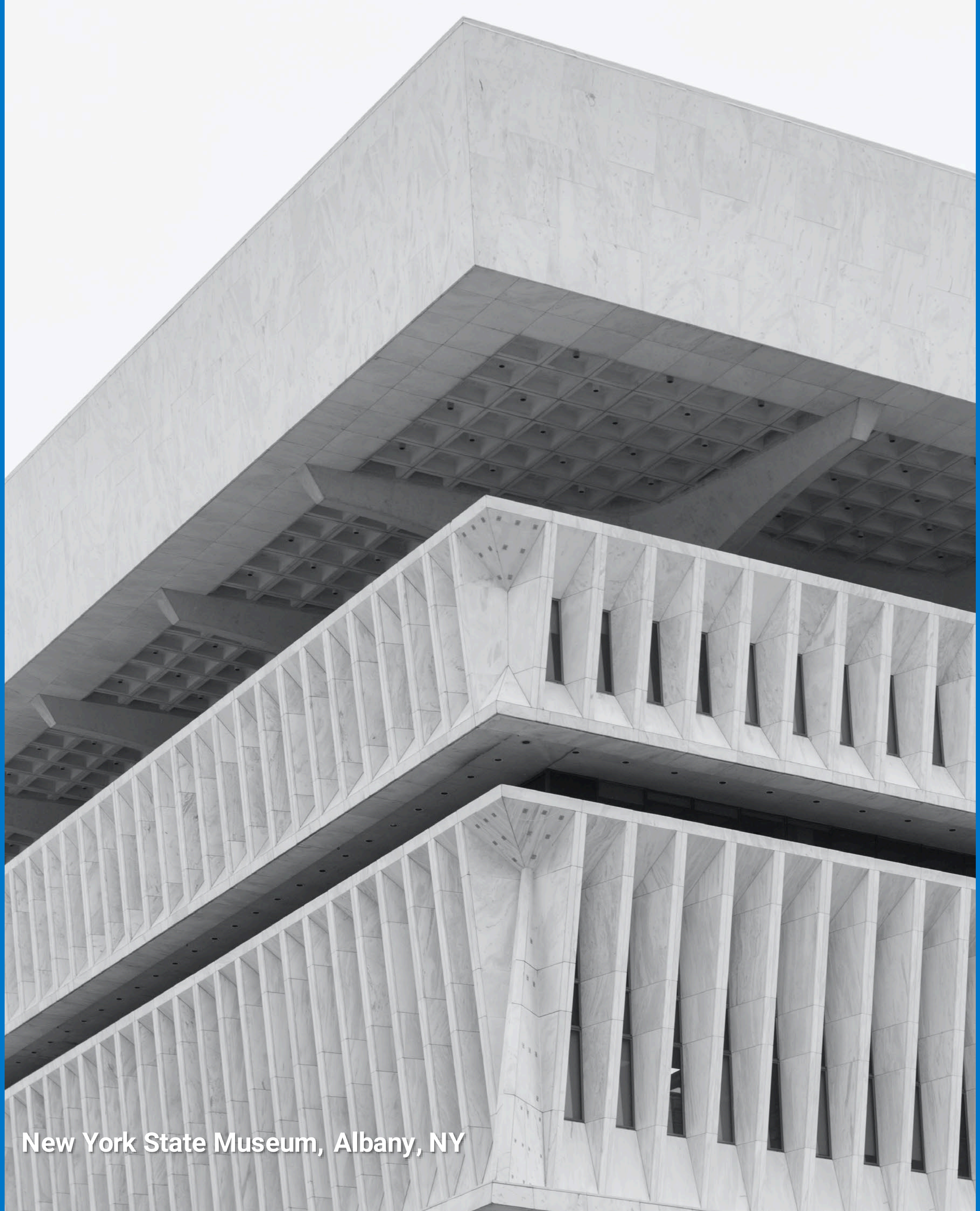
NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Roadmap Overview: Day 1

Concepts Covered

- Definitions for carbon neutral buildings
- Metrics for carbon neutral buildings
- The New York building stock
- Technologies for carbon neutral buildings
- Building electrification
- Limits to electrification
- Resiliency

NEW YORK STATE OF OPPORTUNITY. | NYSERDA



Doreen Harris

NYSERDA

President and CEO

Roadmap Presentation Speakers

Greg Hale

NYSERDA

Senior Advisor for Energy Efficiency Markets & Finance

Mikhail Haramati

NYSERDA

Carbon Neutral Buildings Fellow

Cara Carmichael

Rocky Mountain Institute

Principal

Dan Aas

Energy and Environmental Economics, Inc. (E3)

Director

Amanda Stevens

NYSERDA

Senior Project Manager, Environmental Research

Chapter 1: Introduction

Climate change is a reality. **New York State is fighting it.**

- Committed to the most aggressive clean energy and climate agenda in the country
- Climate Leadership and Community Protection Act (Climate Act) goals empower every New Yorker to fight climate change at home, at work, and in their communities

Kathleen Grimm School for Leadership and Sustainability at Sandy Ground (P.S. 62), New York, NY

New York State’s carbon reduction target requires transformation of the built environment

- Climate Act goals look to **reduce carbon emissions by 85%** by 2050 across sectors.
- Buildings contribute **~30% of total direct carbon** emissions.
- Roadmap is prioritizing building decarbonization **policy recommendations** and **technology RD&D** centered on cost reduction, innovation, grid flexibility, equity, and societal benefits.

New York State Clean Energy Goals

Climate Leadership and Community Protection Act (Climate Act)

now

CLEAN ENERGY ECONOMY
nearly 159,000 clean energy jobs

by 2025

RENEWABLE ENERGY
6,000 MW of distributed solar

RESILIENT and DISTRIBUTED GRID
1,500 MW of energy storage

ENERGY EFFICIENCY
185 TBtu end-use savings
in buildings and industrial facilities

by 2030

RENEWABLE ENERGY/
CLEAN ENERGY STANDARD
70% electricity from renewable energy

GHG REDUCTION
40% reduction in greenhouse
gas emissions from 1990 levels

3,000 MW of energy storage
30,000 employed in storage sector

by 2035

RENEWABLE ENERGY
9,000 MW of offshore wind

by 2040

CLEAN ELECTRICITY
100% zero-emission
electricity

by 2050

GHG REDUCTION
85% reduction in greenhouse
gas emissions from 1990 levels

Requires 35% with a goal of 40% of the benefits from clean energy investment to flow to disadvantaged communities.

