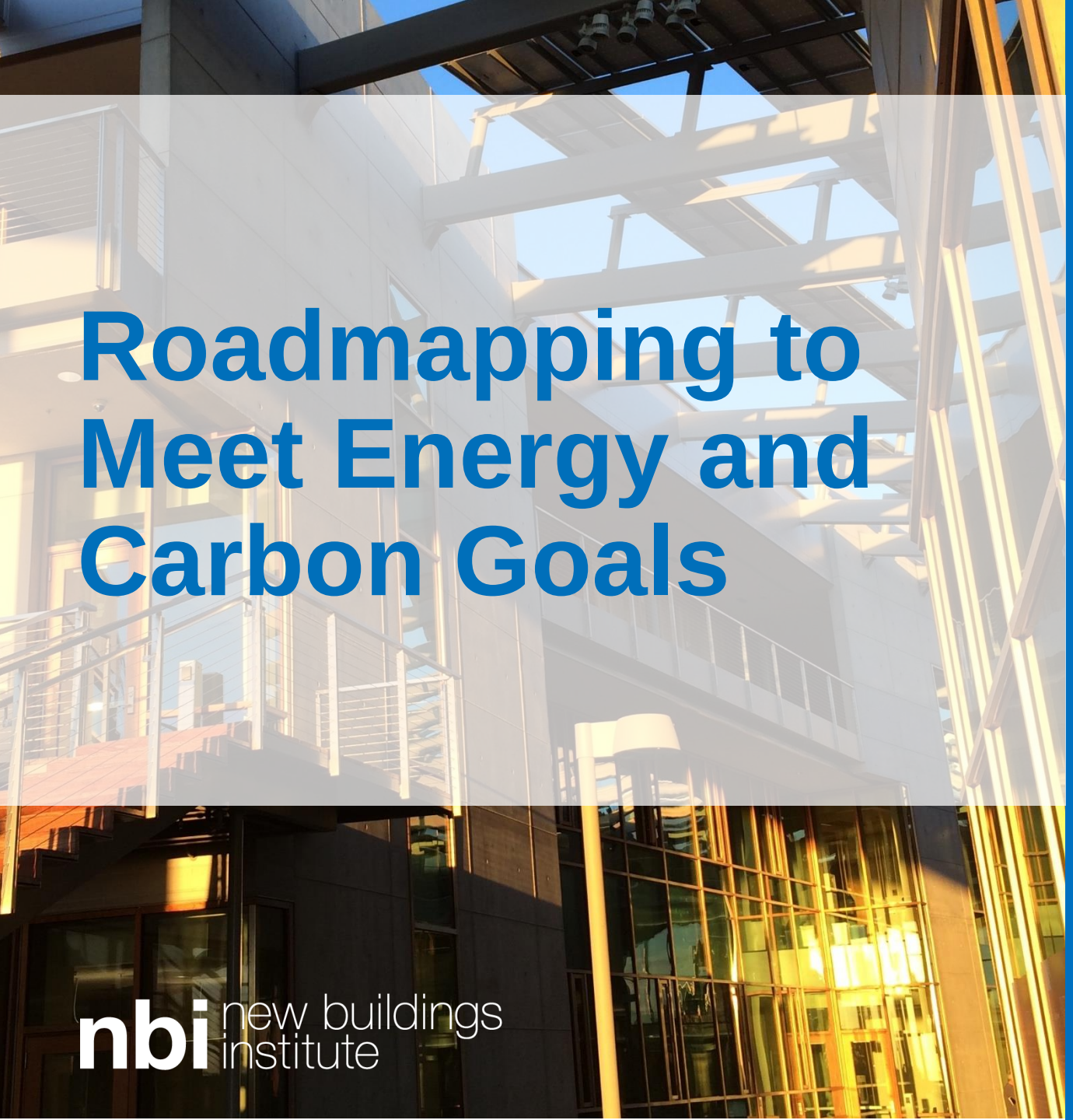

Roadmapping to Meet Energy and Carbon Goals

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Eric Makela

Associate Director

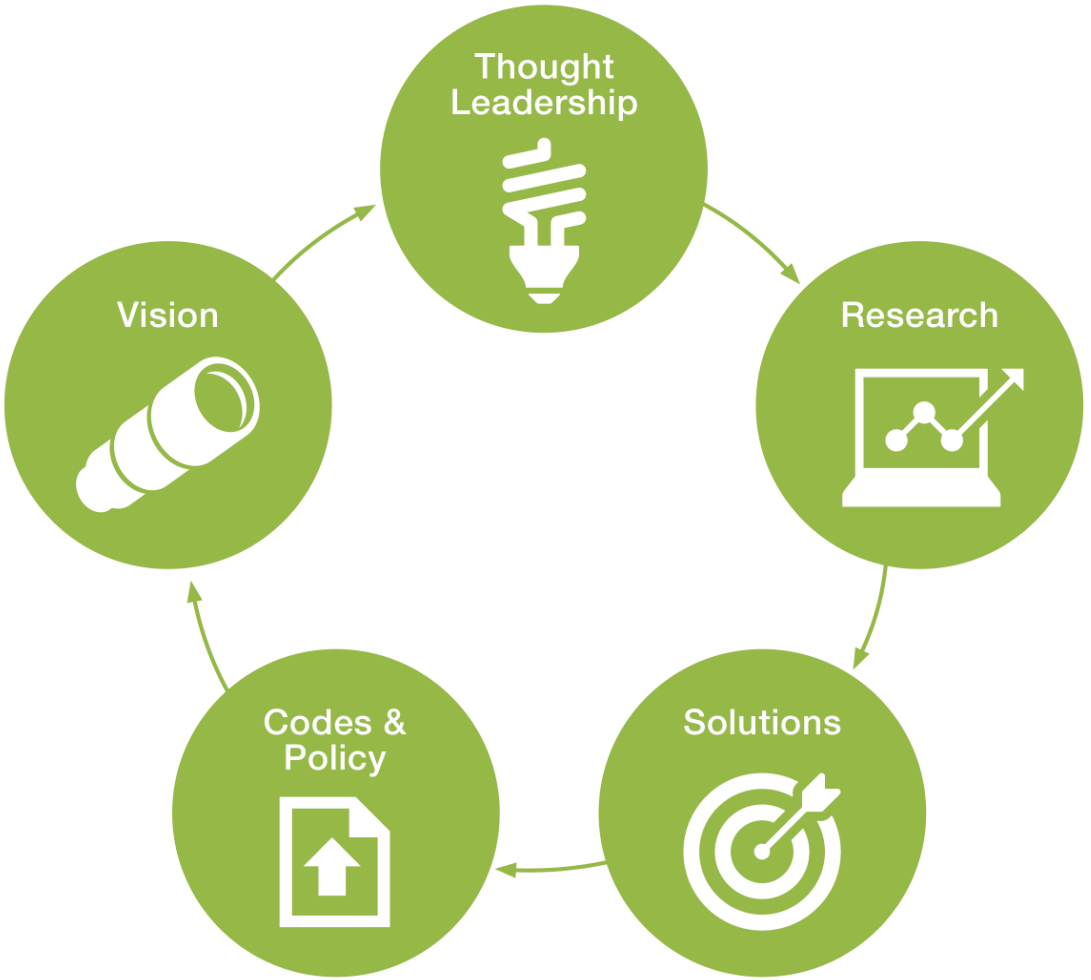
New Buildings Institute

Redefining energy efficiency in the built environment

NBI is a national nonprofit working to improve buildings for people and the environment.

