MA Decarbonization Roadmap: Buildings Sector

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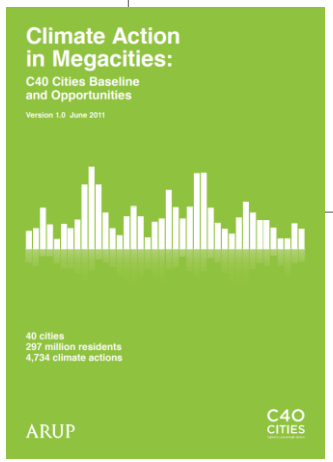
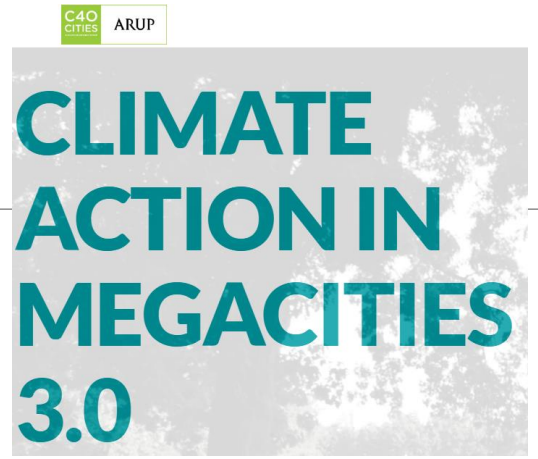
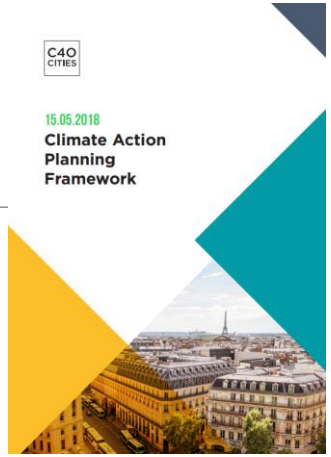
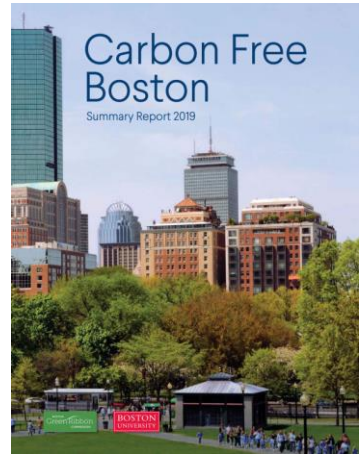
C40 CITIES
CLIMATE LEADERSHIP GROUP

+ ARUP










DEADLINE
2020
How cities will get the job done
C40 CITIES
ARUP
An analysis of the contribution C40 cities can make to delivering the Paris Agreement objective of limiting global temperature rise to 1.5 degrees.

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HEADLINE FINDING 4

DEADLINE 2020: ACTION TAKEN IN THE NEXT FOUR YEARS WILL DETERMINE IF IT IS POSSIBLE FOR CITIES TO GET ON THE TRAJECTORY REQUIRED TO MEET THE AMBITION OF THE PARIS AGREEMENT.

If sufficient action is not taken over this period, limiting temperature increases to below 1.5 degrees will be impossible. C40 cities collectively delivered nearly 11,000 climate actions between 2005 and 2016. In the four years to 2020, an additional 14,000 actions are required. This represents an additional 125% in less than half the time.

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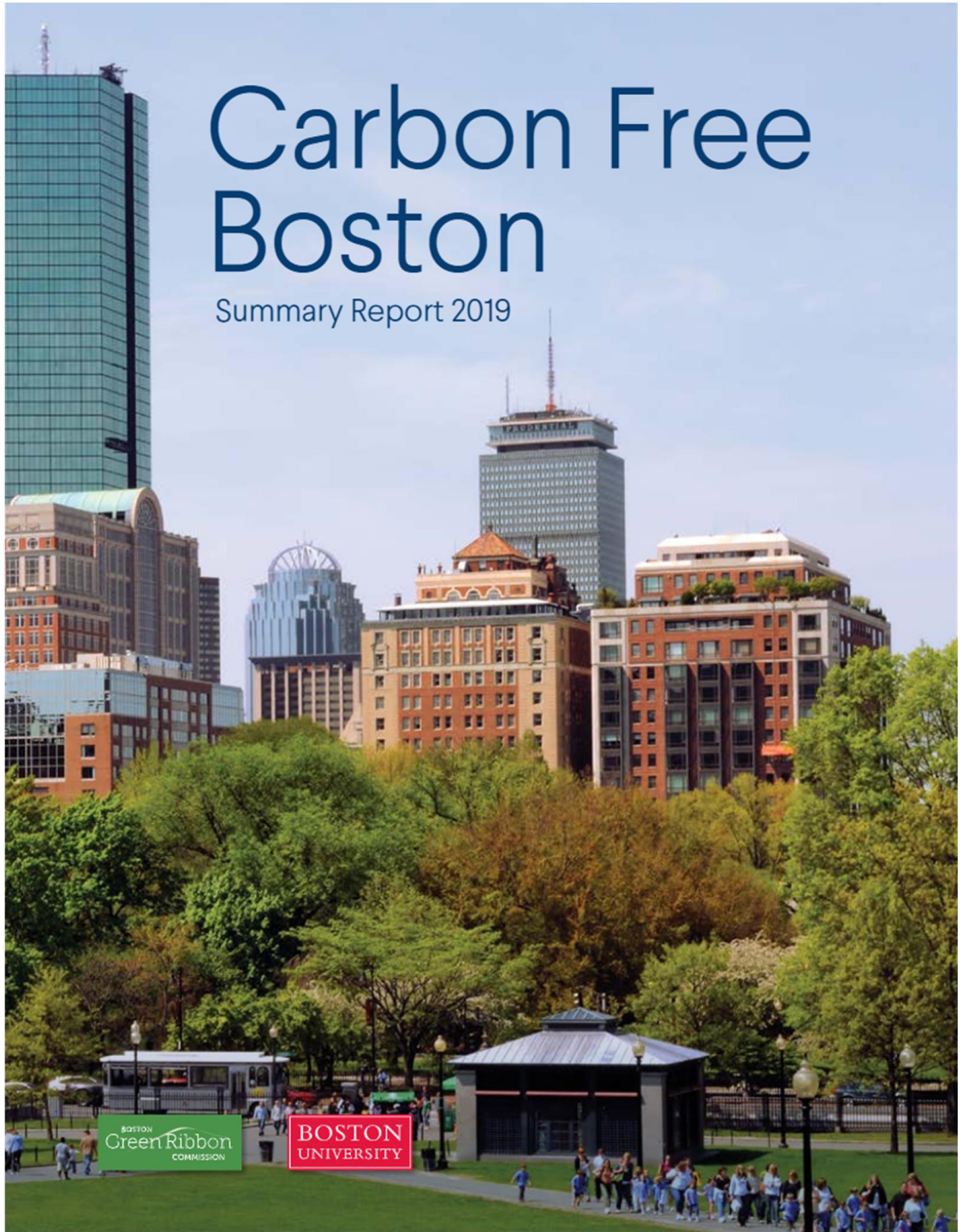
Carbon Free Boston: Buildings Sector



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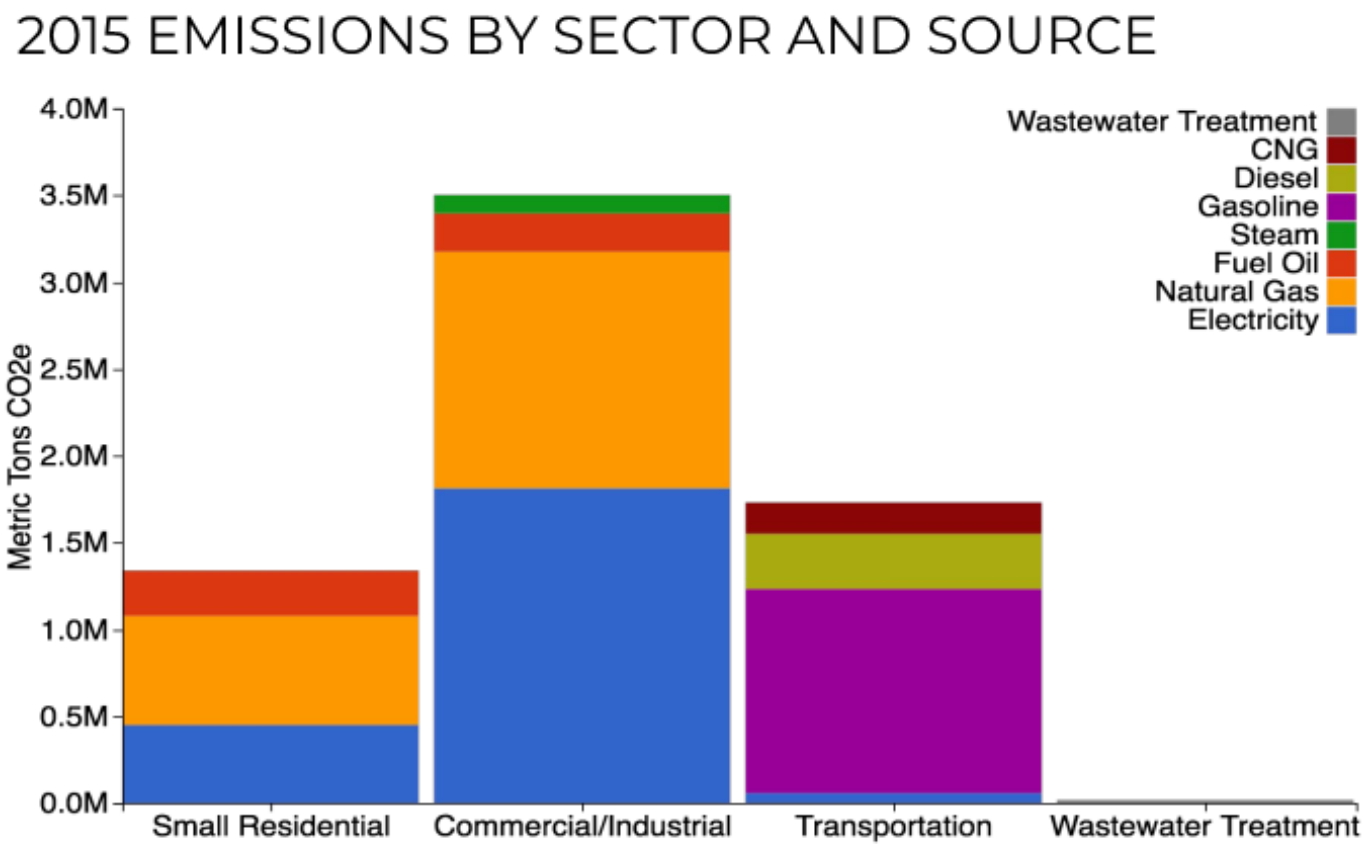
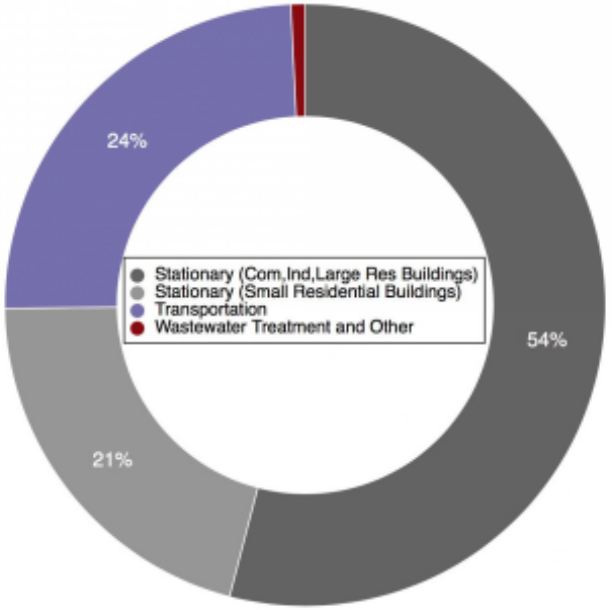
Boston's GHG Emissions Profile



Stationary sources dominate, accounting for 75% of total emissions.