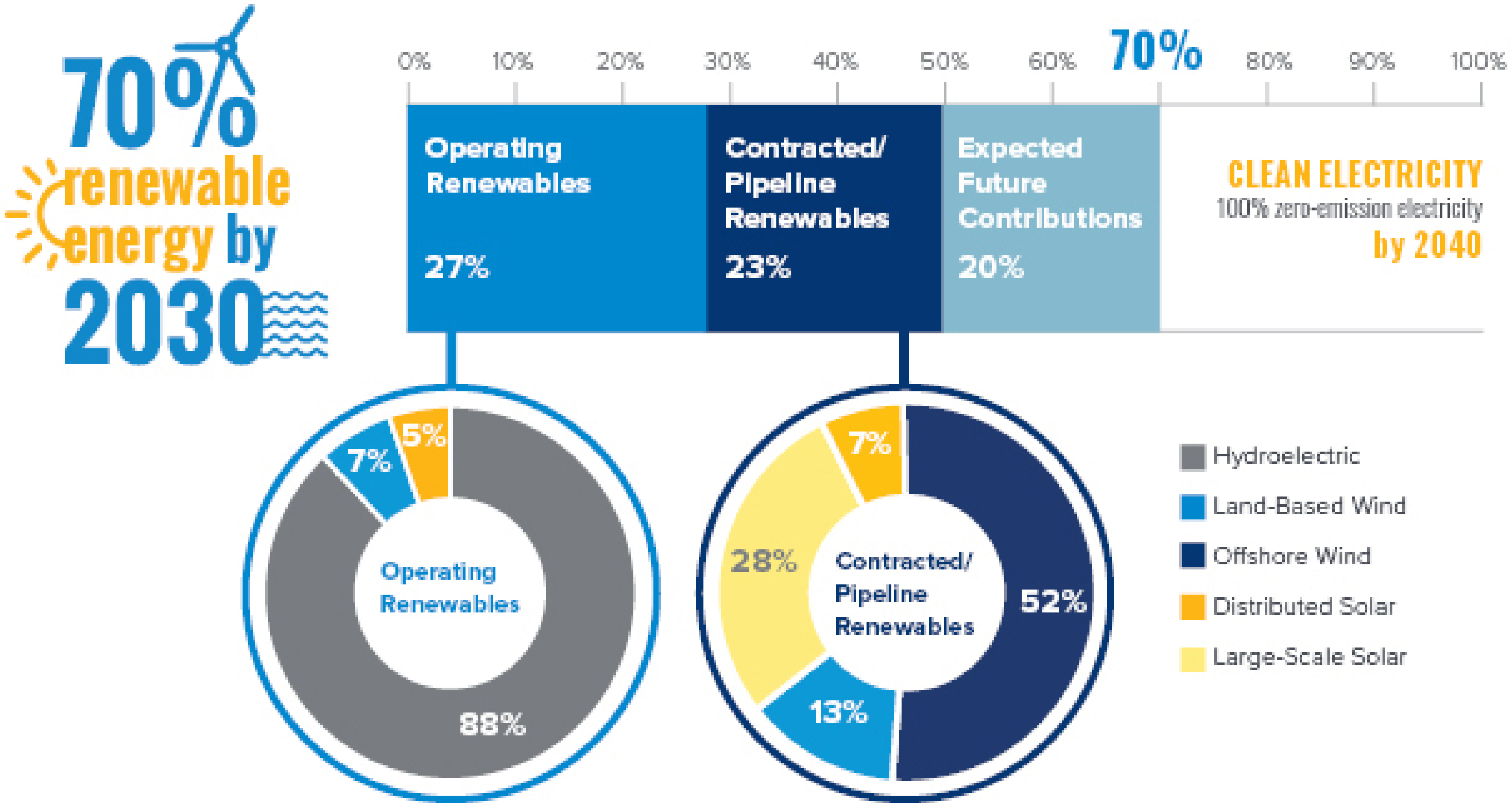
Established a Climate Action Council

- The **22-member Council** is developing a scoping plan to put New York on a path to carbon neutrality.
- Co-chaired by Department of Environmental Conservation and NYSERDA.
- Includes two governor, four Senate, and four Assembly appointments as well as representatives from a broad set of New York State agencies:

-Department of Transportation
-Department of Health
-Empire State Development
-Department of Agriculture and Markets
-Homes and Community Renewal
-Department of Labor
-Public Service Commission
-NY Power Authority
-Long Island Power Authority
-Department of State

New York's Clean Energy Standard

Combined with the existing baseline of renewable facilities, the current pipeline of renewables already under contract and in-development projects will power 50% of New York's electricity once operational.



NEW YORK STATE OF OPPORTUNITY. | NYSERDA


Solara Apartments, Rotterdam, NY

Achieving carbon neutral buildings by 2050

This leading-edge goal requires acceleration or improvement of:

- electrification of thermal loads
- thermal performance of building envelopes
- ability of buildings to store and/or shift energy use and interact with the electric grid
- supplying energy loads from zero emissions resources

Transforming the buildings market by 2050

New Construction

Design and deliver economic, zero emissions buildings.

Existing Buildings

Retrofits in existing buildings are critical to success.

Strategic Sector Focus

- Single-family residential
- Low- and mid-rise multifamily
- Office buildings
- Higher education

Roadmap scope

A common definition and understanding of carbon neutral buildings

Studies to showcase **construction practices and technologies useable today, and the potential for technology cost reductions**

Modeled solutions focused on **building electrification** and **grid implications**

Explains the **business case** for carbon neutrality

Recommends **policy solutions** to ratchet down emissions and reduce cost

Solutions-focused for impact

Managing the cost

There are commercially available solutions in the market today that we expect to have significant cost reduction in the future.

Technology ready

The solutions rely predominantly on off- the-shelf tech and those with a demonstrable RD&D path. Also, seeks technology gaps that can be bridged with focused investment.

Policies drive scale

Policy solutions support speed and scale and lead to equitable job creation, resiliency, and greater societal benefits.

Solutions-focused for impact

Prioritizing disadvantaged communities

Decarbonization solutions must directly benefit disadvantaged communities with investment and better access to jobs.

Focusing on load flexibility

Grid interactive building solutions will provide cost and carbon benefits to both owners and grid operations, and are an essential, emerging decarbonization solution.

Engaging stakeholders

Multi-stakeholder processes and engagement are critical to drive robust and equitable solutions in the varied communities across the State.

Chapter 2: Defining and Measuring Carbon Neutrality

A carbon neutral building is one where the **design, construction, and operations do not contribute to emissions of greenhouse gases** that cause climate change.

Attributes of a carbon neutral building

1 Maximizes energy efficiency

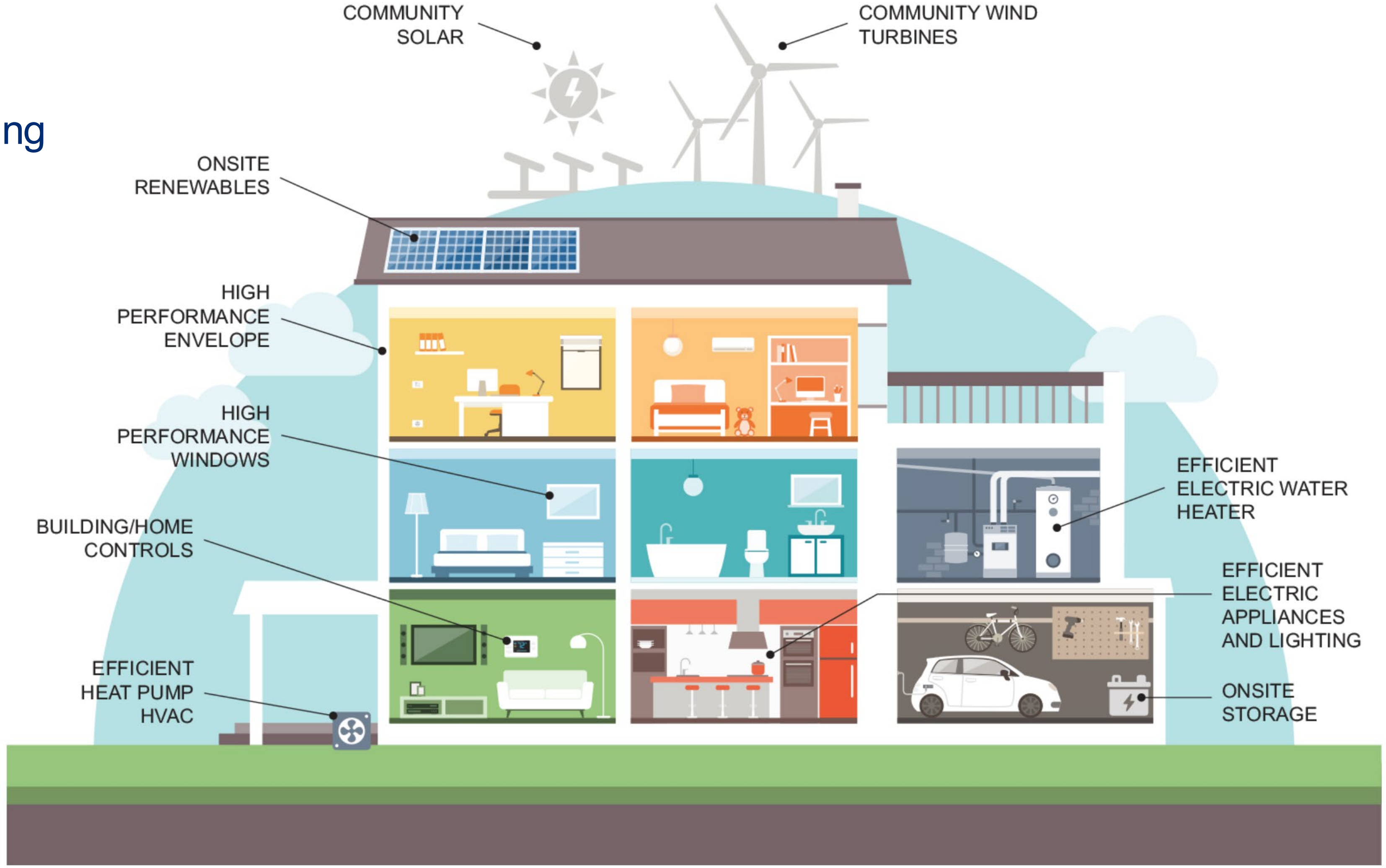
2 No fossil fuel combustion for building energy services (all-electric end uses)