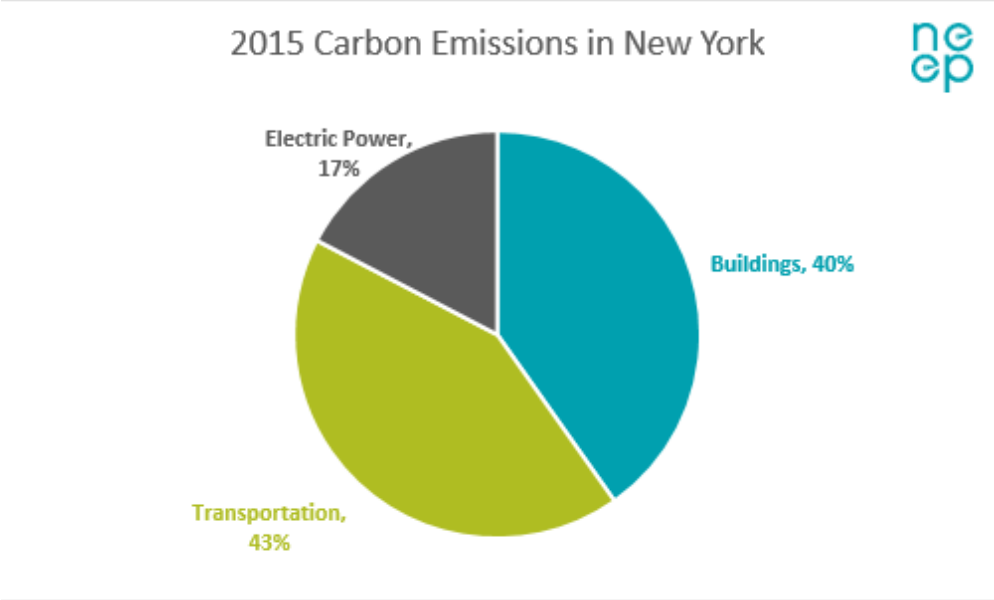
Program Areas:

1. Zero Energy Leadership
2. Building and Program Innovation
3. Advancing Codes and Policy



Goals and Buildings

- Statewide greenhouse gas emission reduction goals of 15 percent by 2015, 30 percent by 2025, and 80 percent by 2050, based on 2005 levels.
- Statewide greenhouse gas reduction targets of 1990 levels by 2020 and 60 percent below 1990 levels by 2050.
- Reduce the state's greenhouse gas (greenhouse gas) emissions to 20 percent below 2005 levels by 2025 and 80 percent below 2005 by 2050.
- DOE: A Zero Energy Building (ZEB) is an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.



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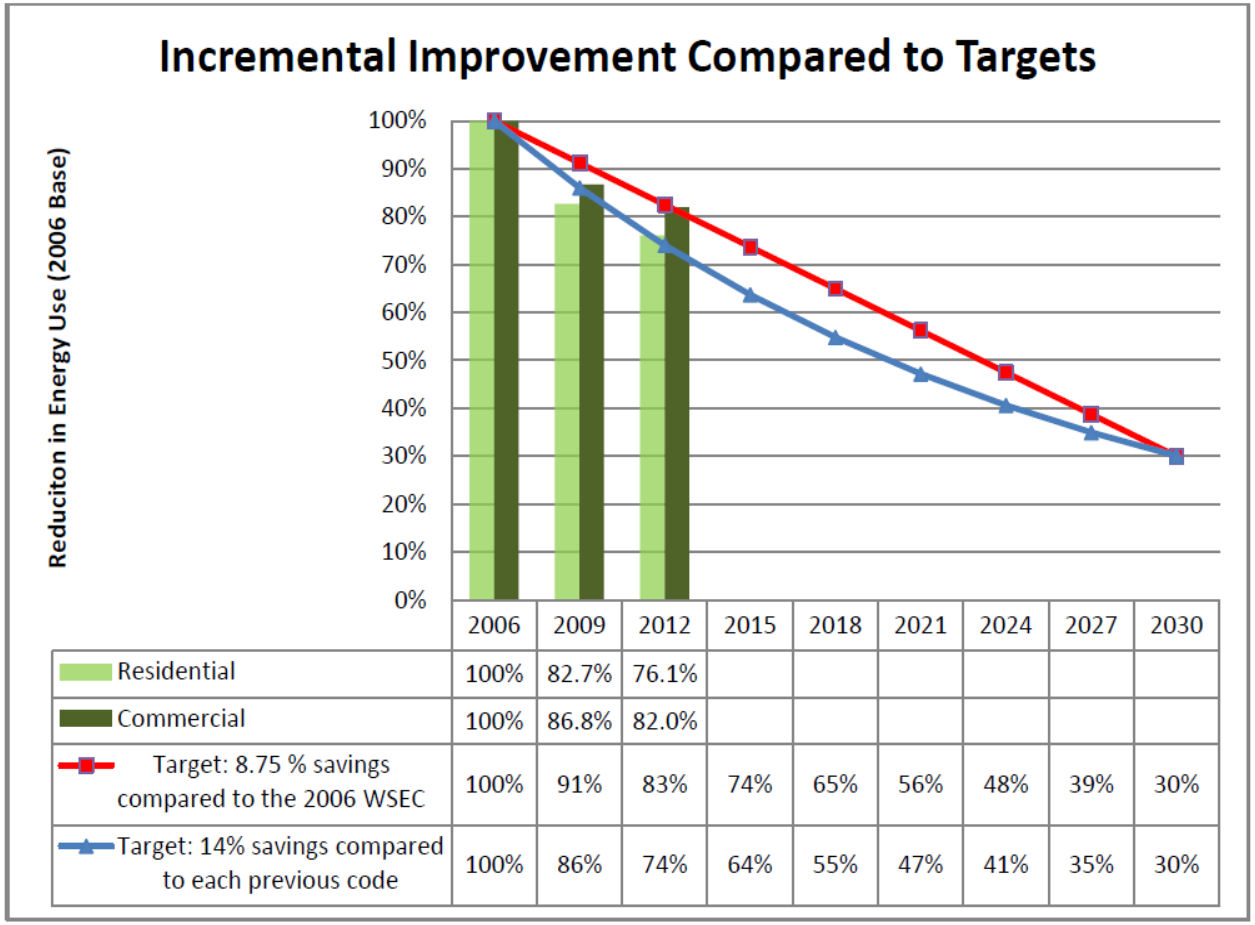
WA Code Improvement Targets



	2006	2009	2012	2015	2018	2021	2024	2027	2030
Residential	100%	82.7%	76.1%						
Commercial	100%	86.8%	82.0%						
Target: 8.75 % savings compared to the 2006 WSEC	100%	91%	83%	74%	65%	56%	48%	39%	30%
Target: 14% savings compared to each previous code	100%	86%	74%	64%	55%	47%	41%	35%	30%

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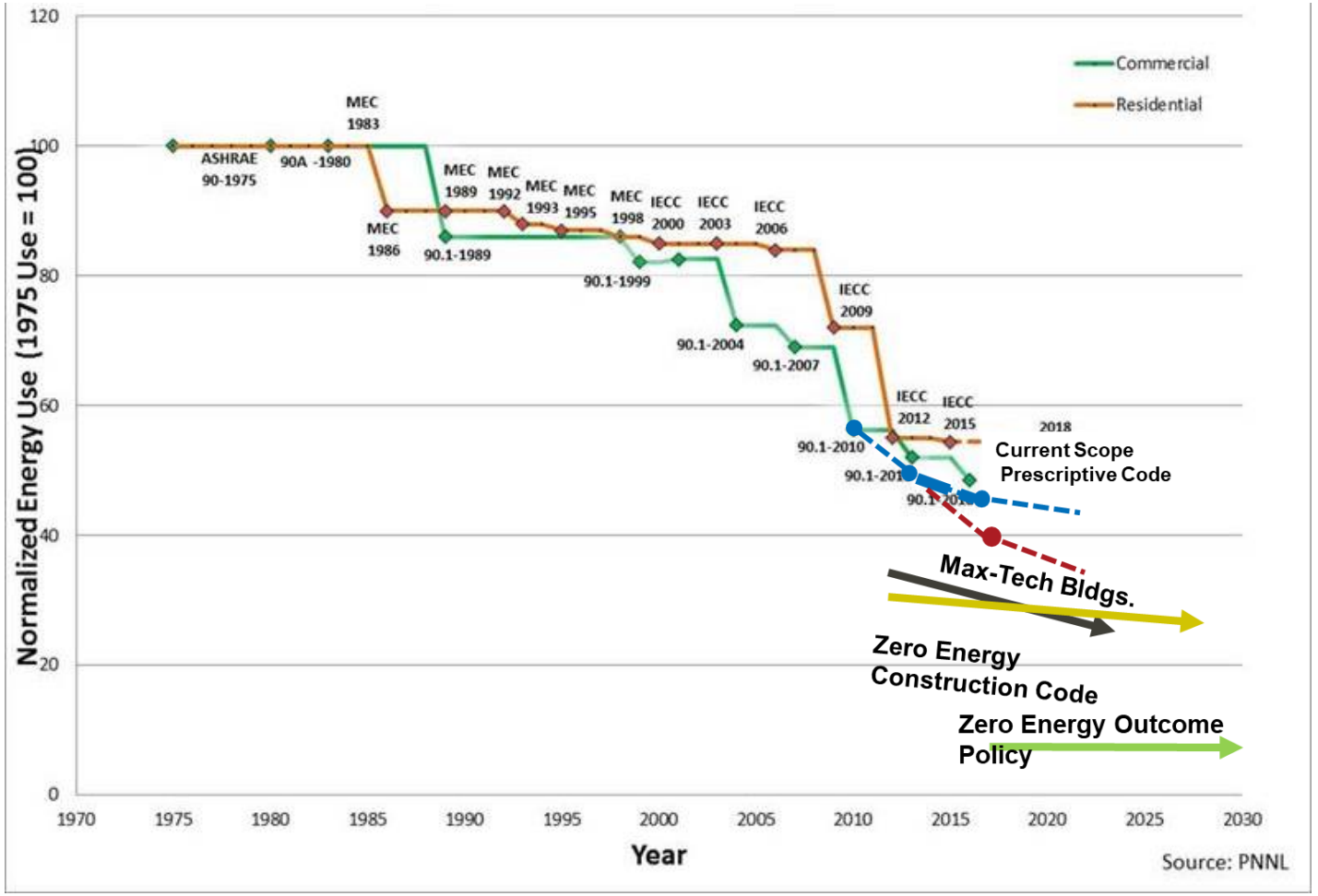
Roadmap to Net-Zero