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Defining the problem

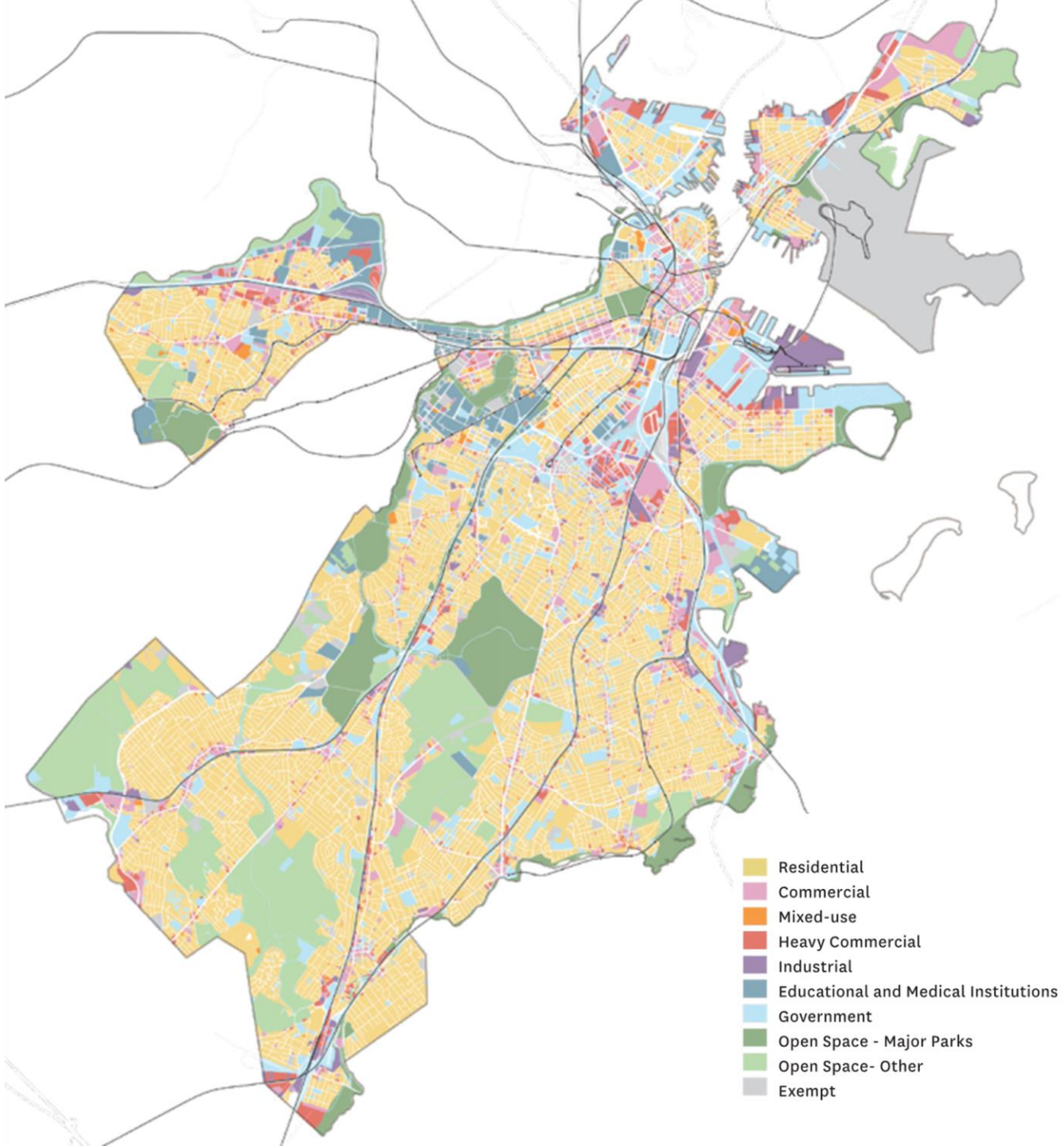
75%

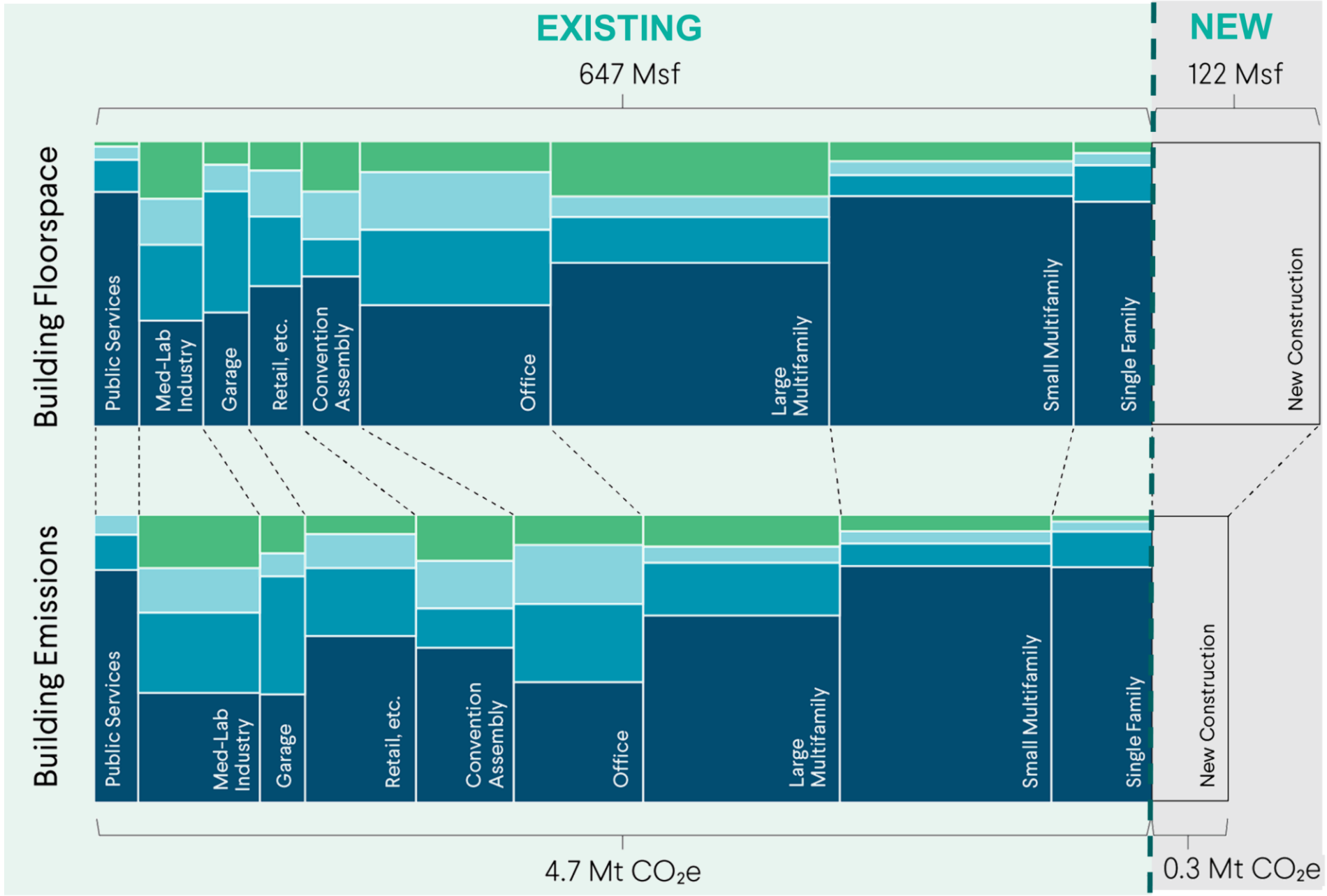
Of Boston's GHG emissions

86,000+

Buildings in Boston

647M sf





https://www.greenribboncommission.org/wp-content/uploads/2019/01/Carbon-Free-Boston-Report-web.pdf

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MA Decarbonization Roadmap: Buildings Sector

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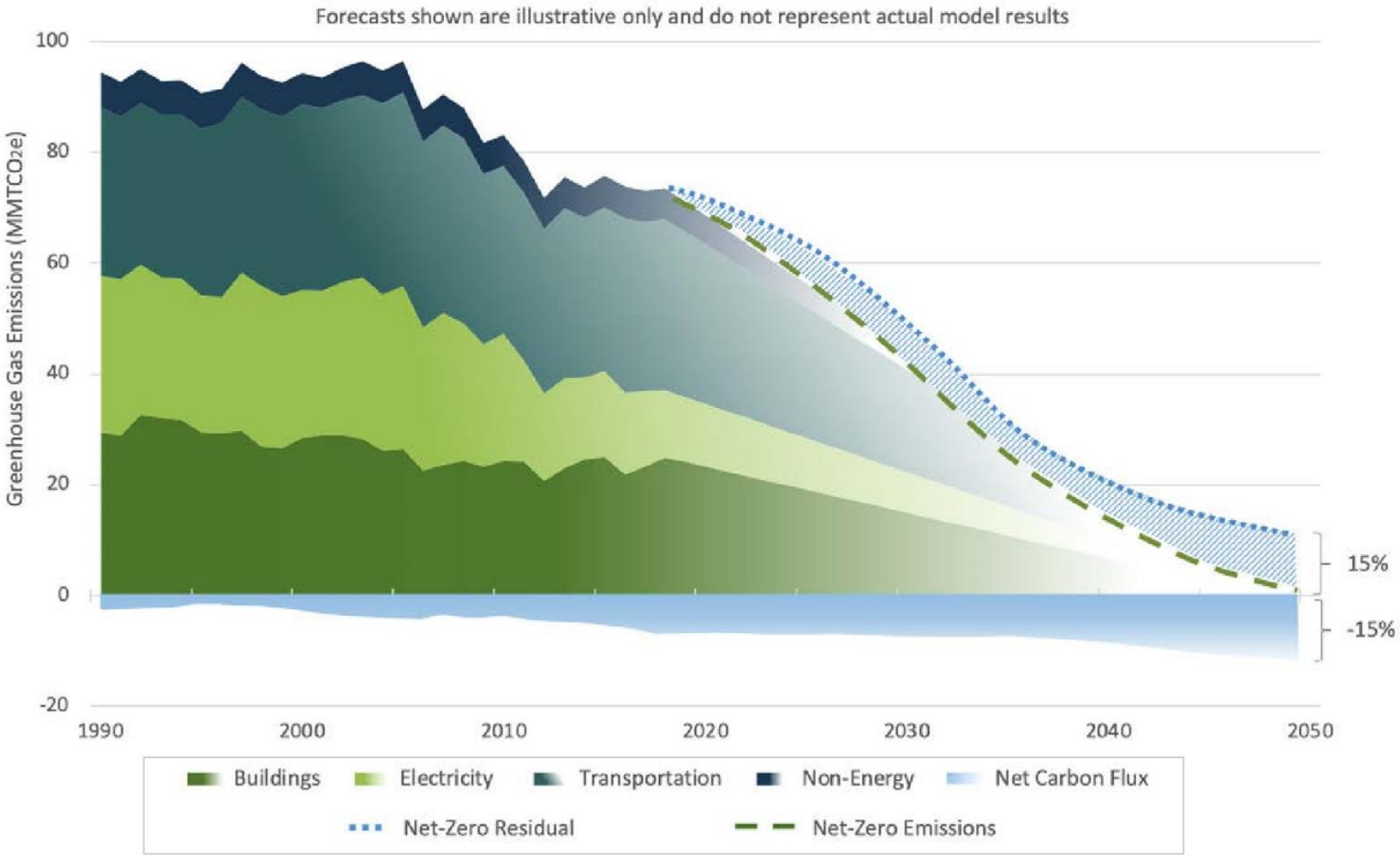
Changing the trajectory

Figure 1. Net Zero requires deeper emissions reductions than the Commonwealth's previous "80% by 2050" target, as well as a new requirement to balance any remaining emissions with the same amount of carbon removal from the atmosphere.