3 Produces or procures zero-emission electricity

4 Designed with flexible loads and/or storage that can respond to grid conditions

5 Features resiliency measures that protect building occupants

6 Designed with attention to embodied carbon and refrigerants



Source: NYSERDA

Metrics for carbon neutral

Metrics to drive three objectives to achieve Climate Act goals.

1. Minimize energy consumption and peak loads.
2. Electrify all possible end uses with 100% zero emission supply, or lowest carbon fuels for that remaining consumption.
3. Facilitate the real-time ability for the building to shift or offset energy loads to be responsive to grid needs and pricing.

A suite of metrics is needed to send clear market signals.

- Site Energy Use Intensity (EUI) and GHG emissions from onsite combustion
- Progress toward decarbonizing the electricity grid
- In combination with any of the above, a measure of Grid Peak Contribution

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Future additions to metrics

Roadmap describes a suite of metrics to determine success in achieving carbon neutrality. Research to define future metrics will include:

1
Optimized peak load flexibility in buildings and grid support

2
Low embodied carbon materials

3
Low global warming potential (GWP) refrigerants

4
Prevention of refrigerant leaks

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Chapter 3:
Our Buildings Today

Climate and geography drive a diverse buildings mix

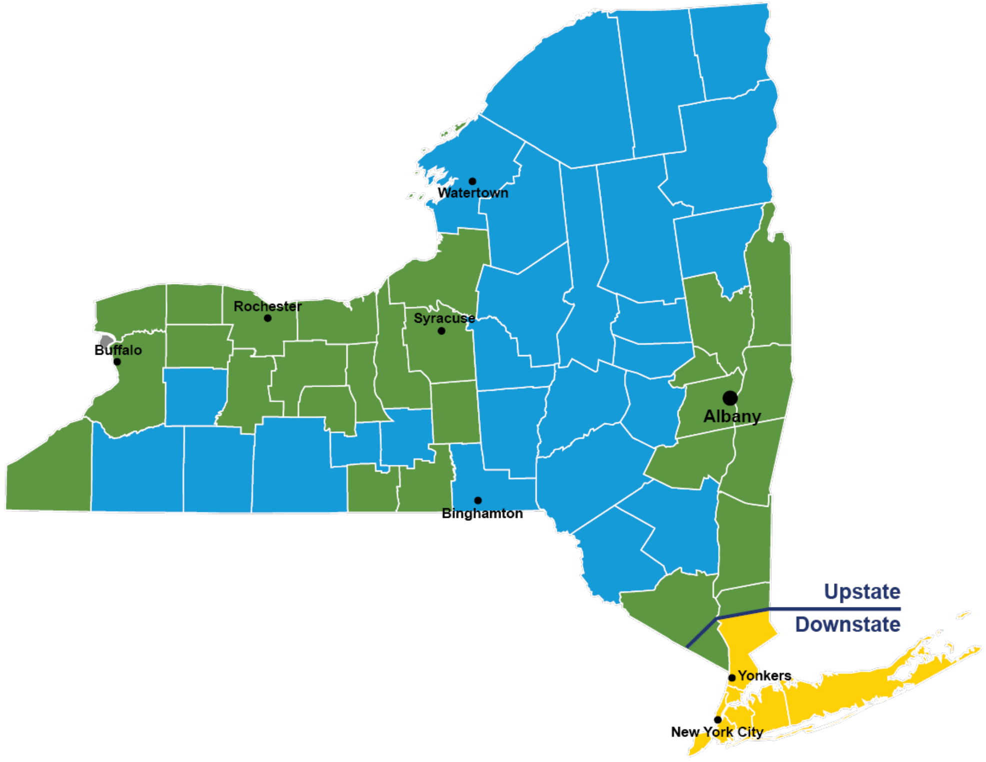
Downstate characteristics

- Mixed-humid Zone 4
- Higher cost of real estate
- High percentage of leased space
- Predominantly urban with taller buildings

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Upstate characteristics

- Colder climate with Zones 5 and 6 which are both cool and humid
- Lower cost of real estate
- Smaller cities and towns with more suburban and rural areas
- Predominantly low-rise buildings