Vermont Comprehensive Energy Plan (2011)

- Net-Zero Buildings Recommendation:

  "Consider and address the potential challenges for net-zero buildings in Vermont and complete recommendations for a clear path to achieve a goal of having all new buildings built to net-zero design by 2030. These recommendations will include the mechanisms that must be instituted to achieve such a goal (such as regulatory codes, energy codes, financing and incentives, and workforce training)."

Improvement in Model Energy Codes



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Potential Approach to Roadmap: Establish the EUI Targets

- Set starting point
- Set absolute energy targets instead of simply “% better than code”
- Couple with other sustainability goals and policies (LEED, etc.)
- Consider existing facility benchmarking results
- Determine solar capacity on roof and/or campus
- Determine incremental increases for code stringency

Data Sources For Potential Targets

Data Sources:

Label	Source	Description
90.1-2016	PNNL Modeling Data for 90.1-2016	Prototype modeling
CBECS 2012	CBECS 2012	Commercial building stock performance
GTZ Tracker	NBI Getting to Zero Tracker	Existing zero energy building performance
Standard 100	ASHRAE Standard 100	ASHRAE Standard 100 energy targets
NREL School Feasibility	NREL - School Technical Feasibility	Maximum achievable energy performance study
ARUP CA Feasibility	ARUP - California Technical Feasibility	Maximum achievable energy performance study
Glazer Max Tech	GARD Analytics - Max Tech Potential	Maximum achievable energy performance study
Toronto	Toronto Zero Emissions Framework	Toronto zero energy performance targets
HERS	Residential Energy Services Network (RESNET)	High performance single family building sample

Building Type Information:

Building Type	CBECS 2012	Building Models	GTZ Tracker
Medium Office	10k-100k sf	53,600 sf, 3 floors	10k-100k sf
Medical Office	All sizes	N/A	N/A
Primary School	All sizes	73,960 sf, 1 floor	All Sizes
Secondary School	All sizes	210,900 sf, 2 floors	All Sizes
Mid-rise Multifamily	N/A	33,600 sf, 4 floors	All Sizes
High-rise Multifamily	N/A	84,360 sf, 10 floors	N/A
Warehouse	All Sizes	49,495 sf, 1 floor	N/A
Large Hotel	N/A	122,132 sf, 7 floors	N/A
Standalone Retail	All Sizes	25,000 sf, 1 floor	N/A

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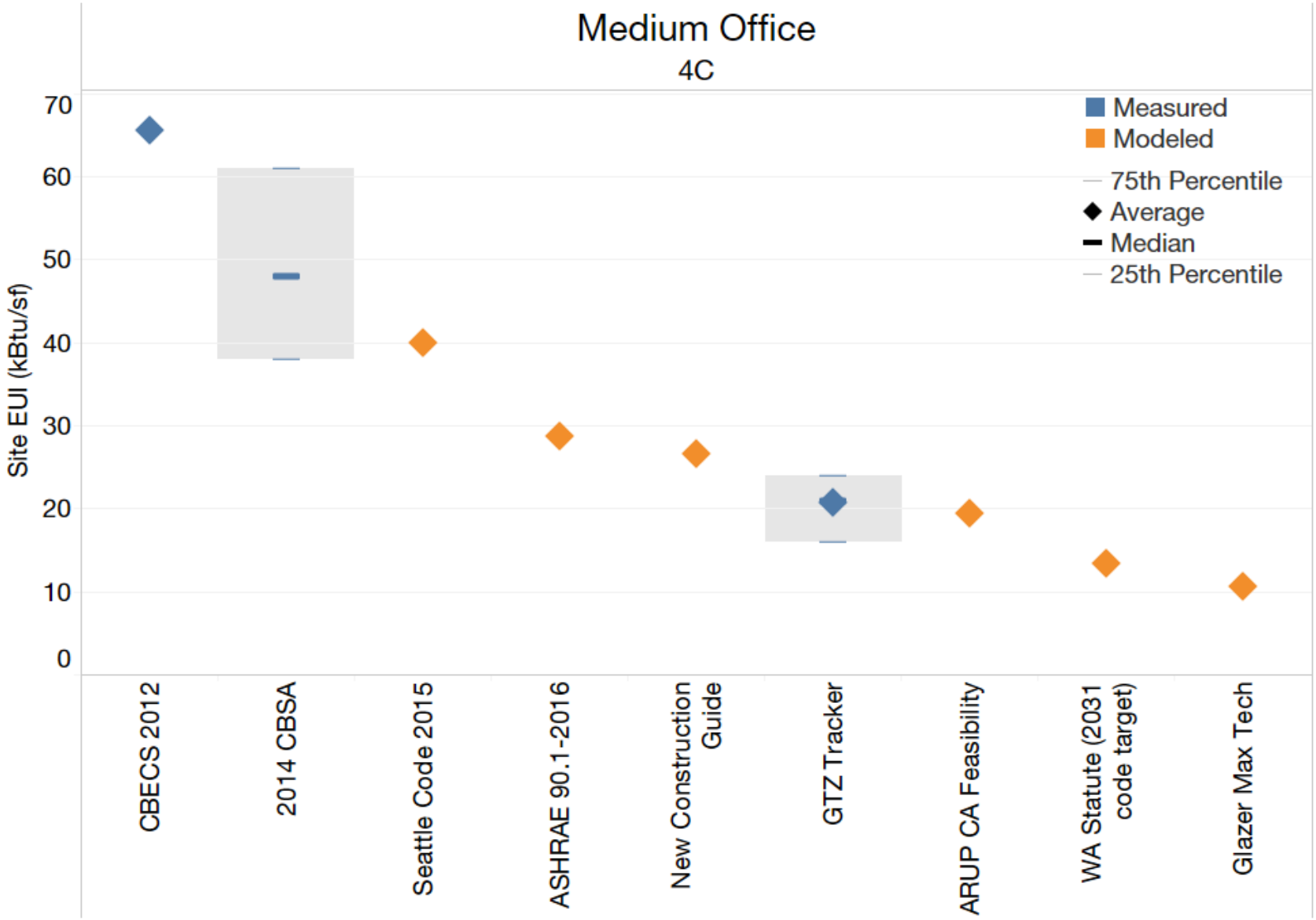
Trends in Modeled EUIs vs. Measured Data - Medium Office