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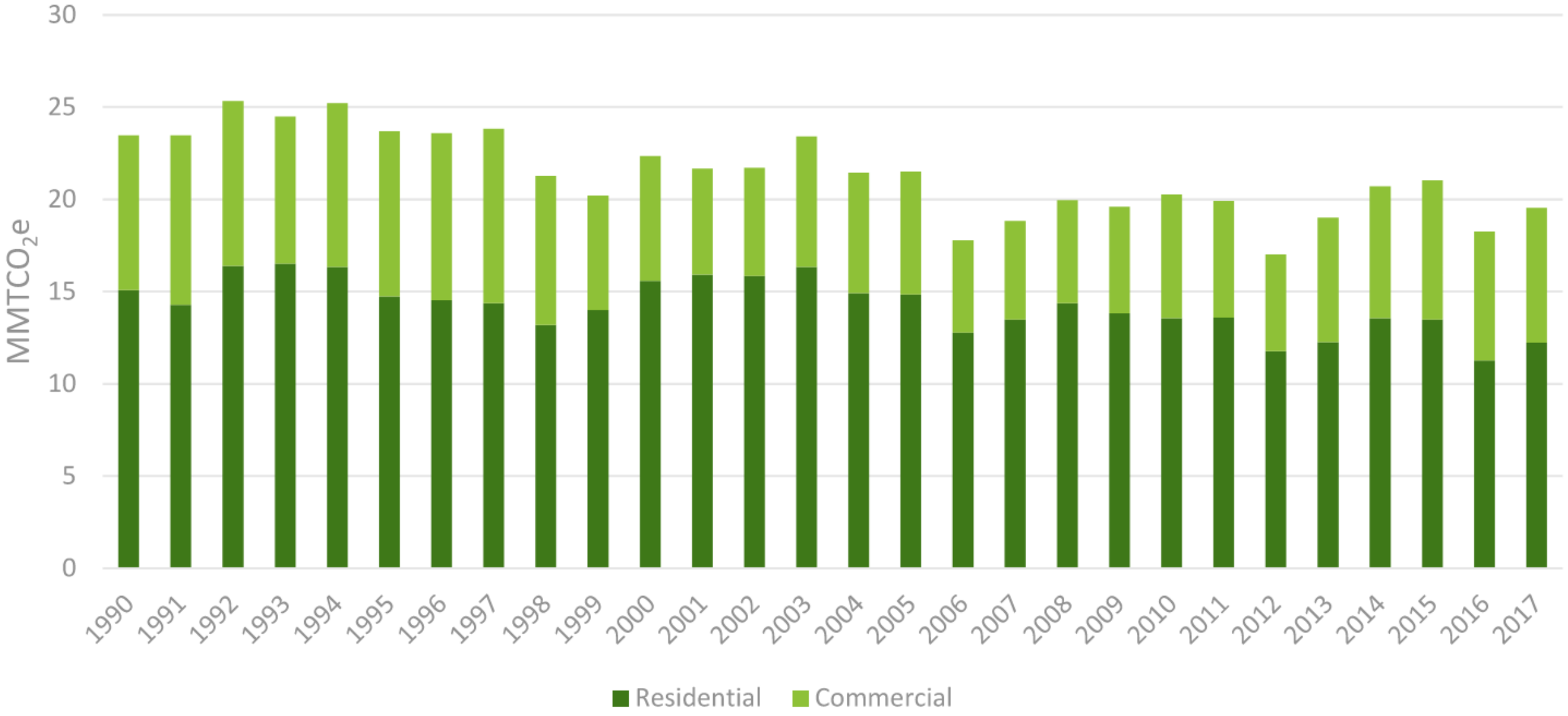
How do we understand the building sector?



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Modeling Approach: Typologies

Category	Building Typology	Vintages				
Small Residential	Single Family Residential	Pre-1950	1950-1979	1980-2000	Post-2000	New Construction
	Small Multifamily Residential (2-4 family)	Pre-1950	1950-1979	1980-2000	Post-2000	New Construction
Large Residential	Large Multifamily Residential (5-19 family)	Pre-1950	1950-1979	1980-2000	Post-2000	New Construction
	Large Multifamily Residential (20+ family, wood construction)	Pre-1950	1950-1979	1980-2000	Post-2000	New Construction
	Large Multifamily Residential (20+ family, steel construction)	Existing				New Construction
Small & Simple	Small Office (< 5,000 sf)	Pre-1980		1980-2000	Post-2000	New Construction
	Medium Office (5,000 to < 50,000 sf)	Pre-1980		1980-2000	Post-2000	New Construction
	Retail	Pre-1980		1980-2000	Post-2000	New Construction
	Supermarket	Pre-1980		1980-2000	Post-2000	New Construction
Large and Complex	Large Office (> 50,000 sf)	Pre-1980		1980-2000	Post-2000	New Construction
	Convention/Assembly	Pre-1980		1980-2000	Post-2000	New Construction
School	K-12 School	Pre-1980		1980-2000	Post-2000	New Construction
Warehouse	Warehouse	Existing				New Construction
Ventilation Driven	Laboratory	Pre-1980		1980-2000	Post-2000	New Construction
	Hospital	Pre-1980		1980-2000	Post-2000	New Construction
DHW Driven	Hotel	Pre-1980		1980-2000	Post-2000	New Construction
	Restaurant	Pre-1980		1980-2000	Post-2000	New Construction
Industrial	Industrial Processes	Process focused: low, medium, or high-grade heat				

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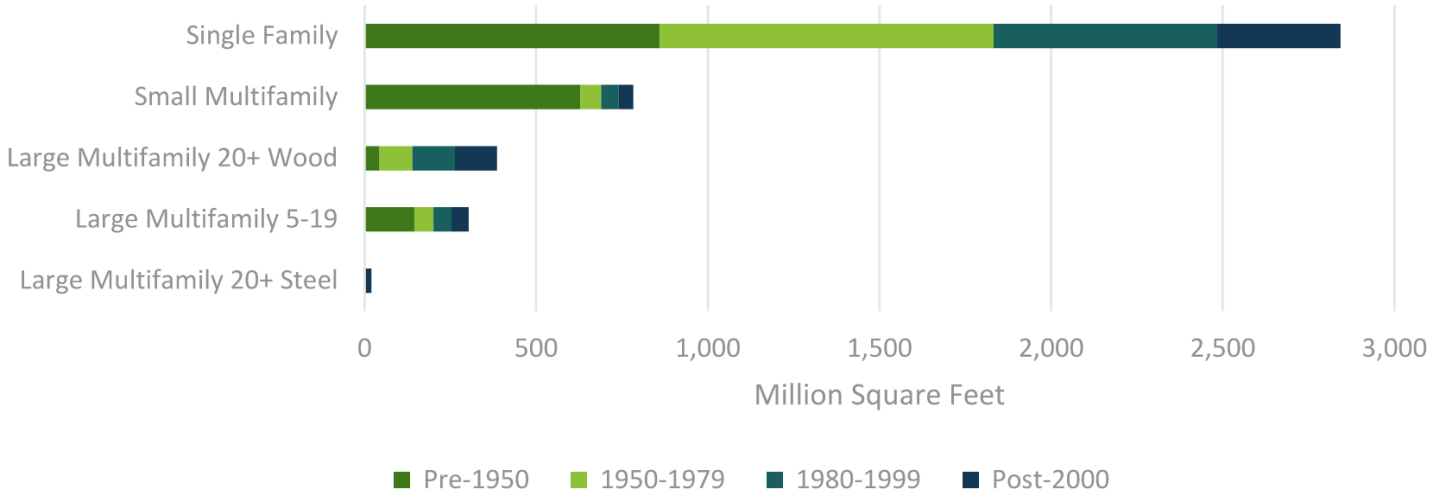
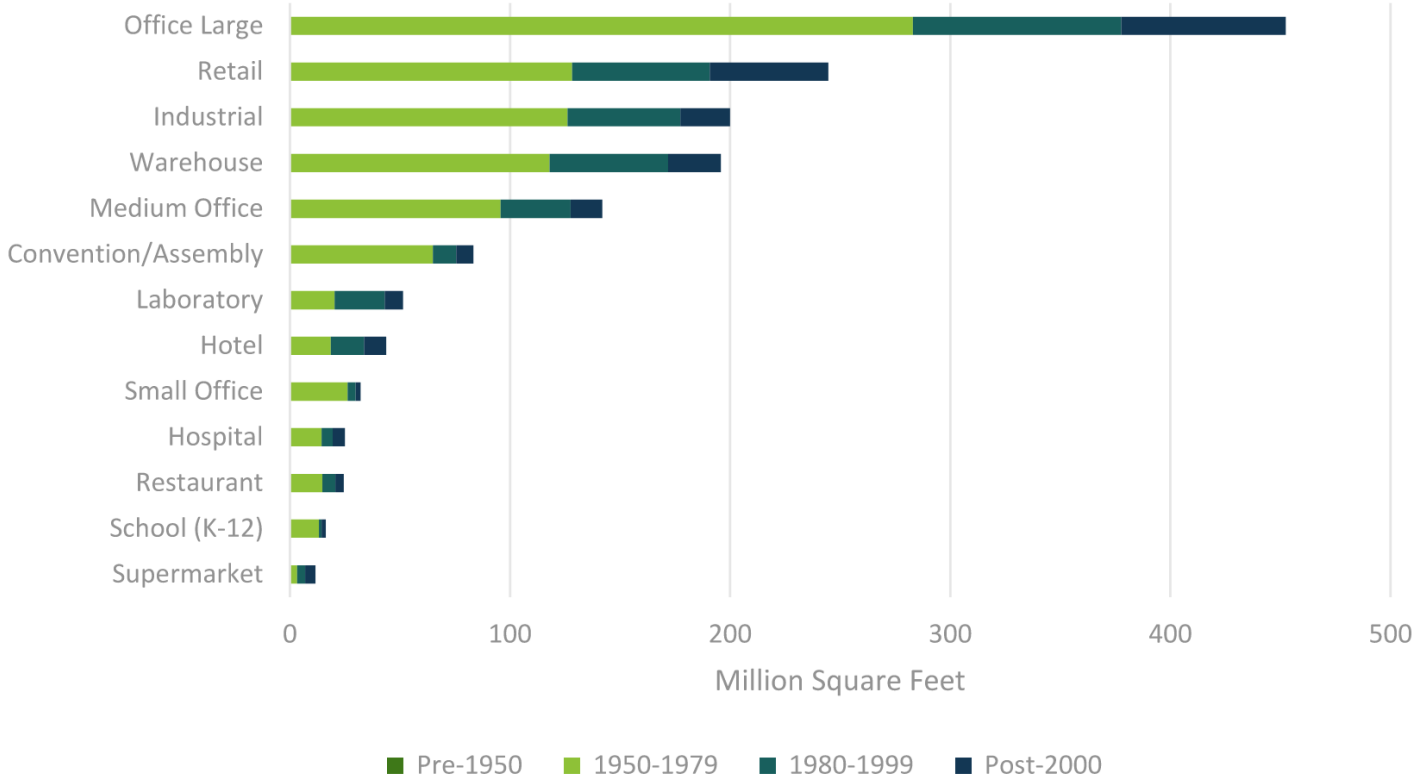
Modeling Approach: Segmentation