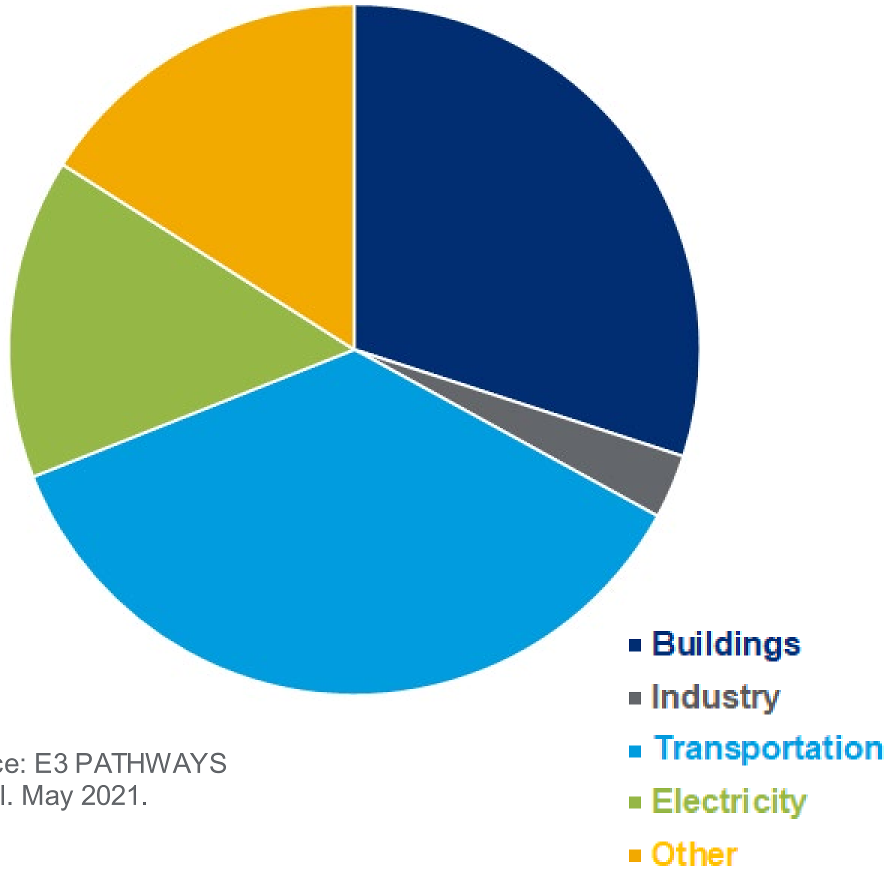


Emissions from onsite combustion

~30%

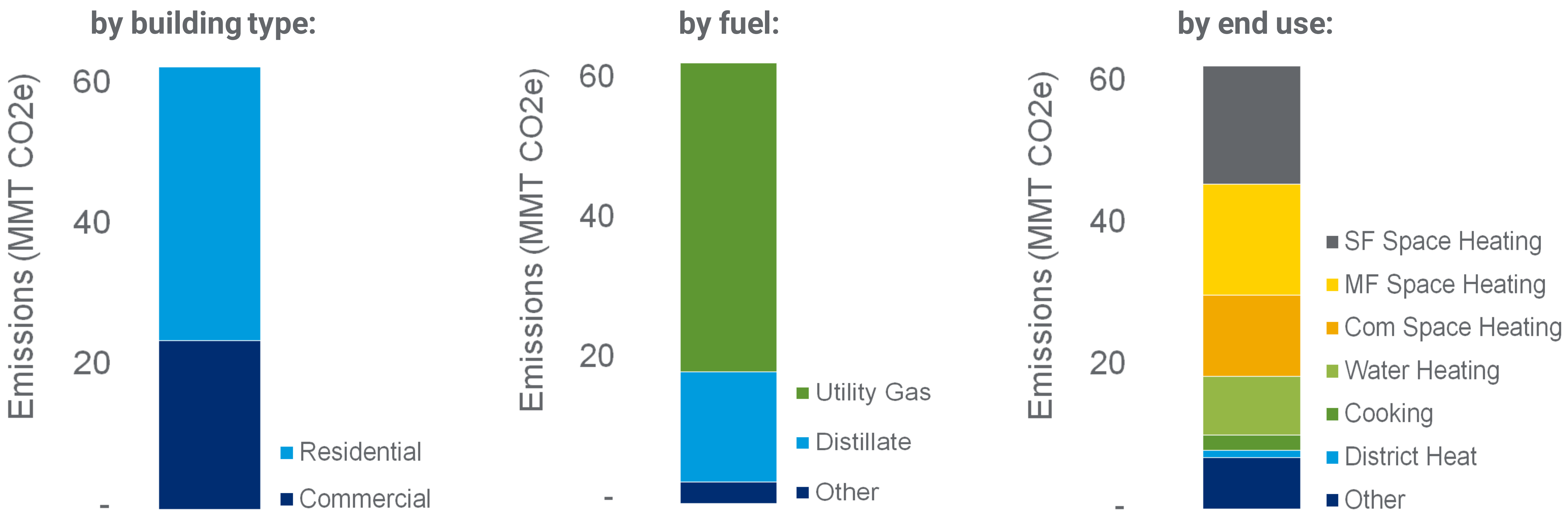
of economy-wide emissions come from direct emissions from residential and commercial buildings through onsite fossil fuel combustion and HFCs.

Economy-wide Greenhouse Gas Emissions



Source: E3 PATHWAYS Model. May 2021.

Residential and commercial building emissions from onsite combustion



Source: E3 PATHWAYS Model. May 2021

Targeting existing buildings

Retrofits of existing buildings are essential to reduce carbon and manage costs.

- Approximately two-thirds of the building area that exists today will still exist in 2050[1].
- Leverage occupant turnover or planned renovations to minimize disruption and optimize opportunities for upgrades.
- Behavior and practice change lead to decarbonization.

6.2 million buildings in New York State

- 4.9 million single family homes
- 250,000 multifamily buildings
- 370,000 commercial and institutional buildings

Scale is required:

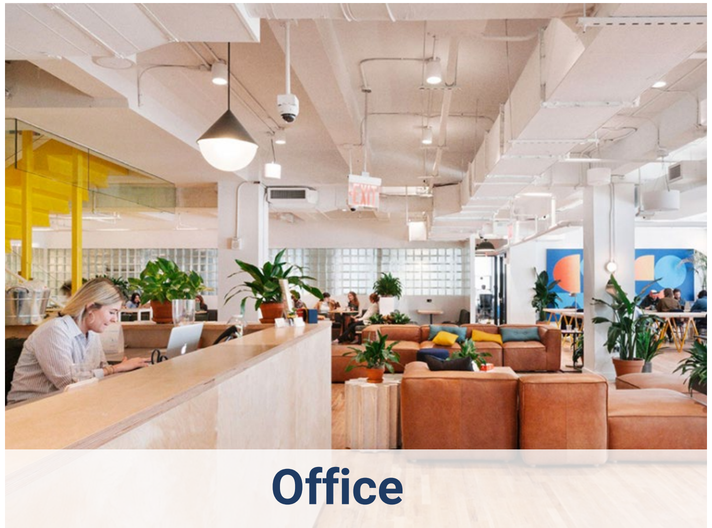
- From 2030 onward, over 200,000 homes per year upgraded to be all-electric and energy efficient.
- By 2050 over 600,000 commercial, institutional, and multifamily buildings need to cut energy use in half and end fossil fuel use.

[1]Architecture 2030. https://architecture2030.org/buildings_problem_why/

Priority building types to create scale


Single-family homes

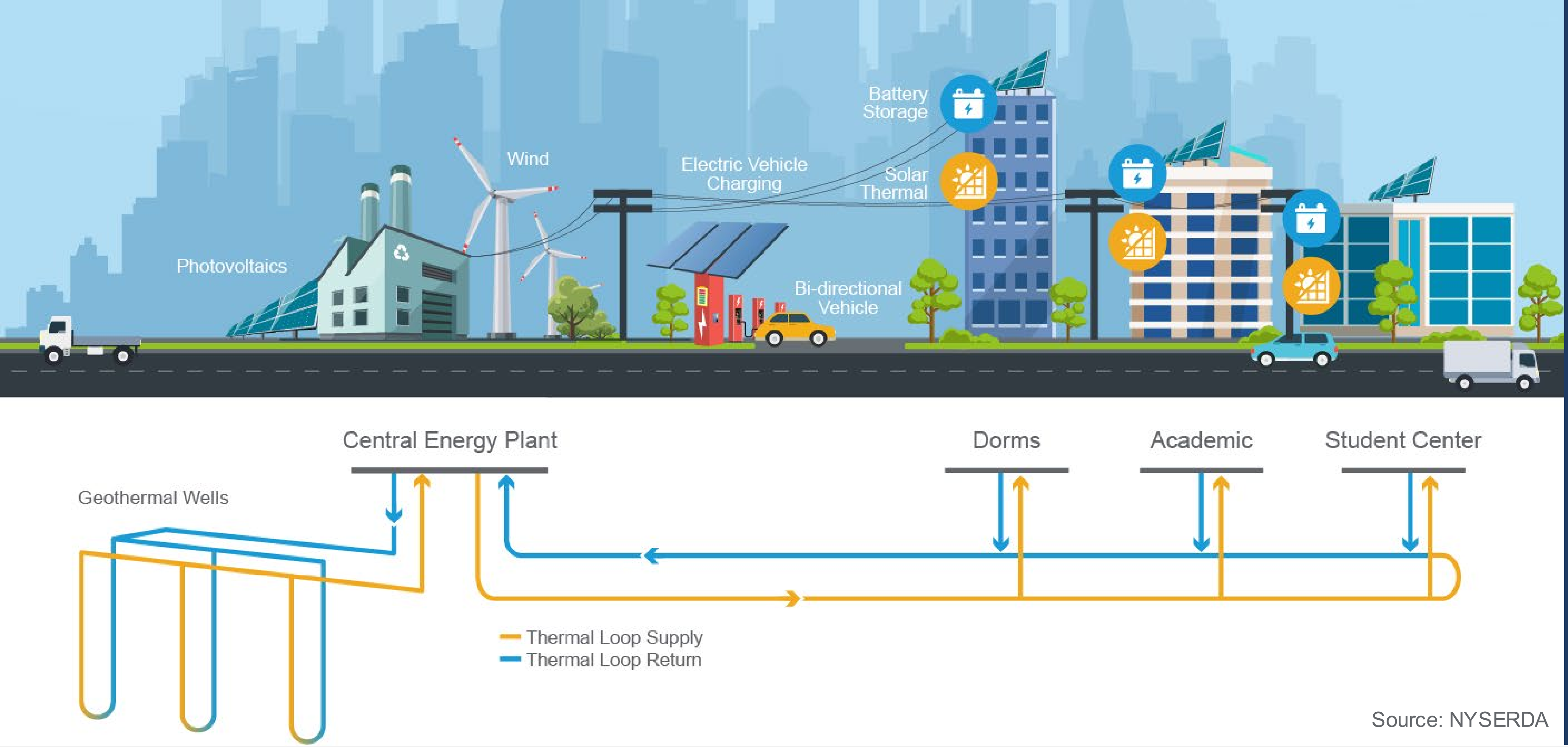

Multifamily


Office


Higher education

~50%

of all building energy use in New York State is represented by these four priority building types



Source: NYSERDA

A Centralized College Energy System

Centralized energy systems produce heating, cooling, and/or electrical power for multiple buildings.