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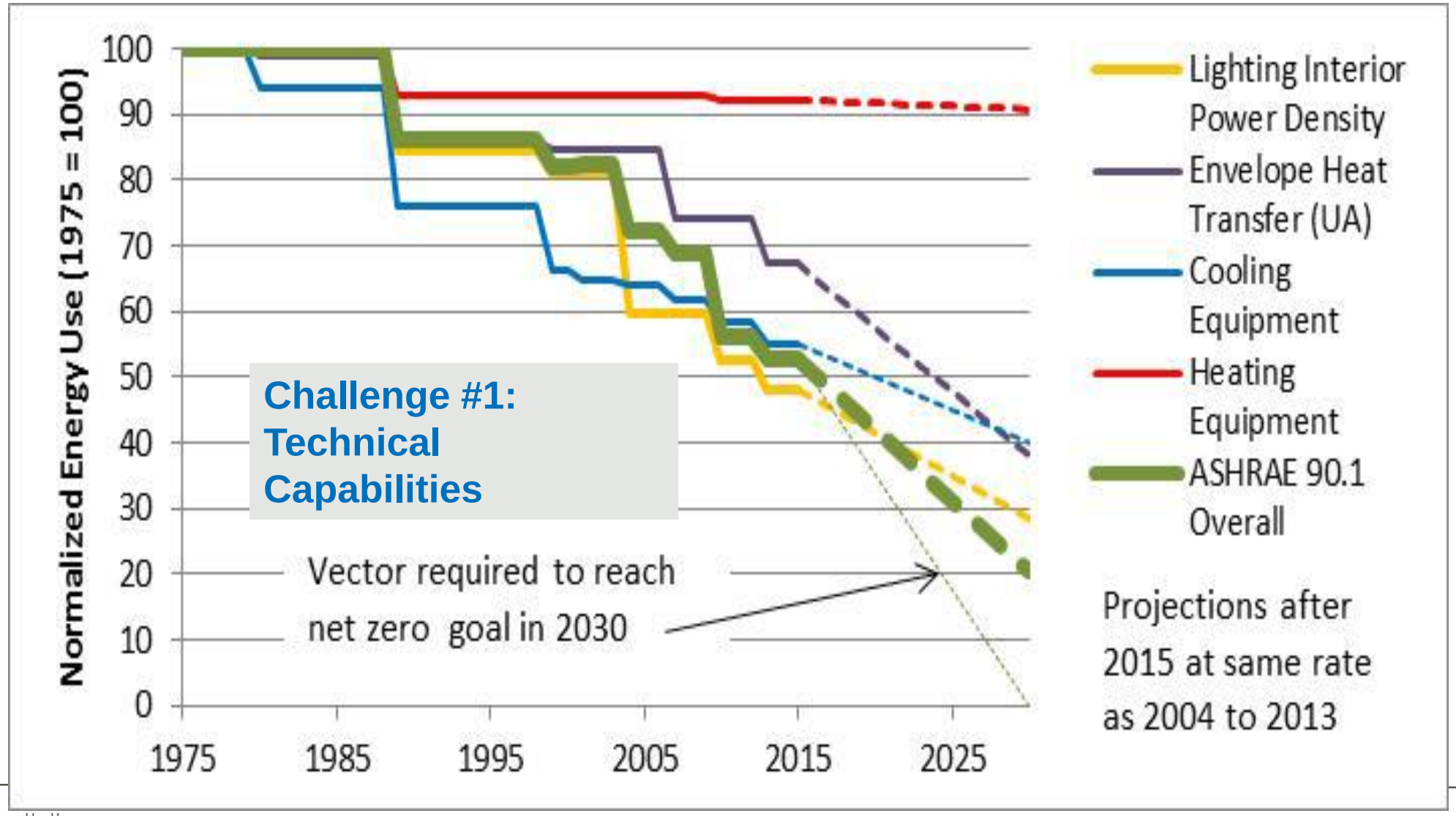
Examples of Zero Energy Targets

Table 3-1 Target EUI

Climate Zone	Site Energy		Source Energy	
	Primary School EUI, kBtu/ft^2·yr	Secondary School EUI, kBtu/ft^2·yr	Primary School EUI, kBtu/ft^2·yr	Secondary School EUI, kBtu/ft^2·yr
0A	22.5	22.9	69.1	70.5
0B	23.1	23.2	71.4	71.6
1A	21.3	21.1	65.5	65.0
1B	21.7	21.6	66.6	66.6
2A	20.9	21.3	63.8	65.1
2B	19.6	19.9	59.7	60.8
3A	18.8	19.1	56.7	57.7
3B	19.0	19.4	57.3	58.8
3C	17.5	17.6	52.6	52.8
4A	18.8	18.9	56.3	56.7
4B	18.4	18.5	55.1	55.5
4C	17.5	17.6	51.9	52.3
5A	19.2	19.1	57.1	56.9
5B	18.7	19.0	55.6	56.6
5C	17.4	17.6	49.7	52.3
6A	21.1	20.6	62.8	61.2
6B	19.5	19.5	57.9	57.9
7	22.3	21.5	66.2	63.7
8	25.2	23.8	71.1	70.7

Technical Progress by Component



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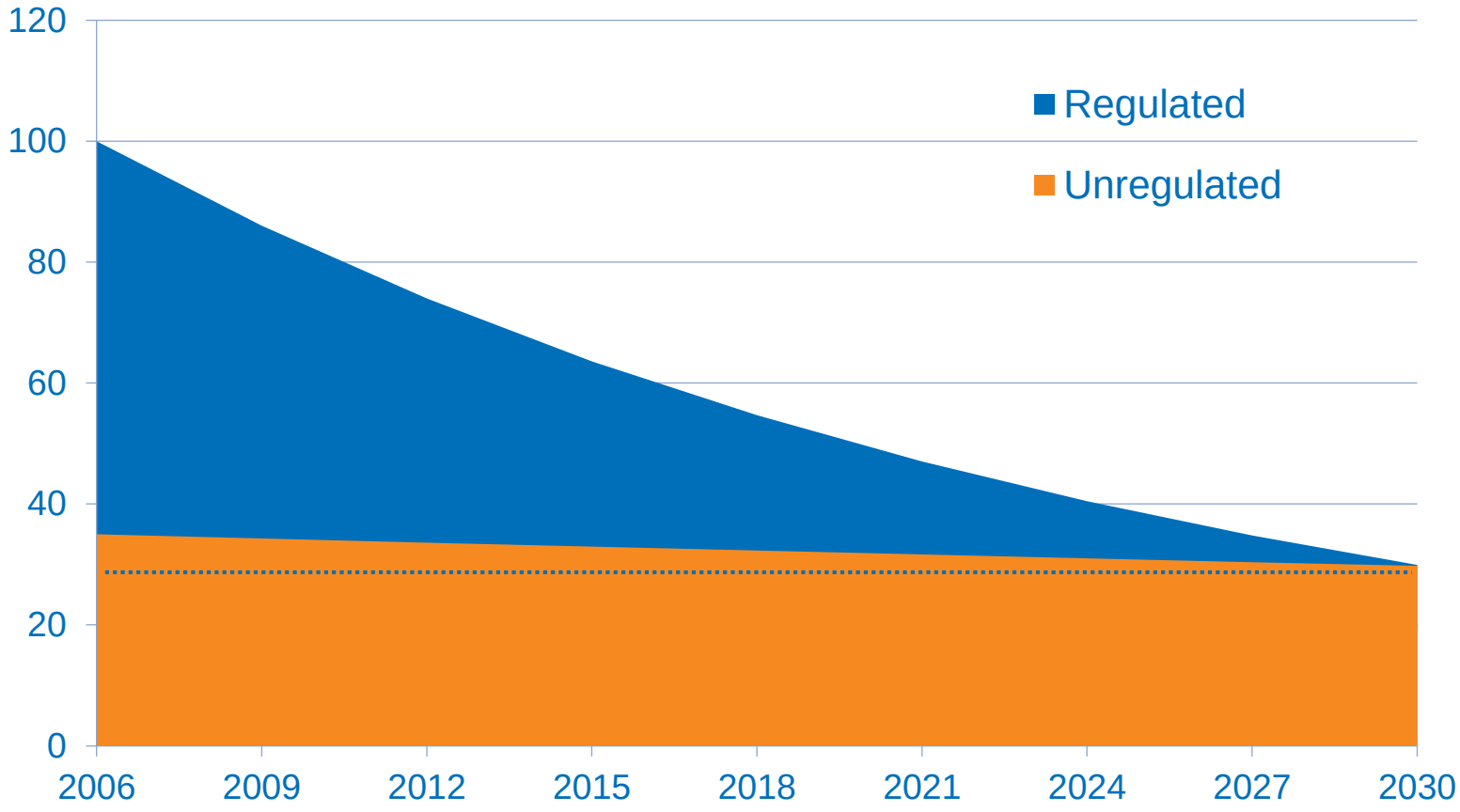
Regulated vs. Unregulated Loads