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Models

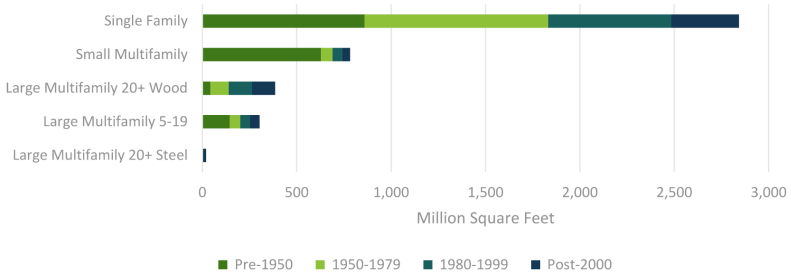
- Single family residential
- Small Multifamily residential
- Large MFR 5-19 family
- Large MFR 20+ family steel
- Large MFR 20+ family wood
- Office Small, Medium + Large
- Hospital
- Laboratory
- Convention/Assembly
- Hotel
- Restaurant
- Retail
- School (K-12)
- Supermarket
- Warehouse

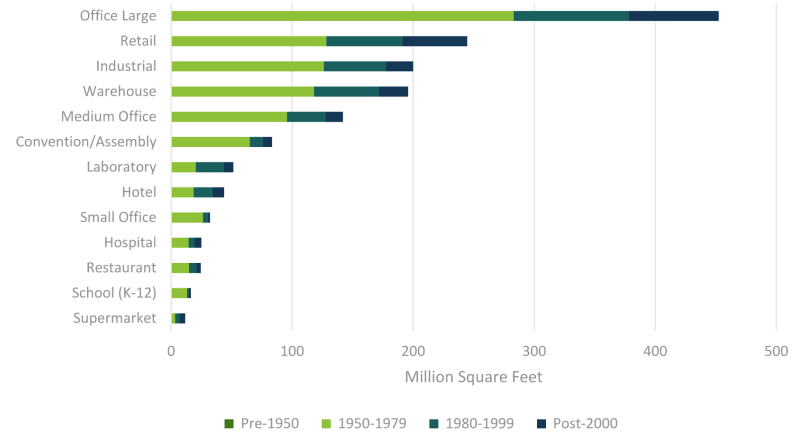
EnergyPlus

python™

aws

Area





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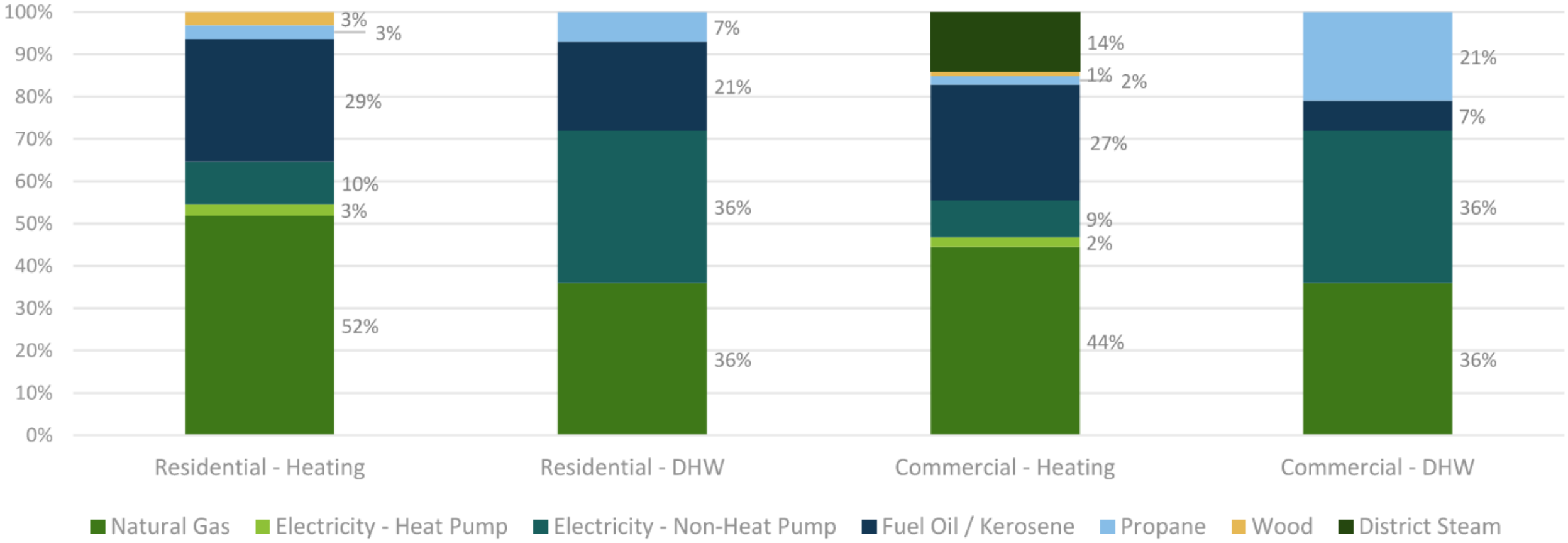
Modeling Approach: Calibration



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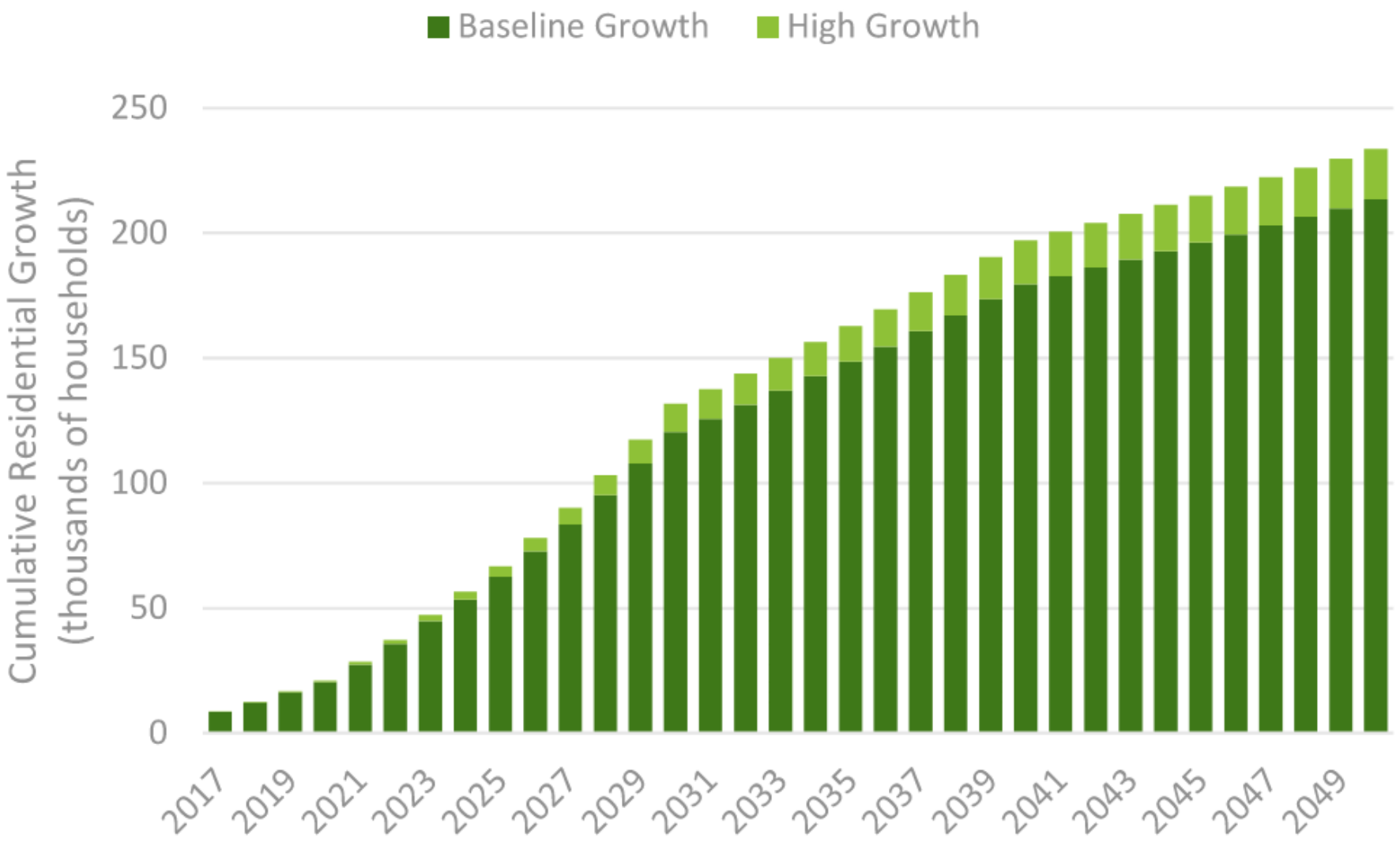
Modeling Approach: Growth



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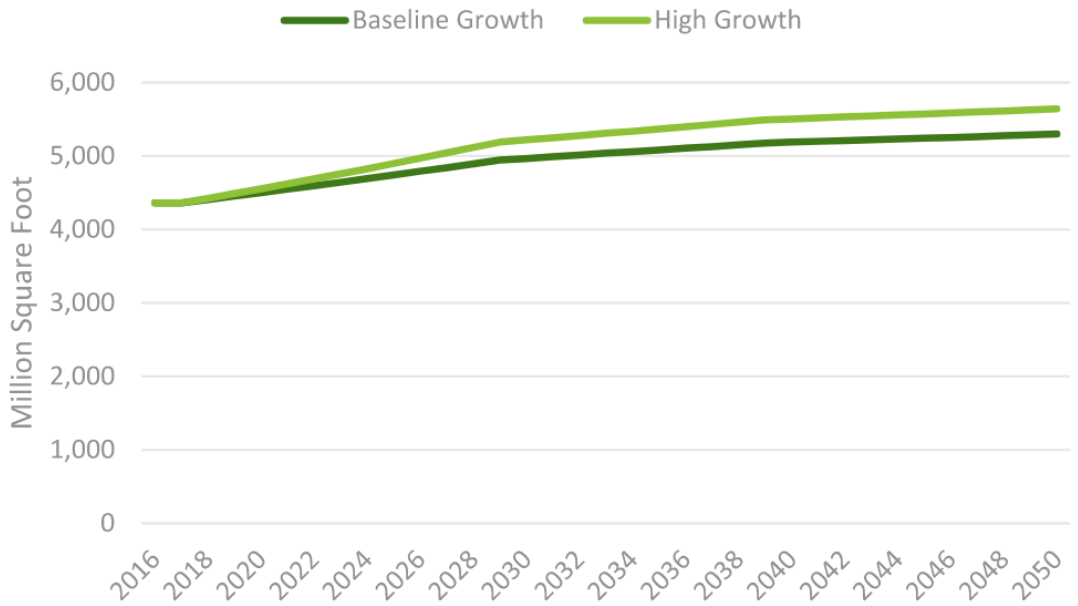
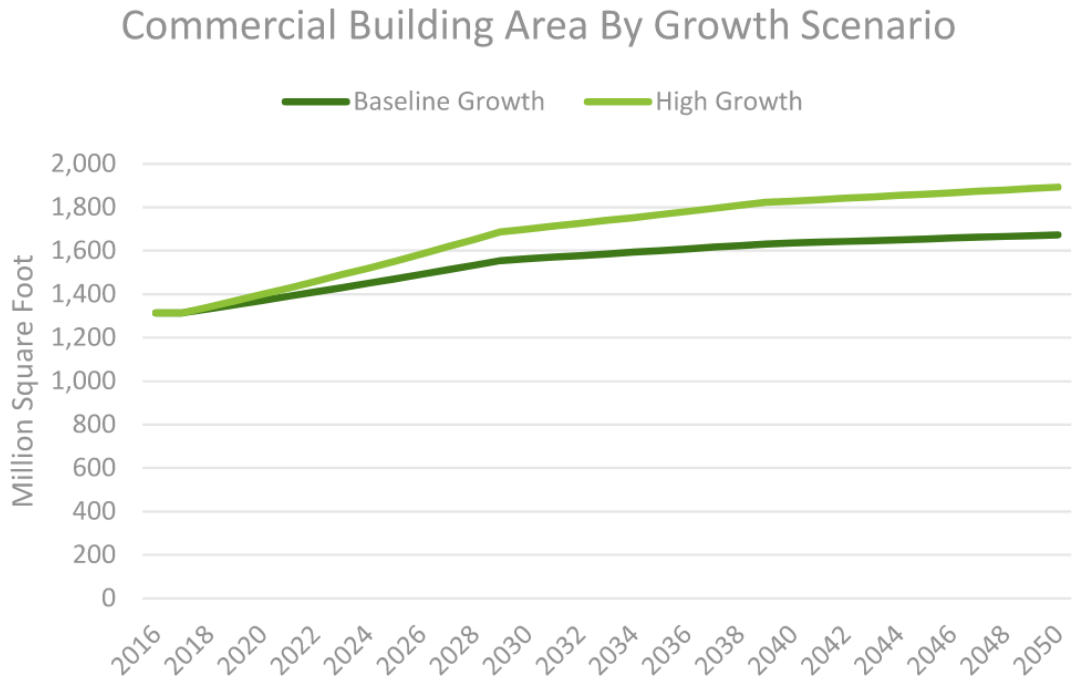
Modeling Approach: Growth