Campuses and communities

Buildings grouped into campuses or communities will have additional flexibility for achieving carbon neutrality by sharing:

- district heating and cooling
- permissible building loads
- storage
- electricity generation

Chapter 4:
Decarbonization Technologies & Building Methods

Technologies to achieve carbon neutrality

Investing in commercialization, workforce development, and expanding the market share of key technologies is critical.

- Scale production and installation
- Reduce carbon emissions
- Minimize disruptions and cost to businesses, homeowners, and ratepayers
- Technology choices impact co-benefits

Outcomes from technology advancement

Cost Reduction

Will help bring down the upfront cost of technologies through manufacturing and supply chain innovation, industry education, removing regulatory roadblocks and reducing technology risks.

Improved performance

Some technologies are commercially available but need ongoing development to improve performance and lower operational cost.

Minimize disruption

Focus on technologies that allow for retrofits without occupant displacement such as integrated mechanical systems and prefabricated panelized solutions.

Low-GHG strategies

Refrigerants and embodied carbon are critical areas of focus in addition to the operational carbon aspects of building decarbonization.

Technology solutions for carbon neutrality

Load Reduction Strategies	▪ High-performance building envelopes ▪ Energy recovery ventilation to optimize heating/cooling demand ▪ LED lighting with occupancy controls ▪ Smart electric appliances, minimized embodied carbon in construction materials
Building Electrification	▪ Cold climate air-source heat pumps (ASHP) or ground-source heat pumps (GSHP) for space heating and cooling ▪ Carbon-free thermal loops in campuses ▪ Heat pump water heaters with storage tanks and demand-flexible controls ▪ Electric induction cooktops and heat pump dryers ▪ Up-to-date electrical capacity and service
Advanced Controls	▪ Load flexibility and advanced controls of hot water, HVAC, and smart appliances
Distributed Energy Resources	▪ Solar PV integrated with battery ▪ Bi-directional Electric Vehicle (EV) charging equipment ▪ Batteries and thermal storage

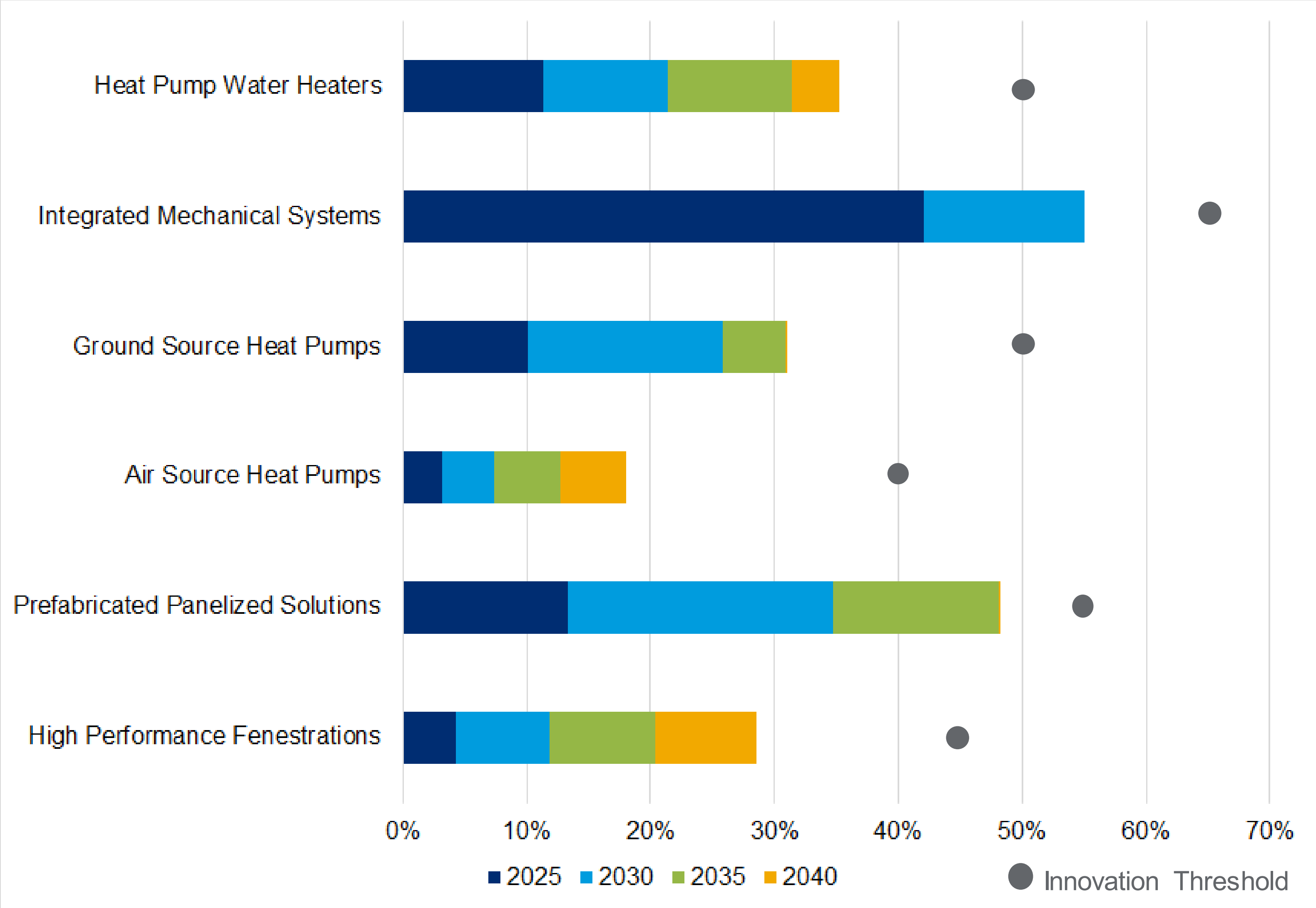
Focus innovation on priority technologies

Load Reduction Strategies	Building Electrification Technologies	Advanced Controls	Distributed Energy Resources (DER)
Air Sealing	**Heat Pumps** (Air-Source Heat Pumps, Ground-Source Heat Pumps)	**Smart Controls**	**Electrical Batteries**
High Performance Insulation	Variable Refrigerant Flow Systems	**Smart Devices and Sensors**	**Thermal Storage**
Thermal Breaks	**Heat Pump Water Heaters**	Metering and Controls Best Practices	Photovoltaic Systems
High performance fenestration	**Integrated Mechanical Solutions**		Solar Thermal
Energy Recovery Ventilators	Induction Cooktops		
Prefabricated Panelized Solutions			
Efficient Lighting			
Smart Electric Appliances			

Energy efficient lighting and energy-efficient appliances have a large amount of market share so while they are important for carbon neutrality, they will not be a major focus for RD&D.