Challenge #2: Code Scope

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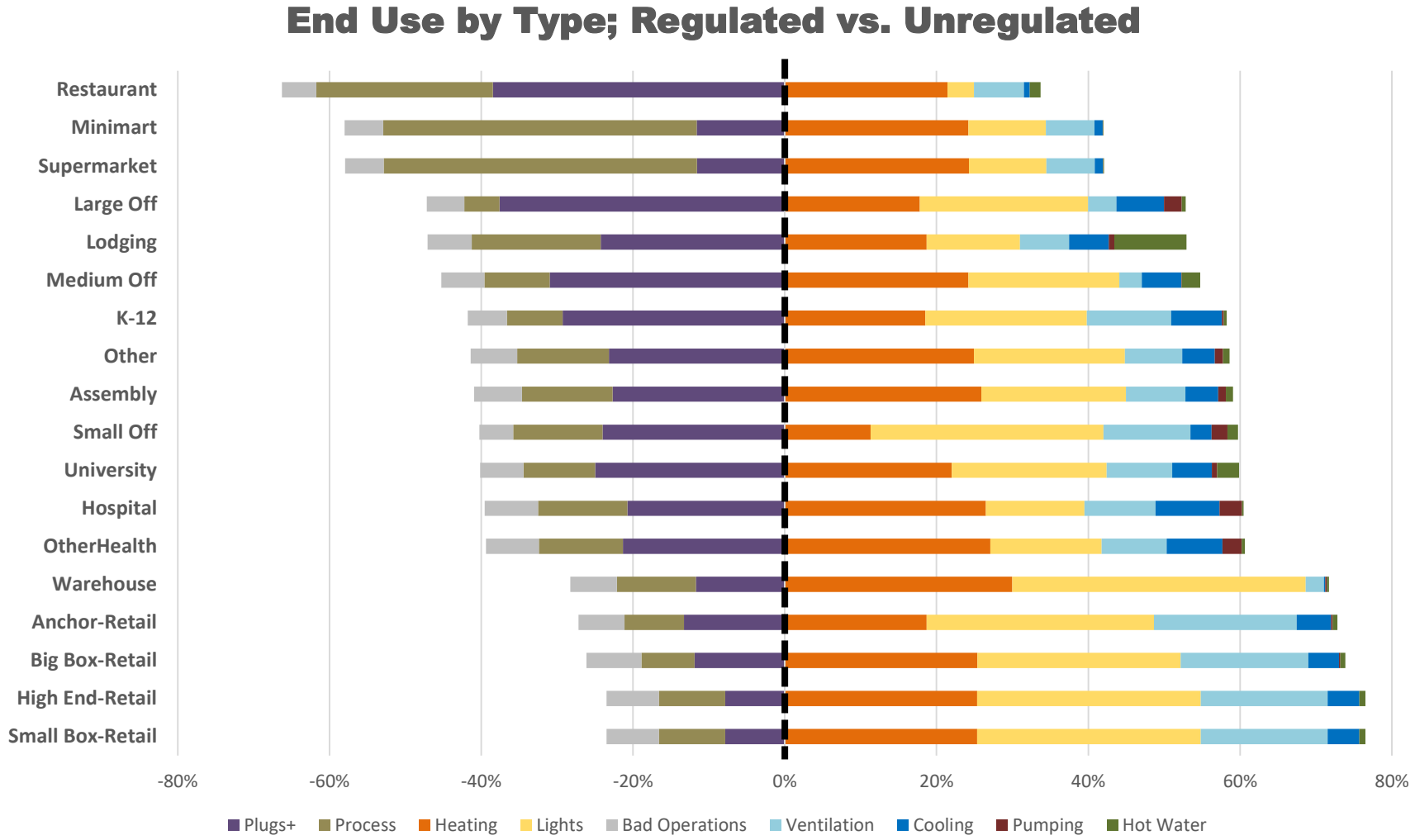
Building Loads



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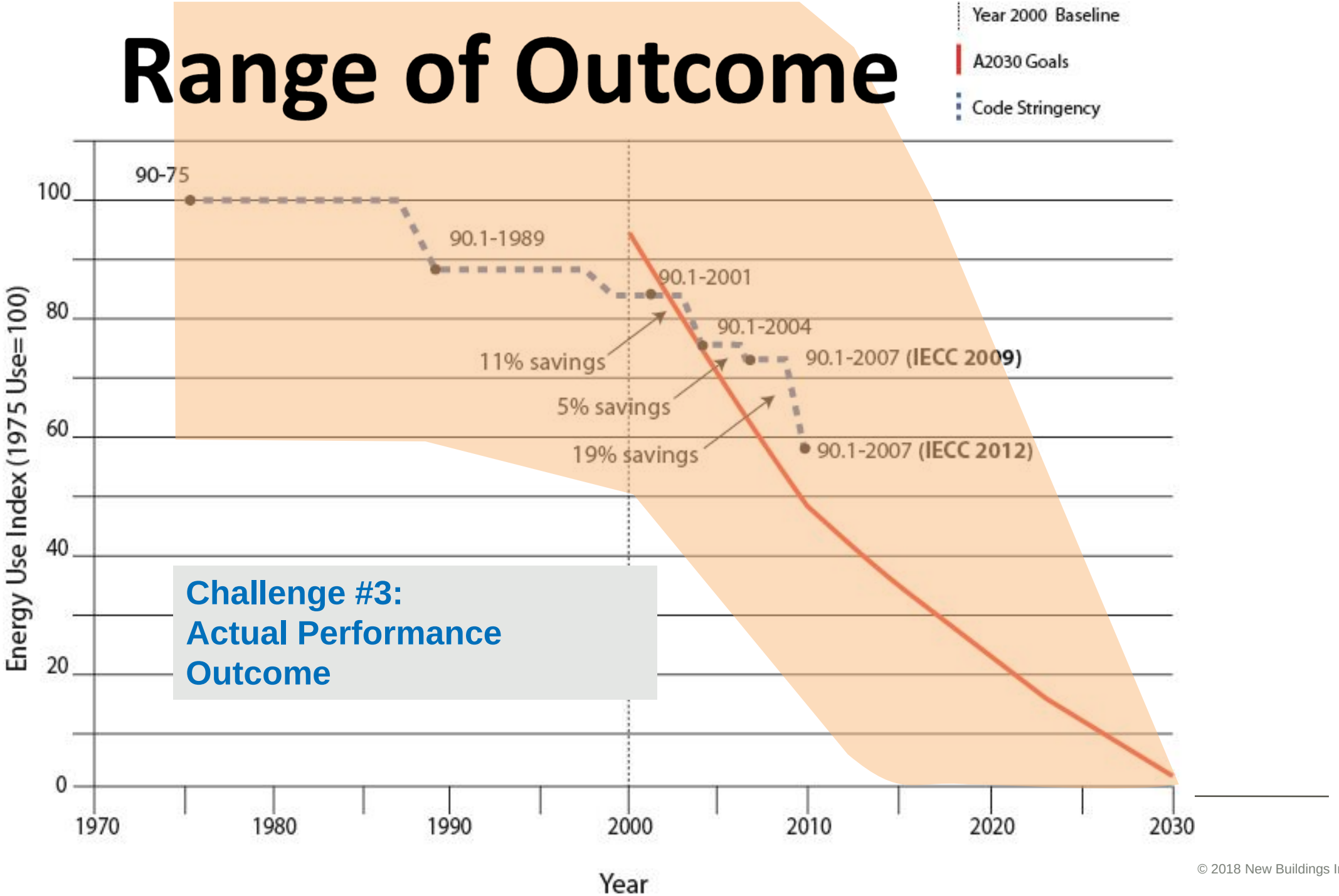
Opportunity Areas		General Interim Steps	Code/ Policy Increments			Barriers	Long Term Goals
Envelope	Insulation	continuous improvement	increased insulation requirements; limitations on thermal bridging impacts	Adopt Passive House or ASHRAE 189 envelope standards, envelope Cx	Continued envelope performance improvements; robust envelope Cx reqs.	cost effectiveness, thermal bridging; construction quality	Super-efficient thermal envelope
	Glazing	increasing dis-incentives for over-glazing, continuous technological advancement	increasing dis-incentives for over-glazing, continuous technological advancement	increasing dis-incentives for over-glazing, continuous technological advancement	increasing dis-incentives for over-glazing, continuous technological advancement	thermal limitations of frames, cost, desire to over-glaze	moderate glazing area, high performance glazing systems
	Infiltration	infiltration testing; increasingly stringent performance requirements; heat recovery ventilation.	broader testing requirements	specific performance criteria, demonstrated by testing	specific performance criteria, demonstrated by testing; DOAS with heat recovery	poor construction practice on air sealing; real or perceived moisture concerns; HVAC pressurization strategies	tight building envelope with heat recovery ventilation
Plug Loads	Computers and other plug loads	regulate equipment efficiency; require automatic controls, engage occupants	require separate plug load circuits; metering; plug load circuit controls in increasing applications; occupant feedback	active plug circuit management and control strategies; manufacturer equipment performance standards	continued equipment performance improvement; occupant engagement programs typical	outside scope of code; requires interaction with building users	more efficient equipment, operated only as needed
	Misc Equipment	regulate equipment efficiency; require automatic controls	sector specific performance requirements (elevators, emergency lighting, security systems, etc.)	increasing sector specific performance requirements	broad sector specific performance requirements and equipment standards	outside scope of code; requires interaction with building users	more efficient equipment, operated only as needed