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Modeling Approach: ECM packages

Single Family and Small Multifamily			
ECM 1 Electrification	ECM 2 Low Efficiency	ECM 3 Medium Efficiency	ECM 4 High Efficiency
	ECM 1 plus:	ECM 2 plus:	ECM 3 plus:
Systems			
Heat Pump Cooling SEER: 15	ECM 1	Heat Pump Cooling SEER: 20	Heat Pump Cooling SEER: ECM 3
Heat Pump Space Heating HSPF: 9		Heat Pump Space Heating HSPF: 10	Heat Pump Space Heating HSPF: ECM 3
Heat Pump DHW Heating UEF: 2.73		Heat Pump DHW Heating UEF: 3.2	Heat Pump DHW Heating UEF: 3.45
Envelope			
None	R-60 Roof/Attic	Window U-value: 0.25	R-30 Walls
	R-15 Walls	Window SHGC: 0.32	Window U-value: 0.21
	Airtightness to 0.4 CFM/sf at 0.3 in. wc.	Airtightness to 0.2 CFM/sf at 0.3 in. wc.	Window SHGC: 0.24
			Airtightness to 0.1 CFM/sf at 0.3 in. wc.
Controls			
Setbacks to 70°F and 75°F in heating and cooling, respectively	**Demand-Control Ventilation**	ECM 2	ECM 2
	70% Effective Energy Recovery		
Appliances			
Electric conversion	ECM 1	ECM 1	ECM 1

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Modeling Approach: ECM packages

Office (Large), Convention/Assembly			
ECM 1 Electrification	ECM 2 Low Efficiency	ECM 3 Medium Efficiency	ECM 4 High Efficiency
	ECM 1 plus:	ECM 2 plus:	ECM 3 plus:
Systems			
Heat Pump Cooling SEER: 15	ECM 1	Heat Pump Cooling SEER: 20	Heat Pump Cooling SEER: ECM 3
Heat Pump Space Heating HSPF: 9		Heat Pump Space Heating HSPF: 10	Heat Pump Space Heating HSPF: ECM 3
Heat Pump DHW Heating UEF: 2.73		Heat Pump DHW Heating UEF: 3.2	Heat Pump DHW Heating UEF: 3.45
Envelope			
None	R-30 Roof/Attic	Window U-value: 0.38	R-40 Roof/Attic
	R-15 Walls	Window SHGC: 0.35	R-30 Walls
	Airtightness to 0.4 CFM/sf at 0.3 in. wc.	Airtightness to 0.2 CFM/sf at 0.3 in. wc.	Window U-value: 0.22
			Window SHGC: 0.25
			Airtightness to 0.1 CFM/sf at 0.3 in. wc.
Controls			
Setbacks to 70°F and 75°F in heating and cooling, respectively	ECM 1	ECM 1	ECM 1
Demand-Control Ventilation			
70% Effective Energy Recovery			
Appliances			
Electric conversion	ECM 1	ECM 1	ECM 1

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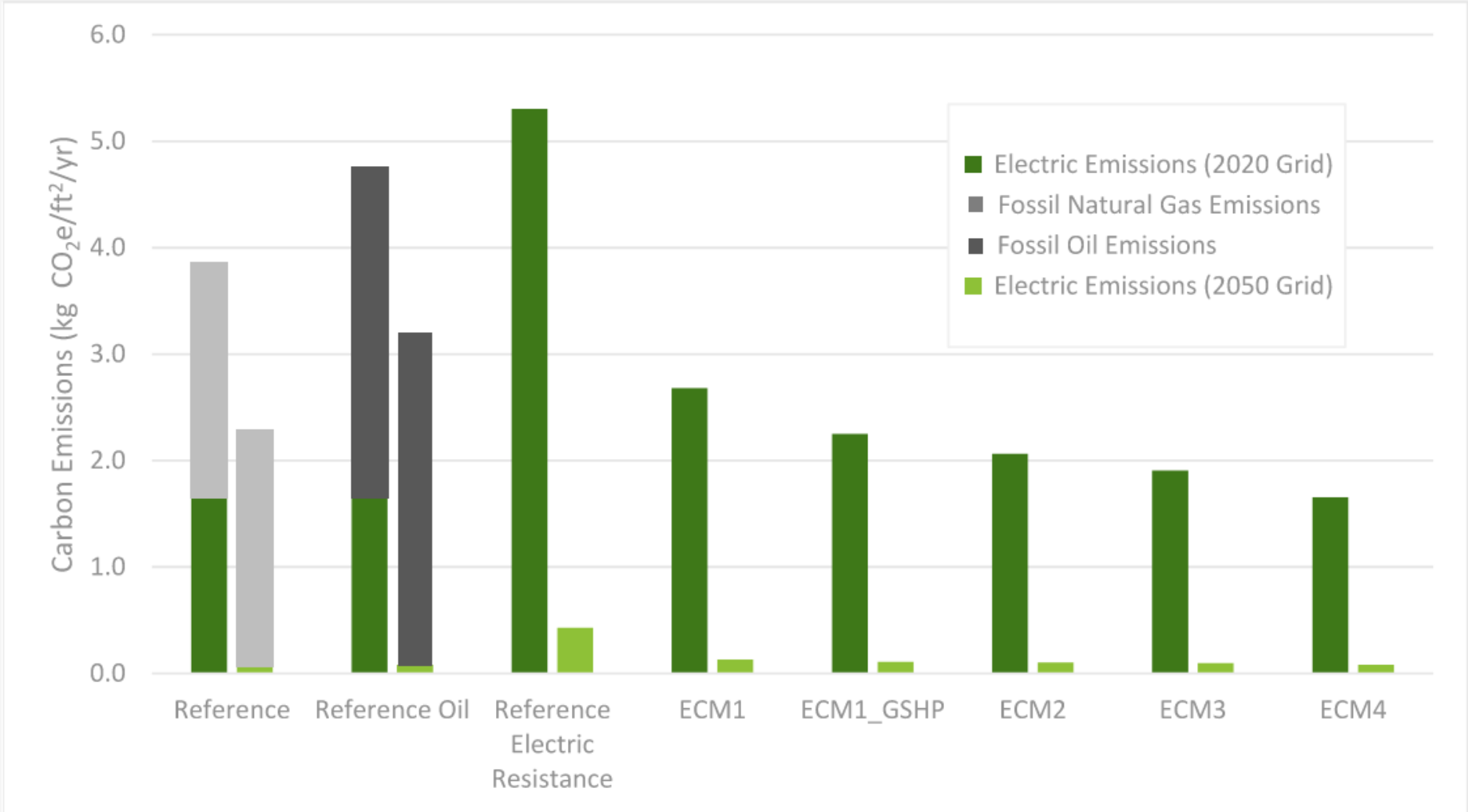
Figure 17. CO_2e emissions intensities for each ECM applied to Pre-1950s Single Family Residential buildings. Aggregate annual emissions factors are used to calculate emissions. 2050 Grid emissions factor is from the All Options pathway analyzed in the Energy Pathways Report.



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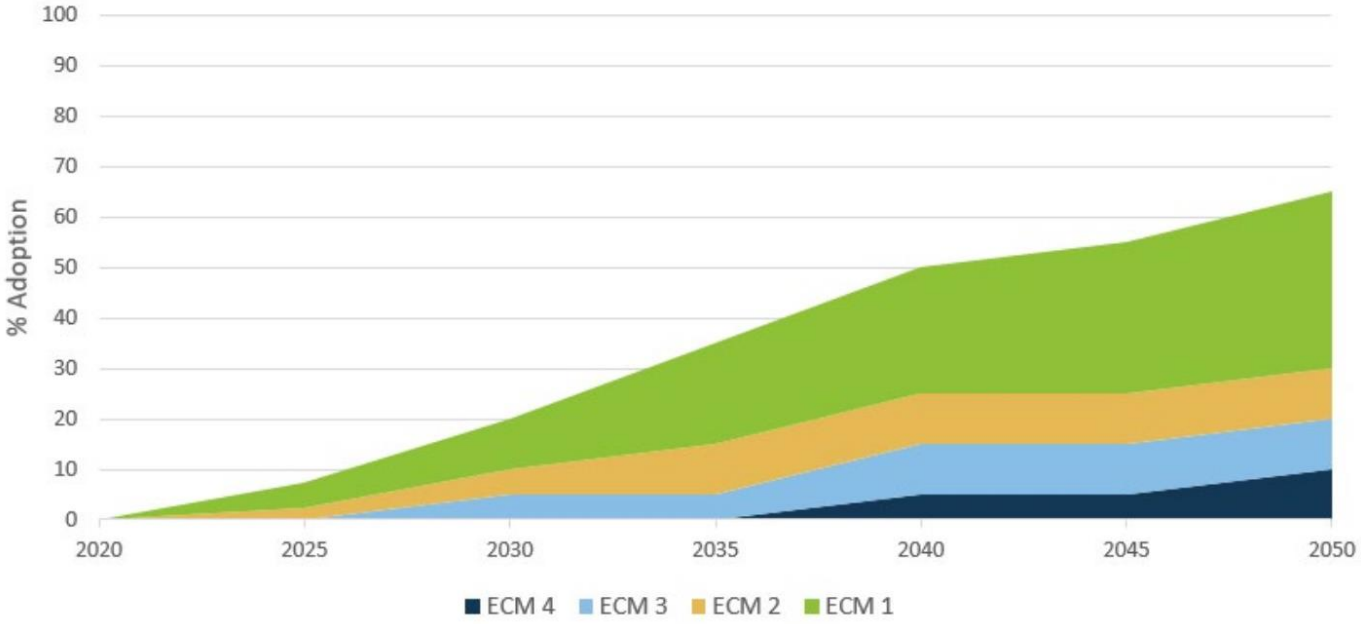
Pathways