Cost reduction potential to 2040

As percent reduction in total installed cost identified at 5-year intervals



Cost Reduction Analysis
Source: ARUP, RMI. December 2020

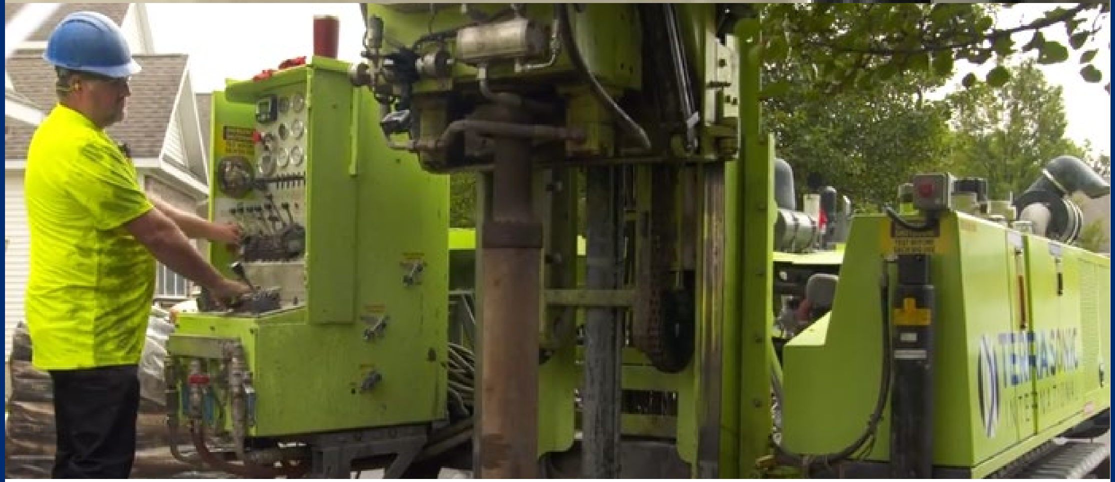
Notes:

1. Cost reduction includes material, labor, commissioning and startup, indirect, and overhead costs.
2. This chart shows the reduction potential for retrofits.
3. These potentials are representative of technologies across all typologies. Integrated Mechanical Systems only apply to residential typologies and are not yet commercially available in the U.S..
4. Cost reduction is in real terms (not nominal). The analysis findings are derived from a study of costs supplemented by a literature review. Not all literature was New York specific.
5. Innovation threshold is based either on identified threshold for widespread adoption in literature or interviews with NYSERDA stakeholders on "moonshot" goals.

Cost reduction

Innovation in ground-source heat pump installation using sonic drilling

- New sonic drilling technology reduces the time and cost of GSHP installation.
- Compact drilling equipment offers opportunities for GSHP installations not serviceable by larger drilling equipment.
- Emerging energy-as-a-service finance solutions offset capital costs.
- Clean energy jobs created.
- Opportunities for further cost reduction: manual J - sizing app, horizontal drilling, database of ground conditions.



Improved performance

Some technologies are commercially available but need ongoing development to improve performance and lower operation expense. Examples include:

- Cold climate air-source heat pumps
- Heat pump water heaters
- Thin/skinny, triple-pane windows
- Panelized solutions
- Battery storage
- Thermal storage

Field studies have shown **cold climate heat pumps can perform well in temperatures below -10°F** based on field tests in Minnesota.

Center for Cold-Climate Air Source Heat Pumps: https://www.mncee.org/blog/july-2018-(1)/cold-climate-air-source-heat-pumps/

Minimize disruption

Investments focused on technologies that allow for retrofits without occupant displacement. These include:

- Panelized retrofits
- Integrated mechanical systems
- Spray foam insulation techniques
- Aerosol-based air sealants

In less than 10 years, Energiesprong was able to achieve **40% cost reduction for panelized solutions, 55% for the mechanical pod, and 60% for the total retrofit cost.**

A multifamily building in the Netherlands before (left) and after (right) an Energiesprong retrofit.

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

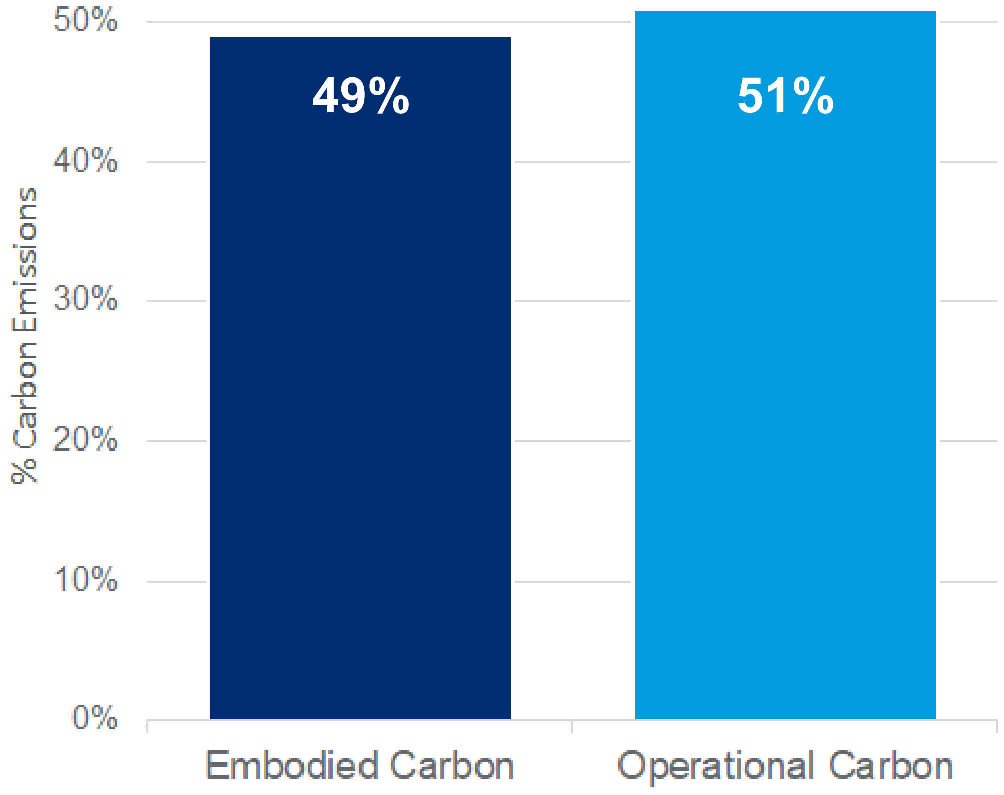
Embodied Carbon

Embodied carbon is a critical area of focus in addition to the operational carbon aspects of building decarbonization.

- Best option is to reuse (retrofit) buildings.
- Conventionally produced concrete, steel, and some insulation products have high embodied carbon.
- Embodied carbon can be reduced by up to 30% in new construction at little or no incremental cost.

Total Carbon Emissions of Global New Construction from 2020-2050

Business as Usual Projection



Graphic Source: Architecture 2030.
Data Source: UN Environment Global Status Report 2017, EIA International Energy Outlook 2017.

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Examples of low-embodied carbon alternatives

Structural and cladding alternatives such as mass timber

Low embodied carbon concrete and other alternatives such as Hempcrete

Insulation alternatives such as cellulose or other bio-based materials

Low global warming potential refrigerants

Further development of low global warming potential (GWP) refrigerants is vital to limiting GHG emissions.

- Common heat pump refrigerants have a global warming potential over 1,000x that of carbon.
- Lowering GWP and limiting refrigerant leaks will be increasingly important with the installation of heat pumps.