Range of Outcome



Challenge #3:
Actual Performance Outcome

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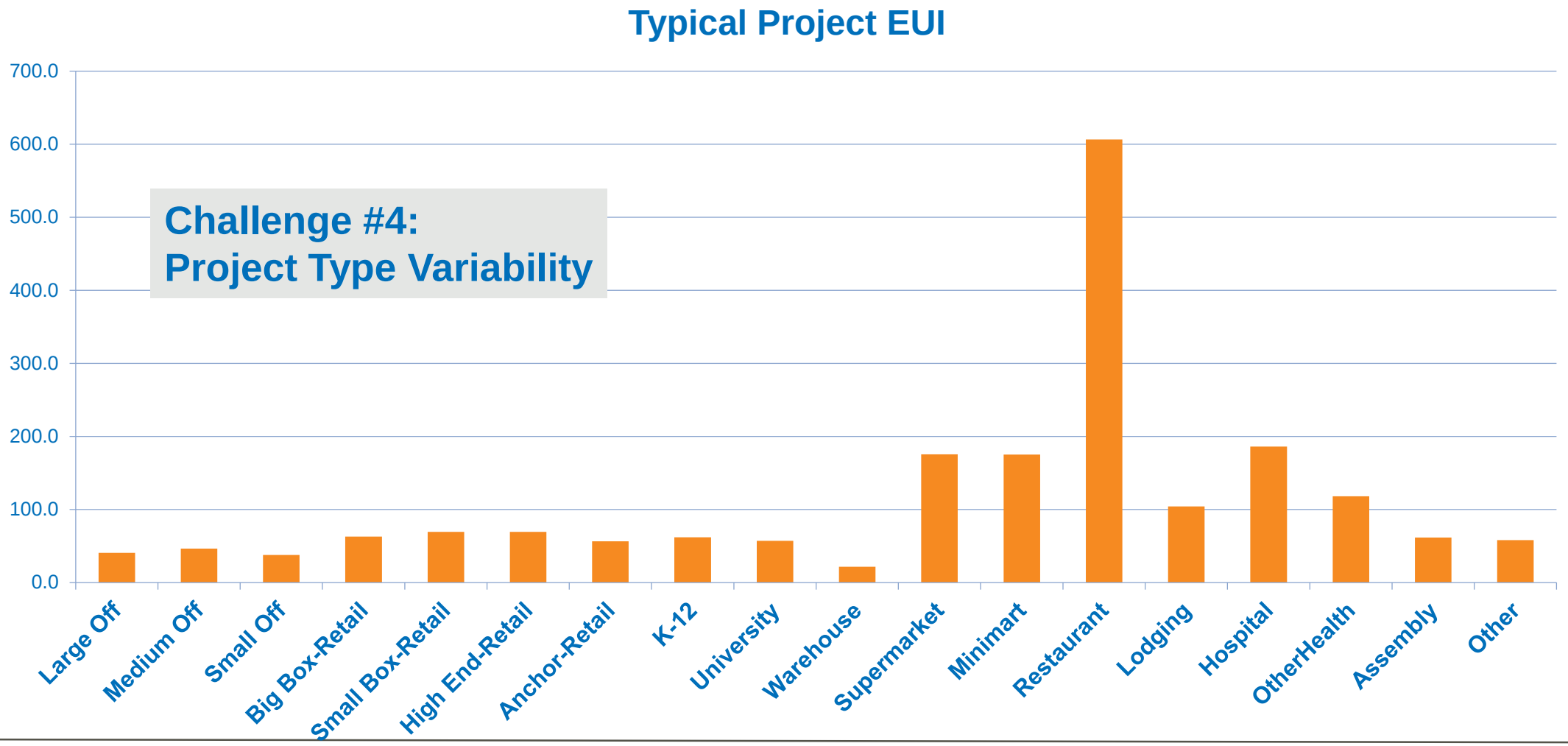
Energy Use by Project Type



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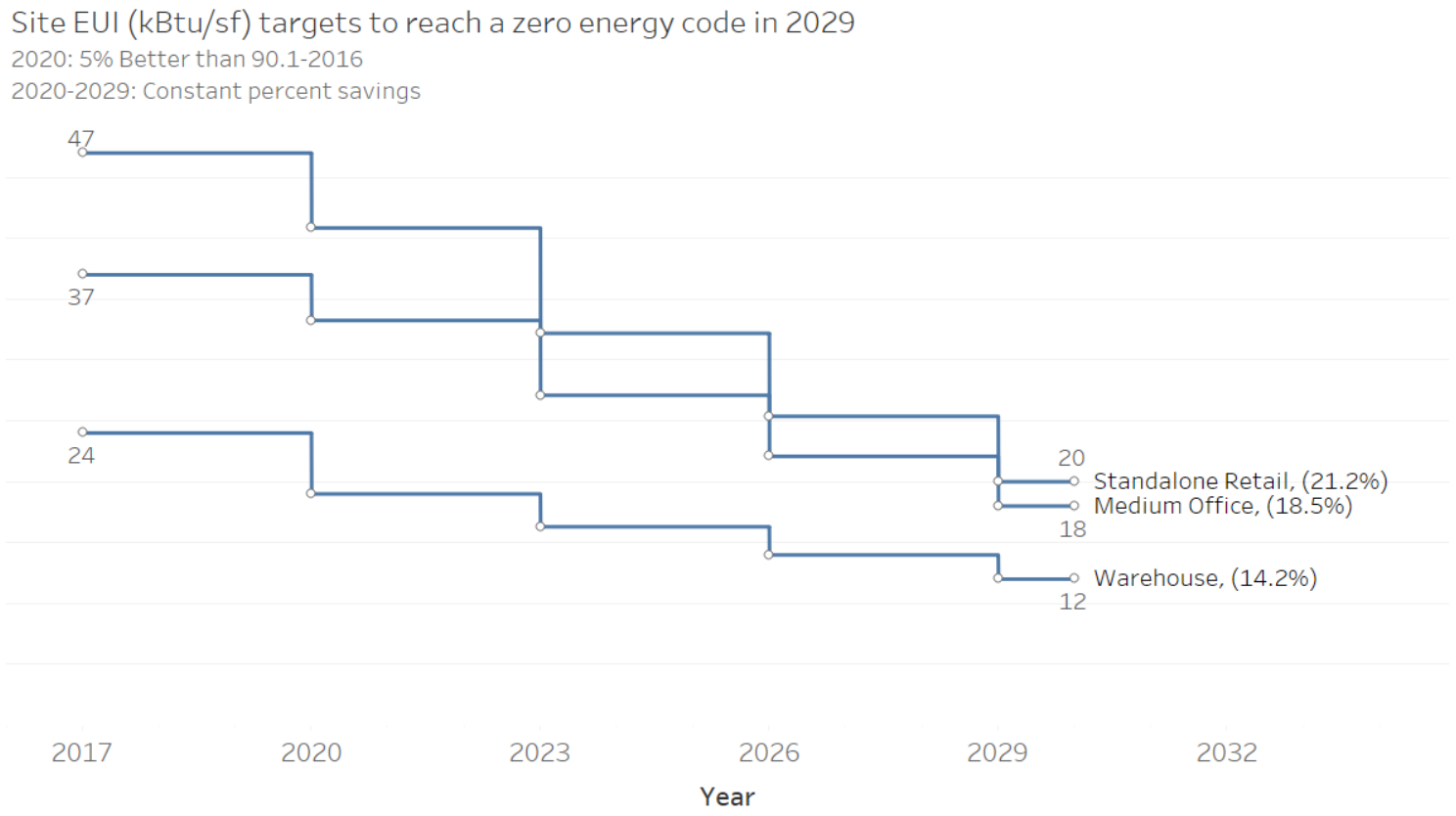
Site EUI targets to reach a ZE code in 2029: Retail, Office, Warehouse