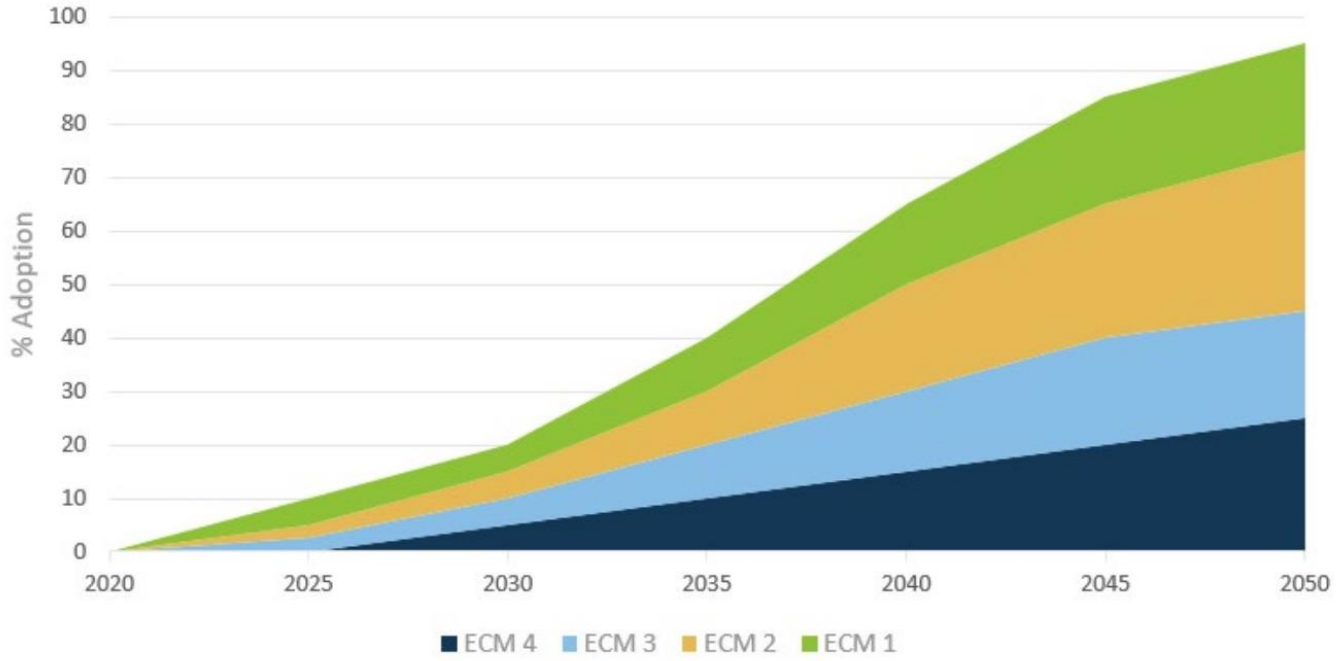
Reference	Anticipated improvements in building energy mechanical and thermal shell systems based on natural stock turn-over and existing market and programmatic efforts. The reference case includes adoption of a Net Zero code for new construction in 2030.
Deep Retrofit Pathway	Deep retrofit approach accelerated combination of highly efficient electrification with improved building mechanical system and thermal shell efficiency improvements. 73% of buildings in 2050 have received at least some element of a buildings shell upgrade (ECM2-4). This pathway is analogous to the *Energy Pathways Report's* All Options Pathway
Electrification-Only Pathway	Electrification approach, with less emphasis on improvements to the building's thermal shell. This pathway is analogous to the *Energy Pathways Report's* Limited Efficiency Pathway. Only 19% of buildings in 2050 have received a buildings shell upgrade (ECM2-4)

Adoption rates

reference



deep retrofit



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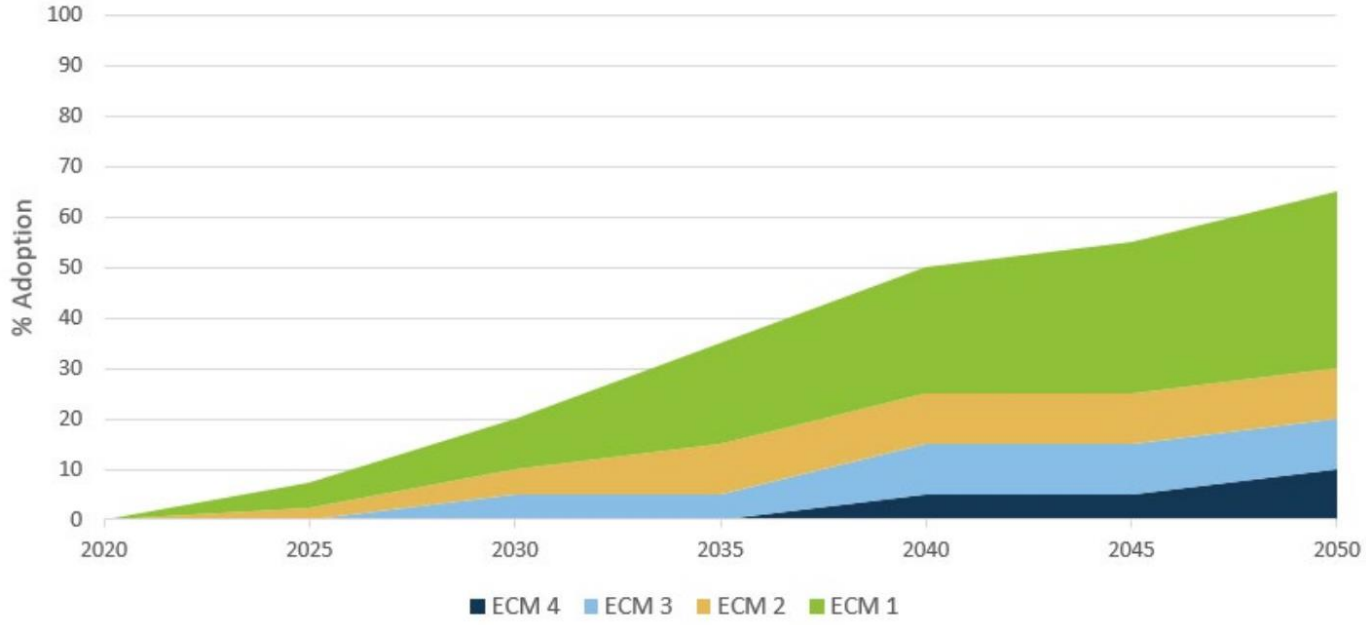
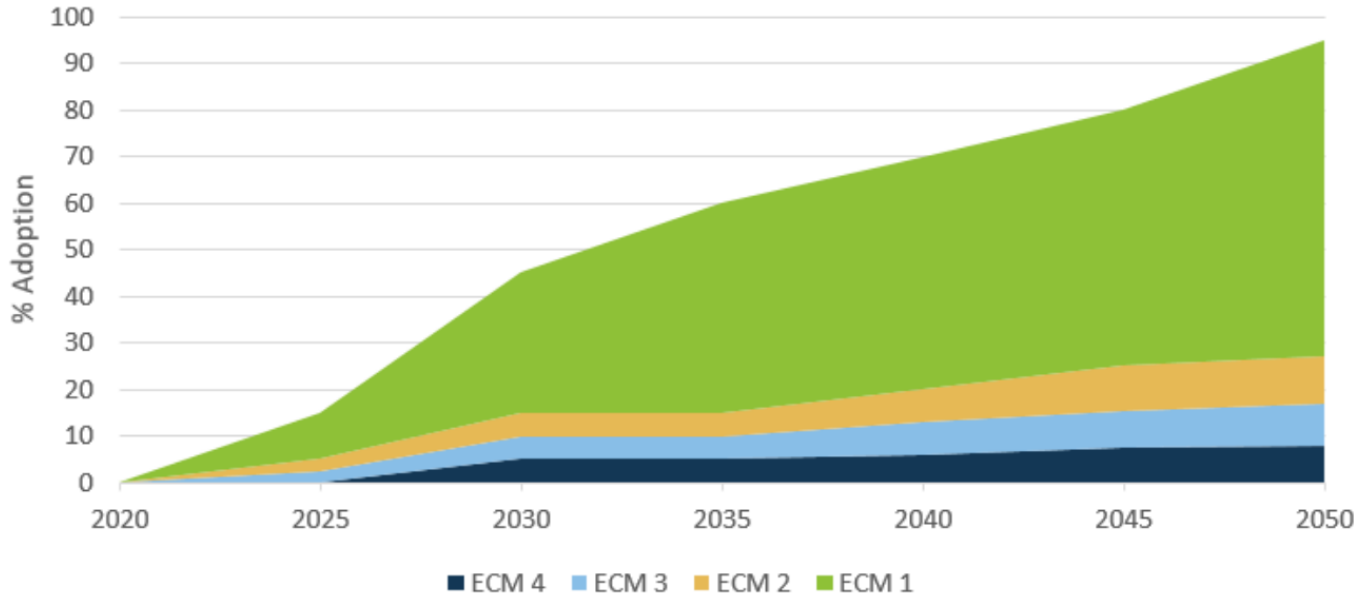
Adoption rates

reference



electrification



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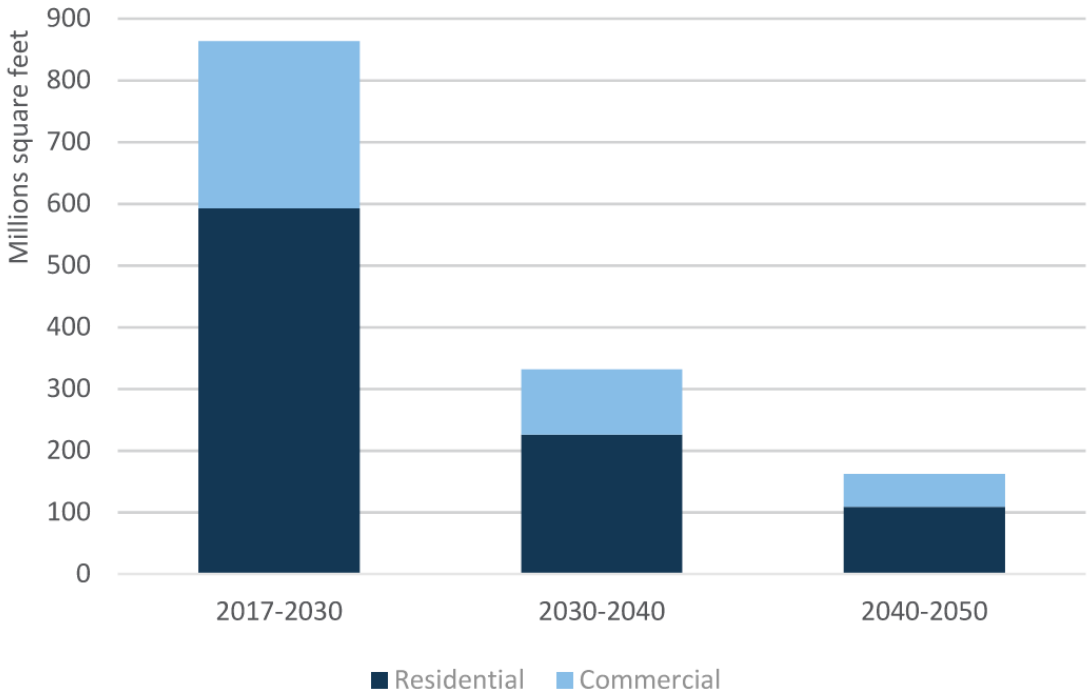
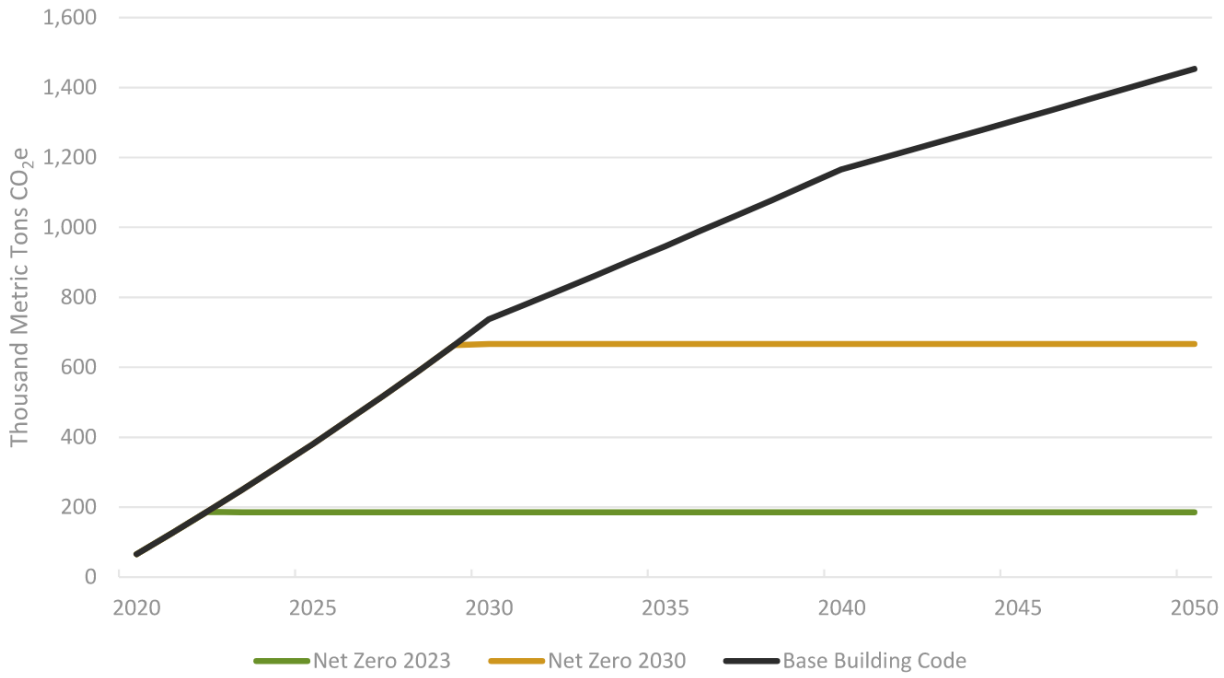
Timing is Significant