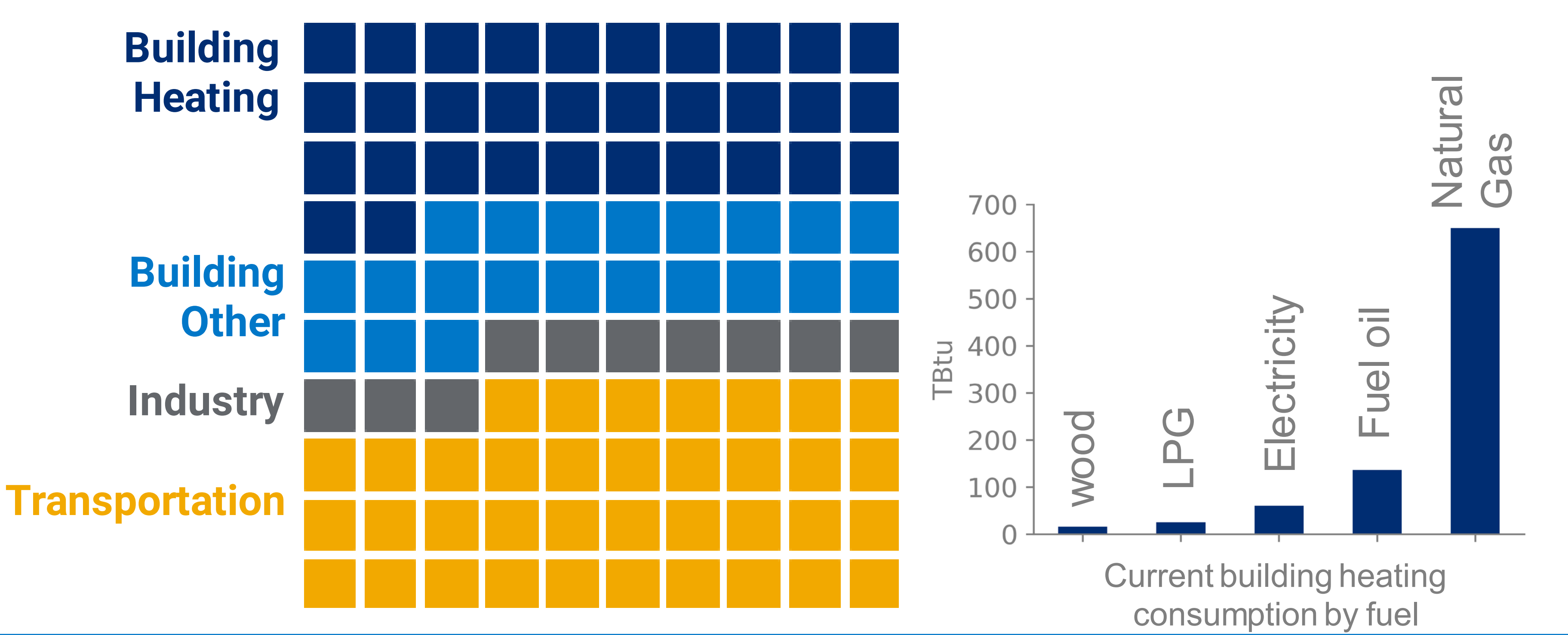
NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Chapter 5:
Building Electrification and the Grid

Heating demand drives on-site building emissions (40% of energy use)

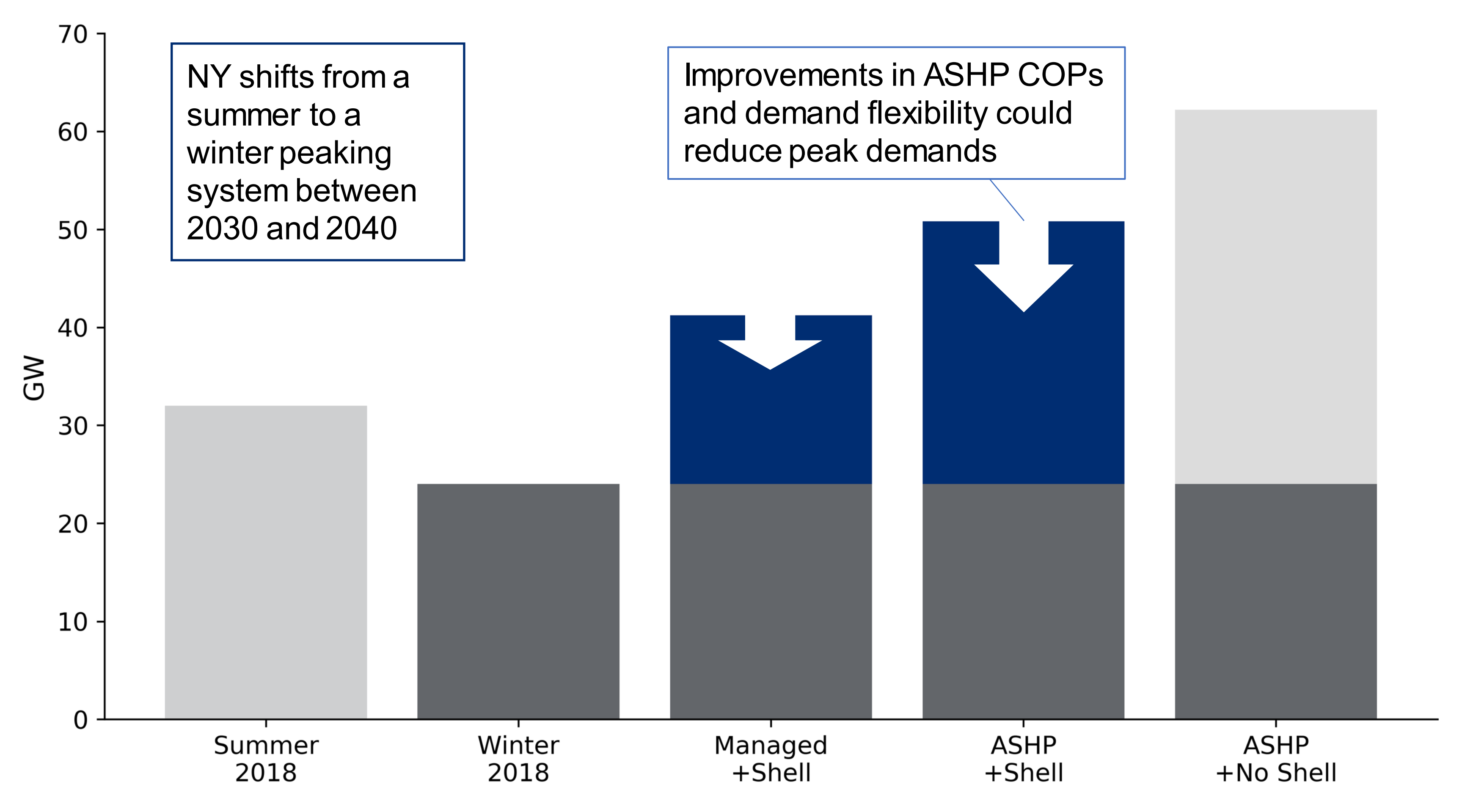
Building heating demands are the second largest source of energy consumption in NYS. Only the transportation sector uses more energy.

Electrification is a core strategy to decarbonize building heating.



New York Final Energy Demands Today, total equals 2.7 quadrillion Btu.

2050 NYS building heating peak demand scenarios



Electrification will add new peak demands to NYS's electric system

The magnitude of those impacts depends on what types of heat pump technologies are deployed and shell investments.

Peak demand of buildings will impact the electric generation and network investments required to achieve NYS's climate goals.

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

ASHP + No Shell: air-source heat pumps that meet the NEEP cold-climate specification minimum
ASHP + Shell: a scenario where 45% of residential and 65% of commercial buildings have an efficient shell
Managed: mixture of air-source heat pumps (40%), ground-source heat pumps (30%) and air-source heat pumps that are paired with a combustion source of supplemental heat (30%). The scenario has the same shell measures as ASHP + Shell.

Managing the impacts of electrification

The shape and magnitude of building electrification loads will have large impacts on the portfolio of electric generation resources required to achieve New York's Climate Act policy goals.

Forced air systems and domestic hot water heaters will be easier to electrify from a technical and cost standpoint than buildings with perimeter radiant heat.

Cost reduction, continued improvements in equipment performance, and moving existing solutions to scale will minimize financial impacts to ratepayers.

Commercialization of lower-GHG refrigerants is important to ensure that building electrification is fully consistent with carbon neutral buildings.

Chapter 6:
Limits to Electrification

Challenging buildings to electrify

Very tall buildings are difficult to electrify due to features like large base energy loads and stack effects.

Buildings with high temperature process loads are less likely to be suitable for heat pumps and costs associated with conversion to electric processes may be prohibitive.