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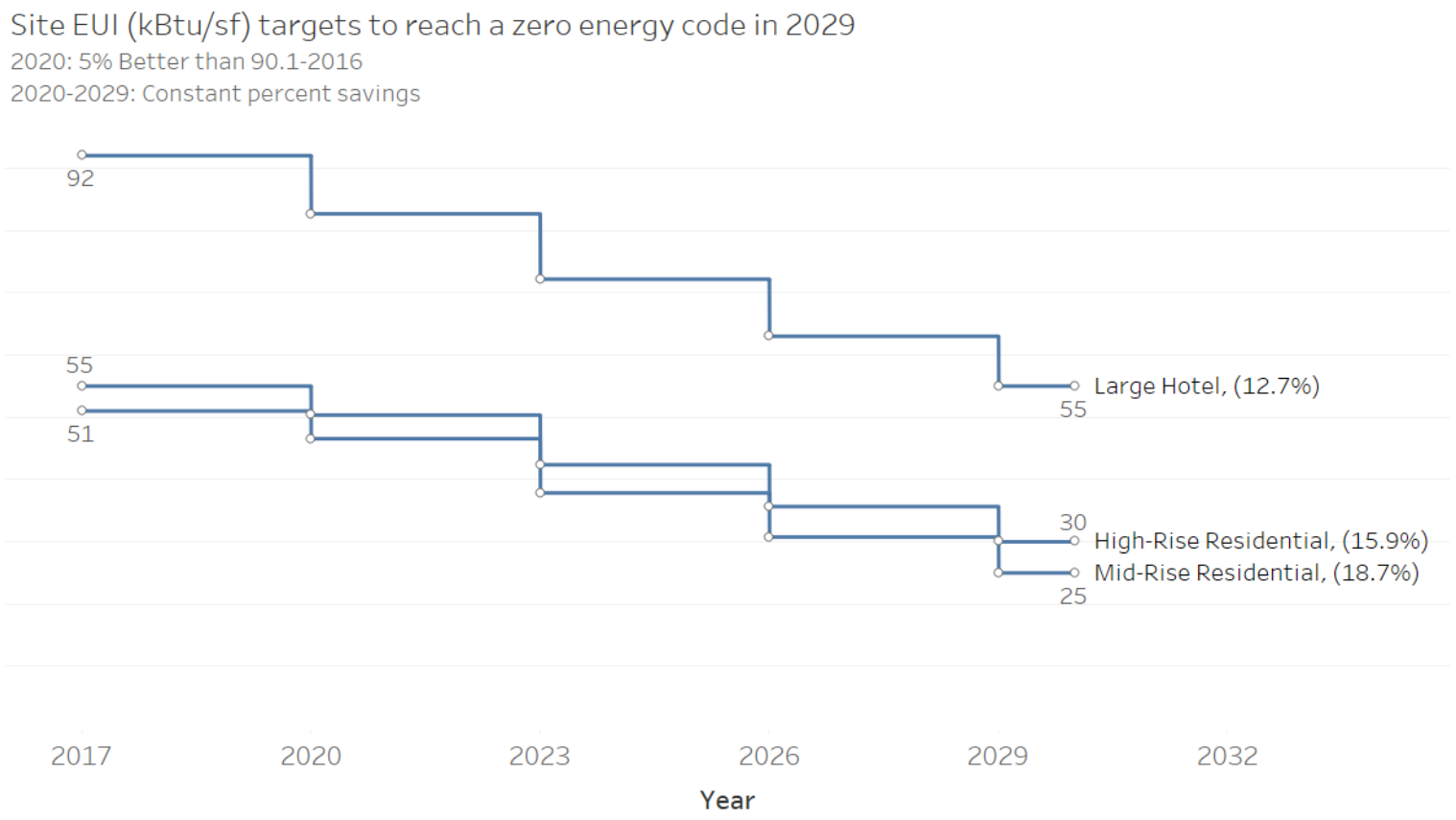
Site EUI targets to reach a ZE code in 2029: Mid-Rise Residential



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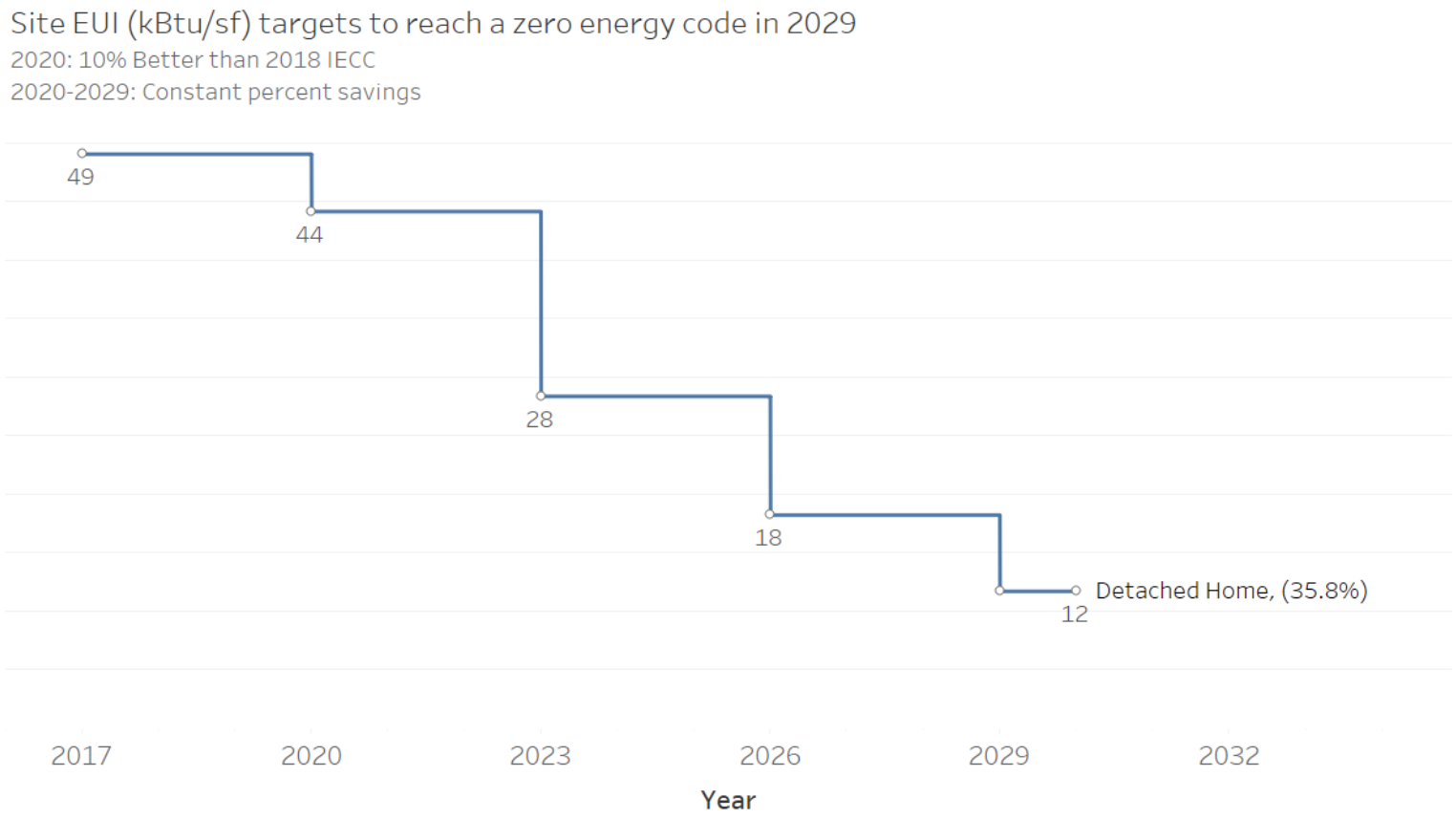
Site EUI targets to reach a ZE code in 2029 – Detached Home