growth



emissions & code



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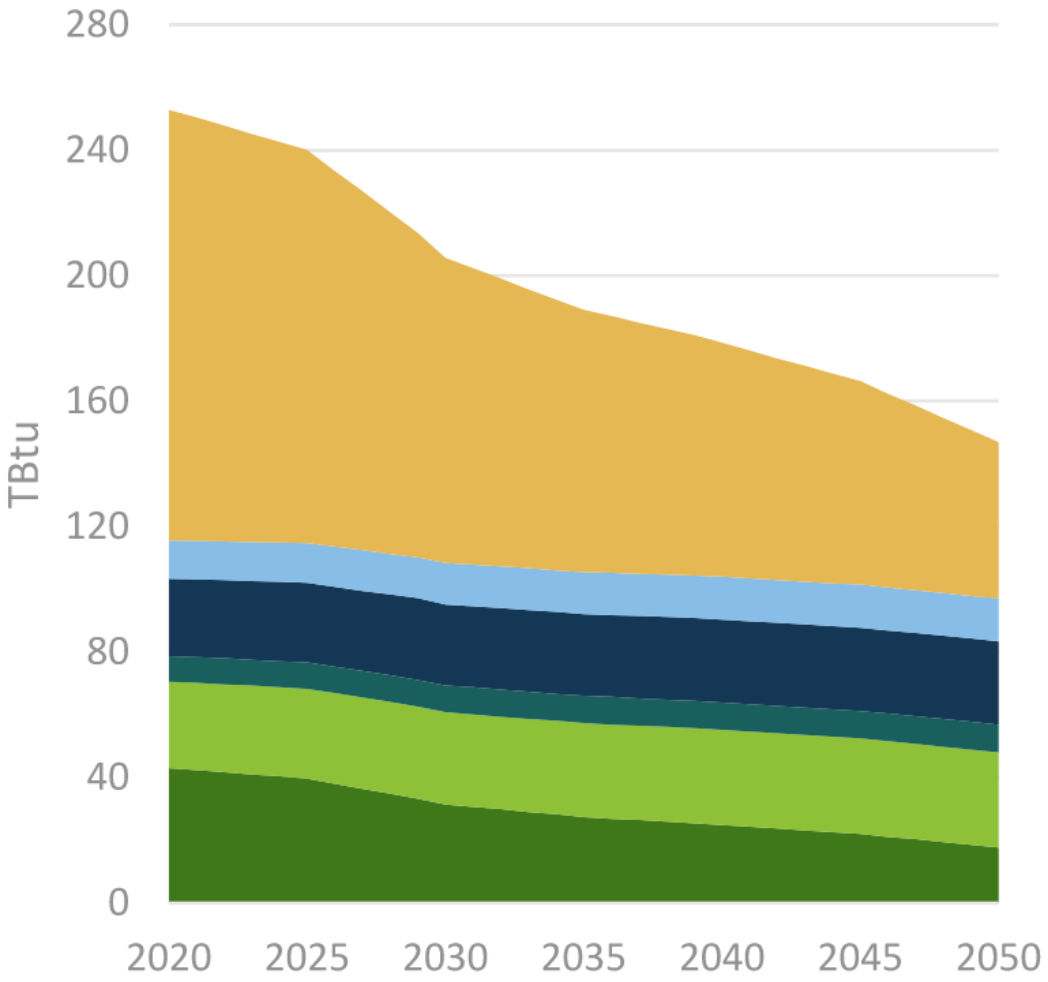
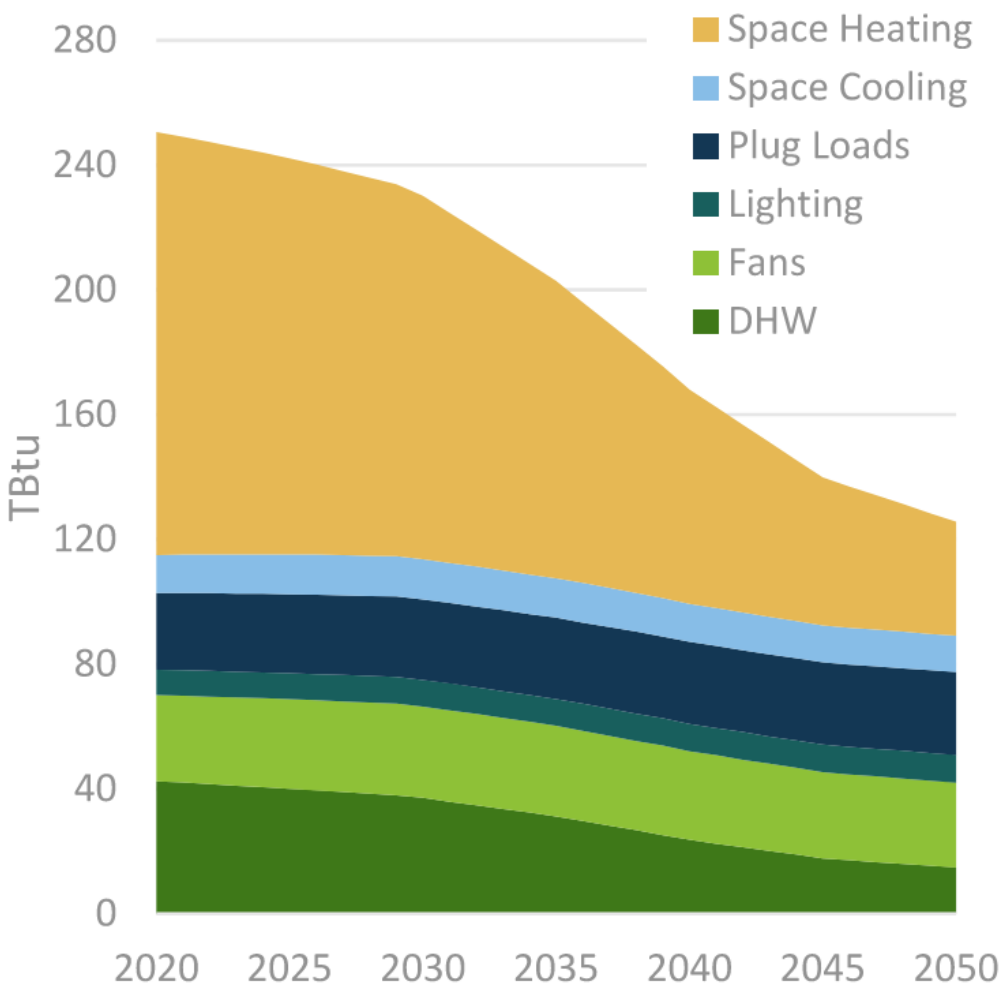
residential



electrification



deep retrofit

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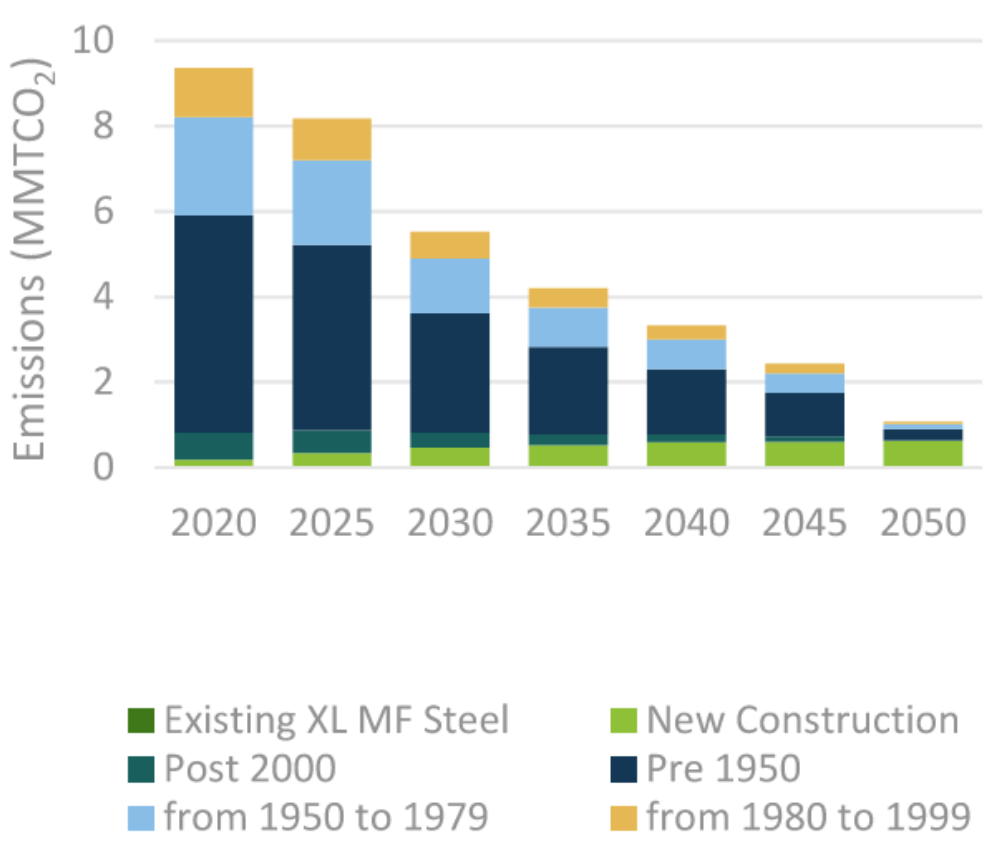
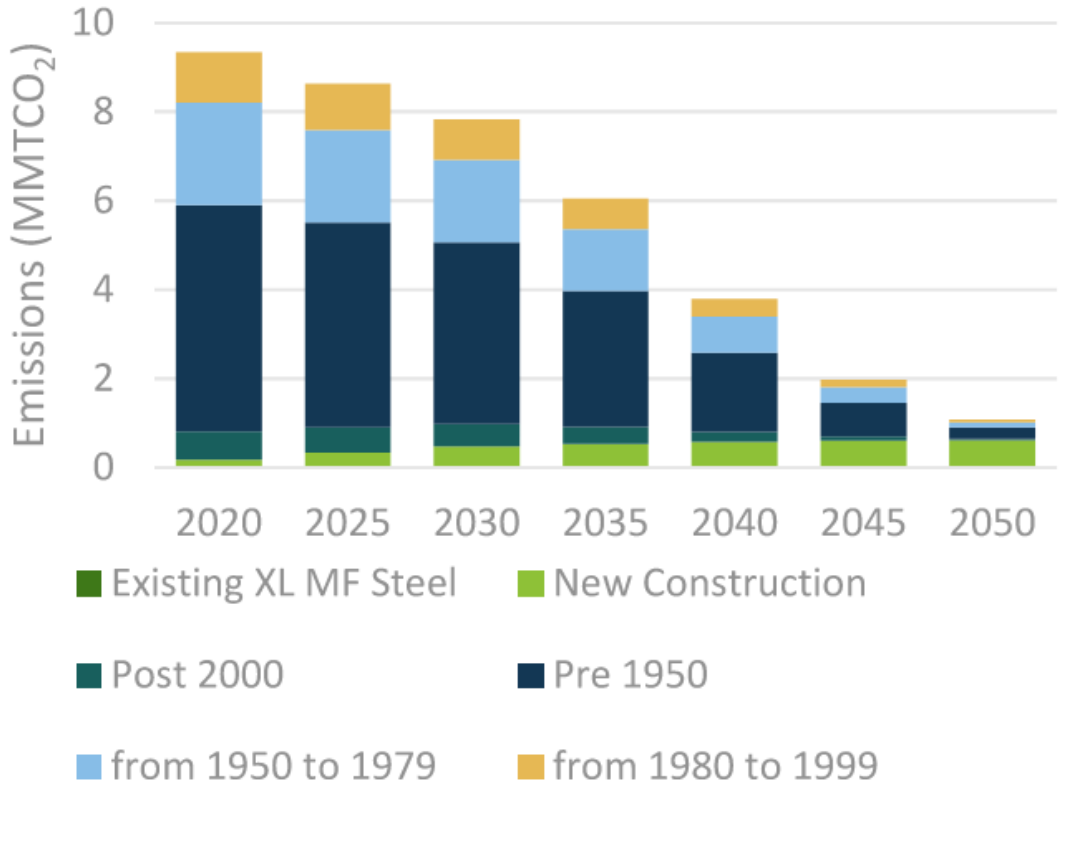
residential