Multi-building central steam plants and district energy systems that use steam face similar issues as process loads. These systems are also long-lived, making end-of-life replacement opportunities more challenging.

Low-carbon fuels may have a role in hard to electrify buildings

In difficult cases, there may be a role for alternative low-carbon and renewable fuels.

However, the role of these fuels in New York's buildings is uncertain given outstanding questions that range from limited supply to technology commercialization to GHG accounting.

Biomass can be converted to both liquid and gaseous low-carbon fuels. Their use in buildings will be limited by their relative scarcity and competition from other sectors of the economy.

Hydrogen can be produced through electrolysis using renewable energy. That hydrogen can either be used directly in buildings or synthesized to produce low-carbon gaseous or liquid fuels. These fuels come at a substantial cost premium.

Chapter 7: Carbon Neutral Buildings and Resiliency

Resilient buildings are designed to **protect the health, safety, and comfort of building occupants** from shocks and stresses, including power outages, the impacts of extreme storm events, and extreme temperatures.

Types of resiliency

Passive survivability

Ability to maintain safe conditions and reasonable functionality during a power outage by keeping energy loads low through passive strategies such as insulation, air sealing, passive solar heating, and natural ventilation.

Functioning when the grid is down

Ability to maintain safe conditions and a reasonable level of functionality in an outage through active systems, such as solar systems with battery storage, and backup generators.

Handling extreme weather events

Ability to protect against floods, hurricanes, fires, etc., through raising, bracing and anchoring equipment, flood protection barriers and strategies, wind and fire-resistant envelopes.

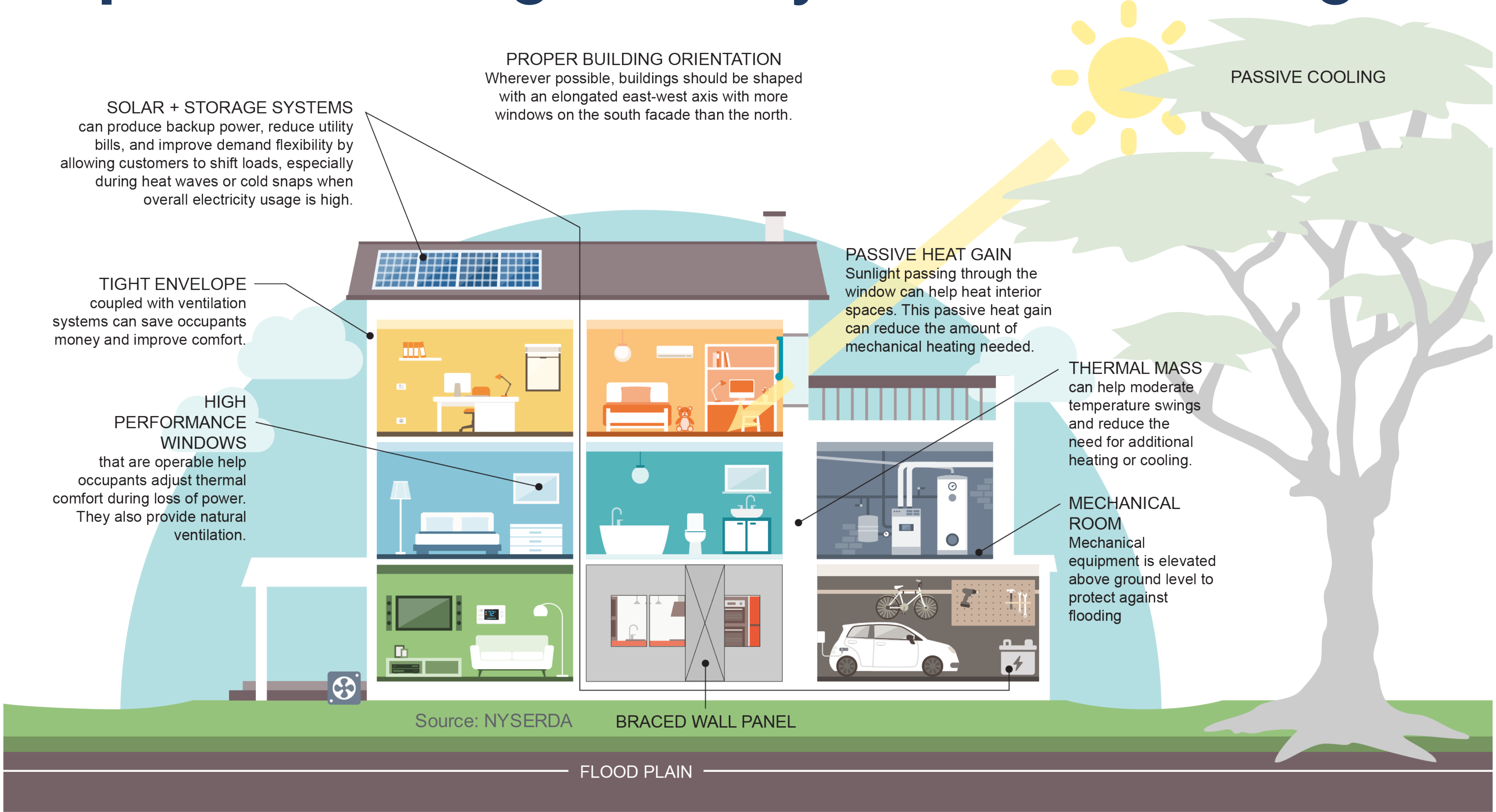
Resiliency considerations

Strategies that improve efficiency and resiliency can be **cost effective over the lifecycle of a building by avoiding costs from damage** due to extreme weather events and by helping buildings last longer, which saves money, materials, and avoids significant embodied carbon.

Designing for climate resiliency should account for the **lifespan of the component or HVAC system and its suitability for future climate conditions** and should be implemented in conjunction with building retrofit triggers such as tenant turnover or upgrades.

Features of a resilient building enhance flexibility and are complemented by building, community, and grid-balancing strategies including solar and storage, microgrids, stormwater management, places of refuge, and cooling and warming shelters with backup power.

Aspects of a single-family resilient building



Key building-level resiliency strategies

1
Building siting

Build new buildings away from flood zones, storm surge areas, and projected sea level rise.

.

2
Insulated building envelopes and operable windows

Preserves comfortable temperatures even with no power.

3
Natural ventilation

Provides improved air quality during power outages.

4
Solar plus storage

Offers backup power systems in the case of an outage.

5
Smart control systems

.

Runs critical building operating systems in grid constrained conditions or islanding mode. Facilitates restarting the electricity grid after an outage.

Key building-level resiliency strategies

6
Flood walls

Stops rising waters from reaching the building

7
Key mechanical equipment

Placed on roof or other secure areas to avoid flood waters.

8
Bracing and anchoring

Prevents equipment damage.

9
Tree cover and other vegetation

Passively cools buildings and reduces heat island effect.

FEMA research suggests that proactive **resiliency investments are highly cost effective, yielding 6:1 benefits** in post disaster recovery costs. So, for every $1 invested, $6 are saved in reconstruction.

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 https://www.nyserda.ny.gov/All-Programs/Programs/Carbon-Neutral-Buildings

2 Share this presentation with colleagues, customers, and others in your network.

3 Learn about NYSERDA programs that will help us realize the Roadmap goals www.nyserda.ny.gov/all-programs

Stay informed

Sign up or follow us to stay informed about new developments and other opportunities.

Sign up here to receive email updates

https://www.nyserda.ny.gov/All-Programs/Programs/Carbon-Neutral-Buildings/Connect-with-Us

Follow us on Social Media
@NYSERDA on all platforms.

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Q&A Session

Thank you!

Join us tomorrow for part II!

Wednesday, June 16th, 2-4pm ET

Concepts covered

- Value proposition and general solution sets
- Policy recommendations
- Disadvantaged communities
- Workforce development
- Outreach and engagement
- Case studies

Link to register:
https://nyserdany.webex.com/NYSERDA-Carbon-Neutral-Buildings

NEW YORK STATE OF OPPORTUNITY. | NYSERDA