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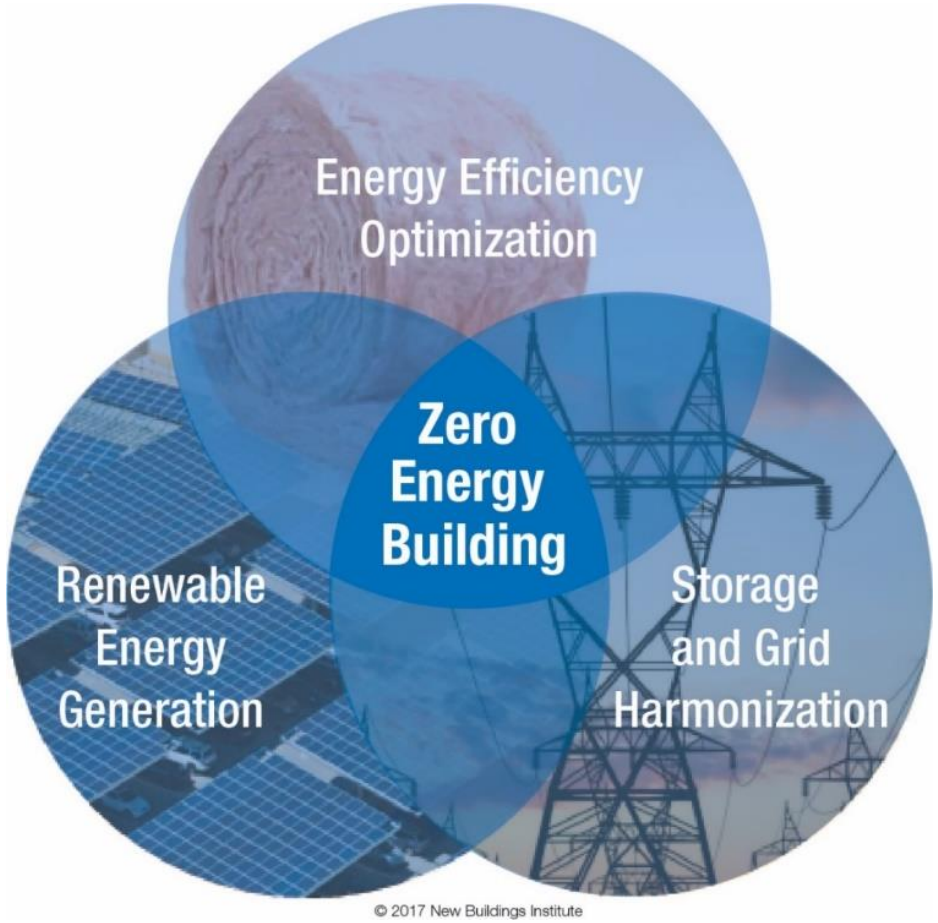
End Game



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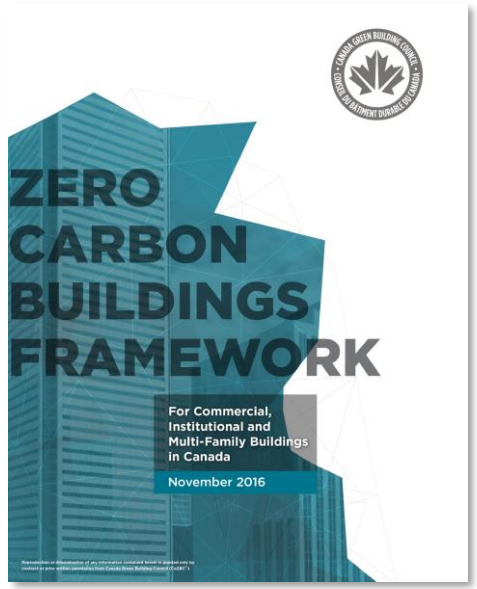
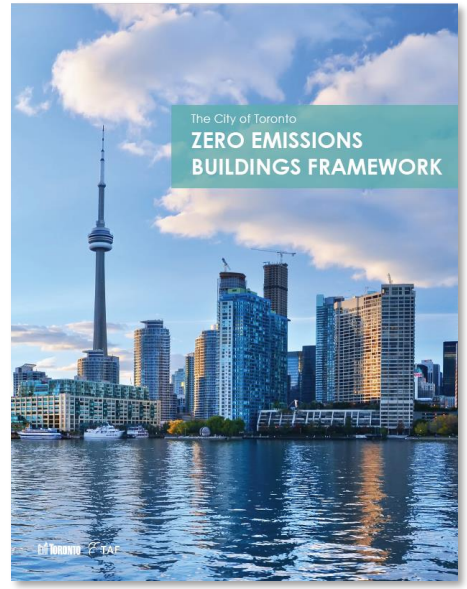
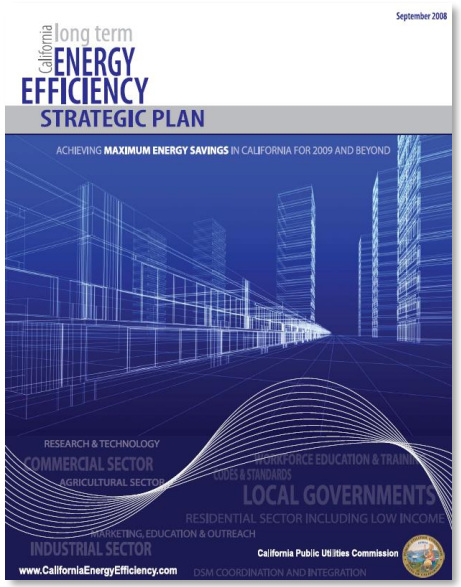
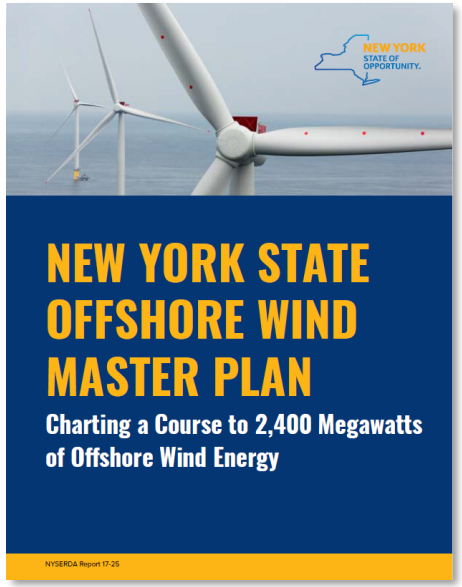
Milestone Roadmaps

- The City of Toronto Zero Emissions Buildings Framework
- California Long Term Energy Efficiency Strategic Plan (And 2011 Update)
- NYS Offshore Wind Masterplan
- Blueprint for Efficiency: An 80x50 Buildings Partnership Report
- Canada GBC Zero Carbon Buildings Framework









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David and Lucille Packard Foundation Building
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