electrification



deep retrofit

Attaining this level of reductions requires a simple annual average of 90,000 retrofits for existing buildings and 7,000 high performance new construction units from 2020 through 2050 (Figure 52).

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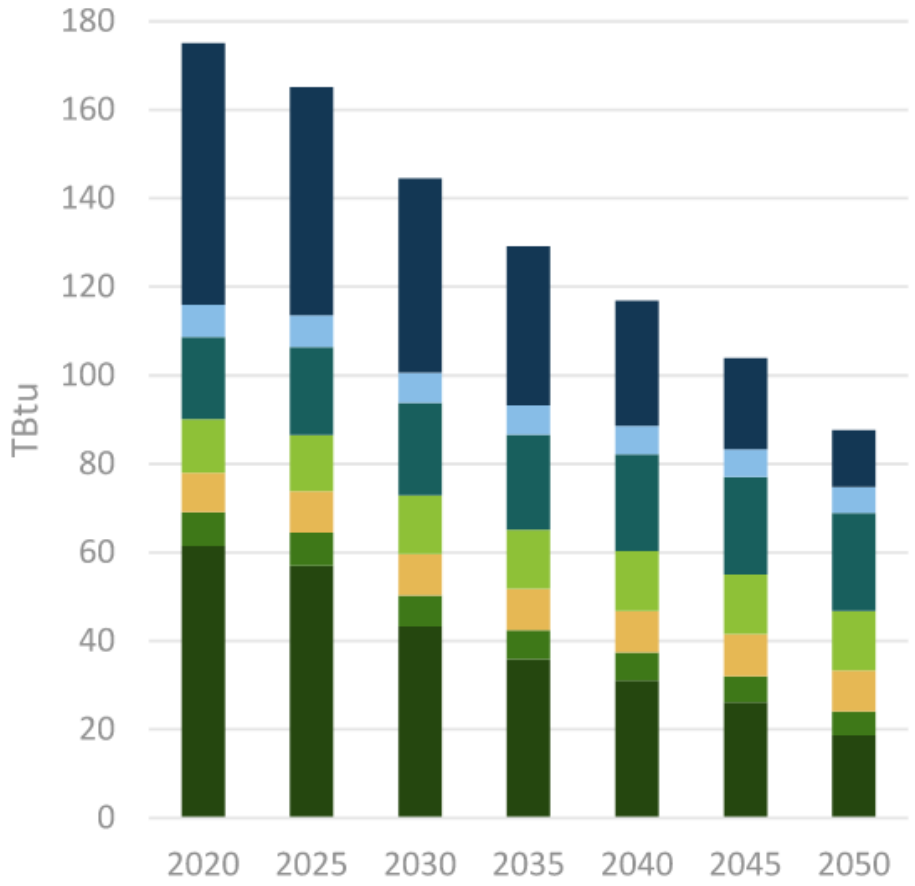
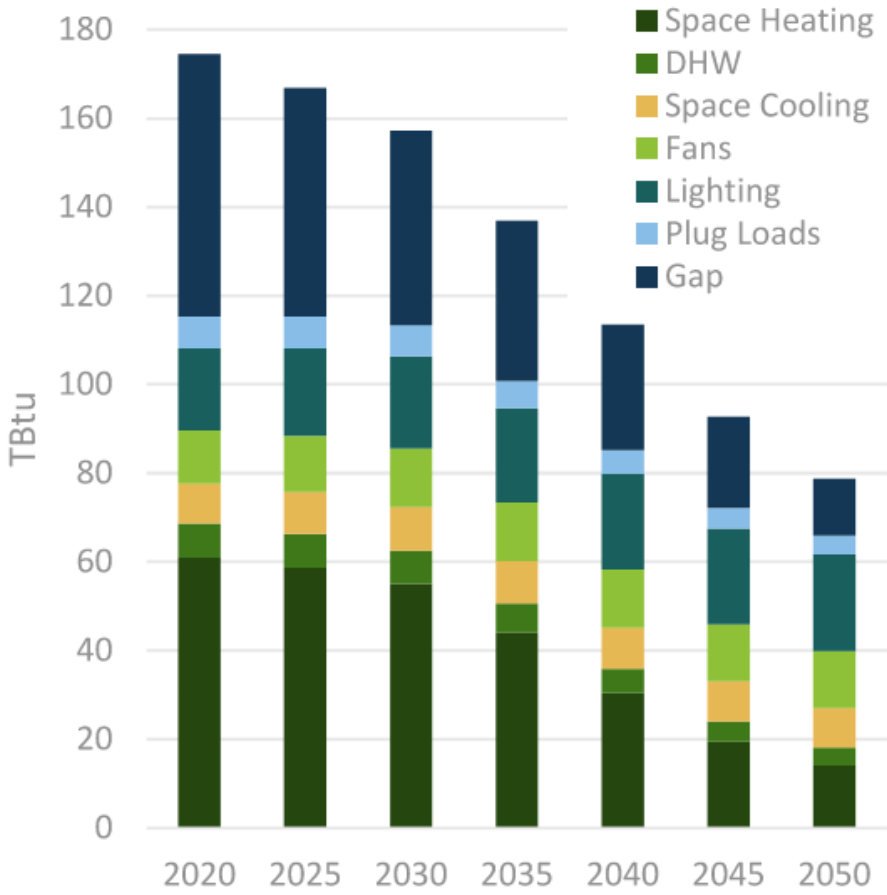
commercial

Figure 55. Commercial Final Energy Demand by End Use, Electrification Pathway (left) and Deep Retrofit Pathway (right).





electrification

deep retrofit

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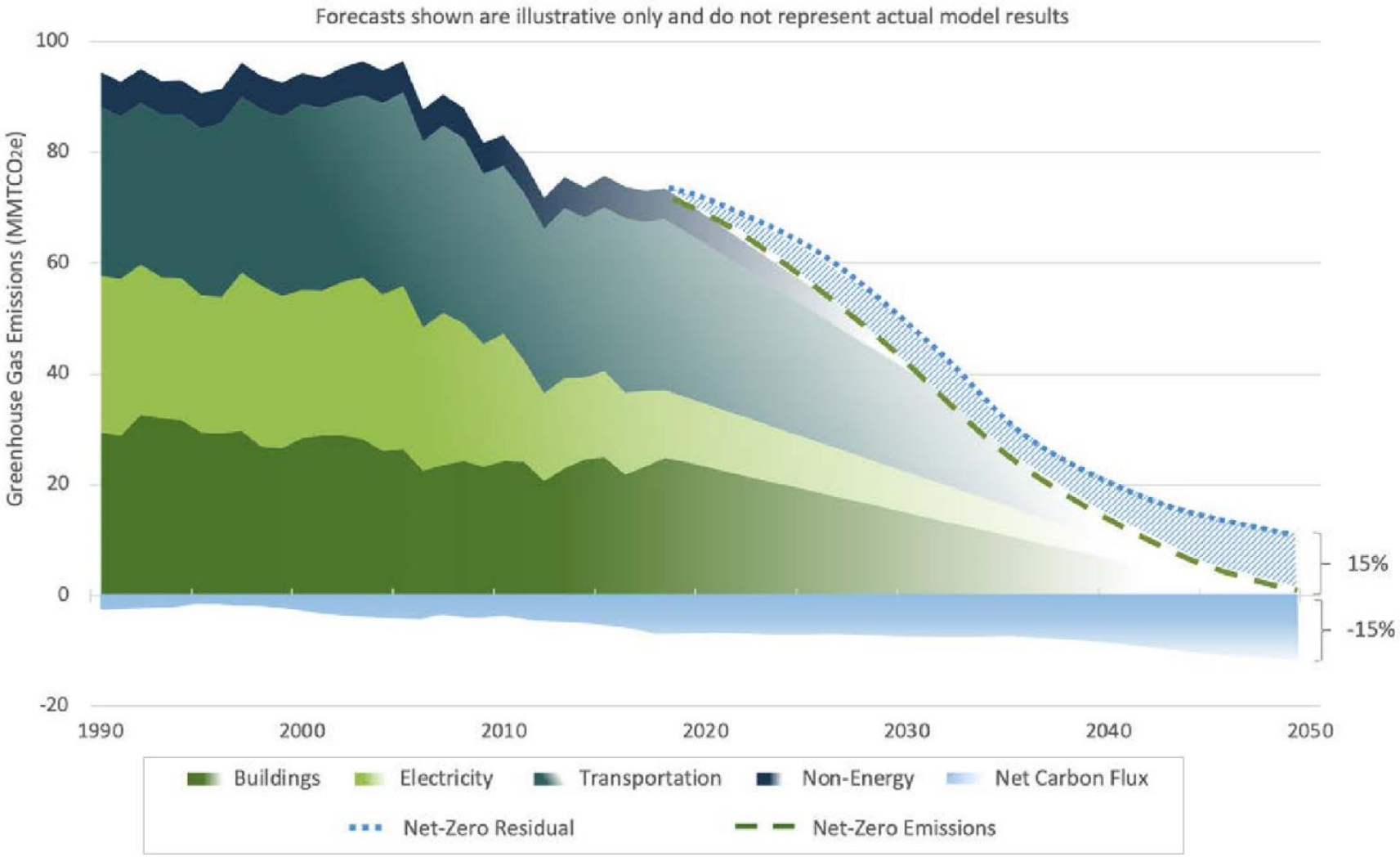
Changing the trajectory

Figure 1. Net Zero requires deeper emissions reductions than the Commonwealth's previous "80% by 2050" target, as well as a new requirement to balance any remaining emissions with the same amount of carbon removal from the atmosphere.



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PRESS RELEASE

Governor Baker Signs Climate Legislation to Reduce Greenhouse Gas Emissions, Protect Environmental Justice Communities

Bipartisan Law Will Combat Climate Change While Growing Massachusetts' Economy

FOR IMMEDIATE RELEASE:
3/26/2021

Governor's Press Office
Office of Governor Charlie Baker and Lt. Governor Karyn Polito
Executive Office of Energy and Environmental Affairs

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Thank you

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