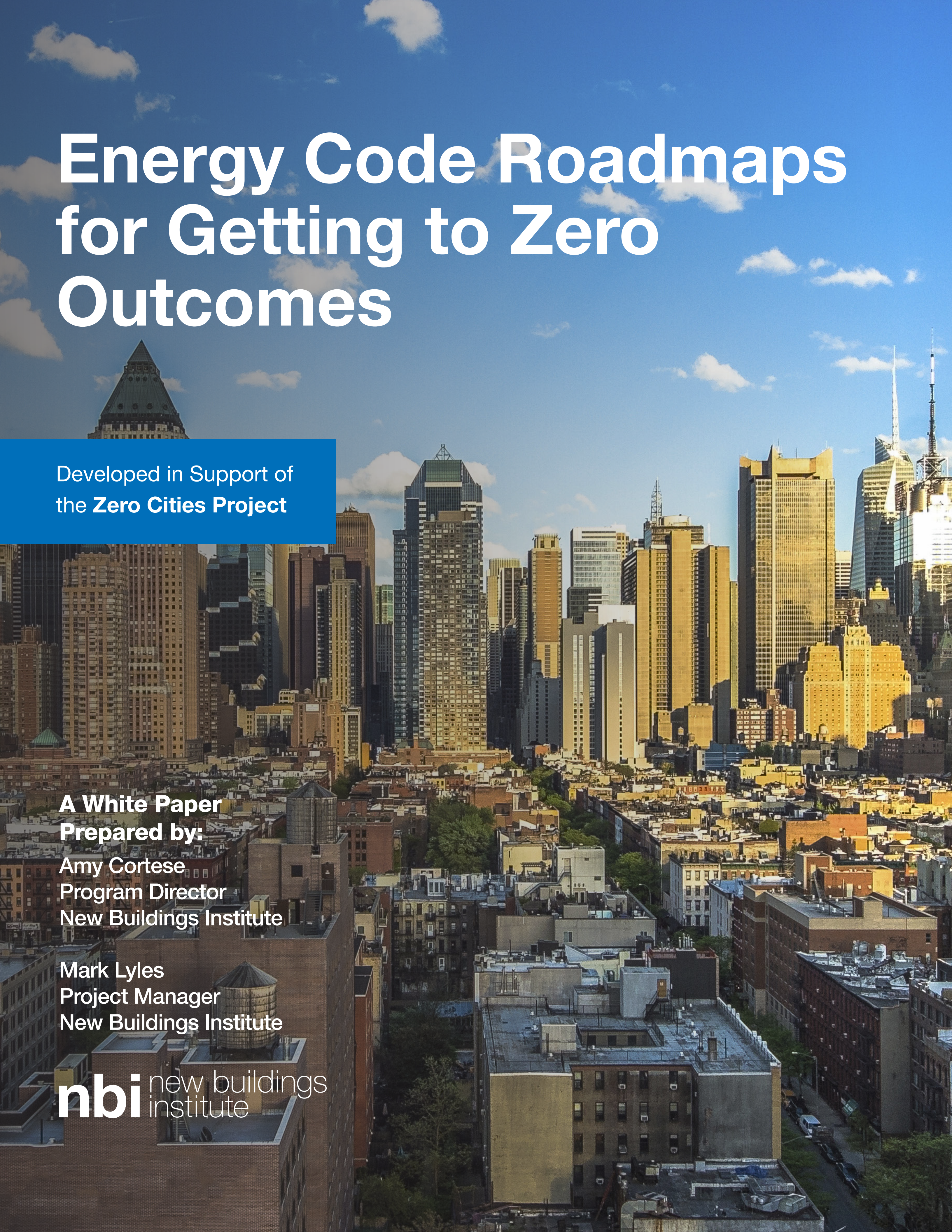

Energy Code Roadmaps for Getting to Zero Outcomes

Developed in Support of
the **Zero Cities Project**

A White Paper Prepared by:

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Advanced energy codes are an important policy mechanism to advance energy efficiency and integrate renewables into the built environment. Energy code roadmaps lay the groundwork by identifying the order and priorities necessary for subsequent code improvements on the path to zero energy and zero carbon emissions. This paper outlines the evolving nature of energy code roadmaps, their effective application and process for development, as well as a proposed roadmap for a leading jurisdiction. This material was developed through research conducted by staff at New Buildings Institute under the Zero Cities Project, a multi-year project supporting both cities and their most impacted communities to co-develop and implement actionable and equitable roadmaps and policy strategies to achieve a zero-net-carbon (ZNC) building sector by 2050.

The Case for Energy Efficiency

Achieving decarbonization in building sector operations involves optimizing building-level energy efficiency, offsetting building consumption with renewable energy, reducing gas consumption in buildings, and reducing the overall carbon intensity of the grid. It's a balancing act influenced my many factors such as grid infrastructure constraints and the rapidly changing economics associated with renewable energy production at both the building and utility scale.

The relationship between these issues is nuanced. However, we know that ultra-low and zero energy buildings (i.e. energy efficient buildings where annual consumption is offset with on-site renewable energy) can be achieved within a reasonable or no-cost increment. Even in the face of steep cost reductions in renewables, a range of efficiency strategies remain less expensive to deploy at the building level. Therefore, energy efficiency will remain an important policy objective to pursue in any code roadmap since full decarbonization of the grid will take time and electrification of the transportation sector will add further demands to an already constrained grid.

Evolving Energy Codes

For decades, energy codes have been **prescriptive**, meaning that each component of the building (i.e., walls, windows, lighting, mechanical systems, etc.) must meet a certain standard.

Performance-based approaches to energy codes allow simulation of whole building designs. These predictions compare the proposed building to a reference building in order to demonstrate compliance with the energy code, but they may not align with how the building actually performs once occupied. **Outcome** approaches hold owners and design teams accountable for achieving certain Energy Use Intensity (EUI) performance goals identified in policy and energy model predictions during the code submittal process.

Both prescriptive and performance-based energy codes have limitations. For one, not all energy uses (like plug in equipment) are covered in energy codes. Second, designers using the performance approach make assumptions during the design process about operation set points, plug load use, and occupancy patterns, which may or may not be true once the building is occupied and operating, so modeling predictions often vary from actual outcomes. Third, some aspects of building

One important way to address these limitations is to bring actual building performance outcomes into line with performance goals and predictions. Moving to an outcome-based strategy will require several iterations of code to prepare the market for low-energy outcomes. The process steps below explain key elements of the approach and the proposed code roadmap for a leading jurisdiction illustrates the application of those steps

Outcome Code Roadmap

Code roadmaps lay out specific goals for new residential and commercial buildings to achieve policy objectives by a certain date. They identify the mechanisms and cycles by which code provisions can evolve over time and multiple code cycles. The outcome code transition is based on three important elements:

- Incremental increases in code stringency to require reduced building energy use.
- Increasing deployment of renewable energy resources to offset remaining building energy use, culminating in zero energy performance.
- Transition to a focus on actual building outcomes, first as a predicted value but increasingly verified as a performance outcome.

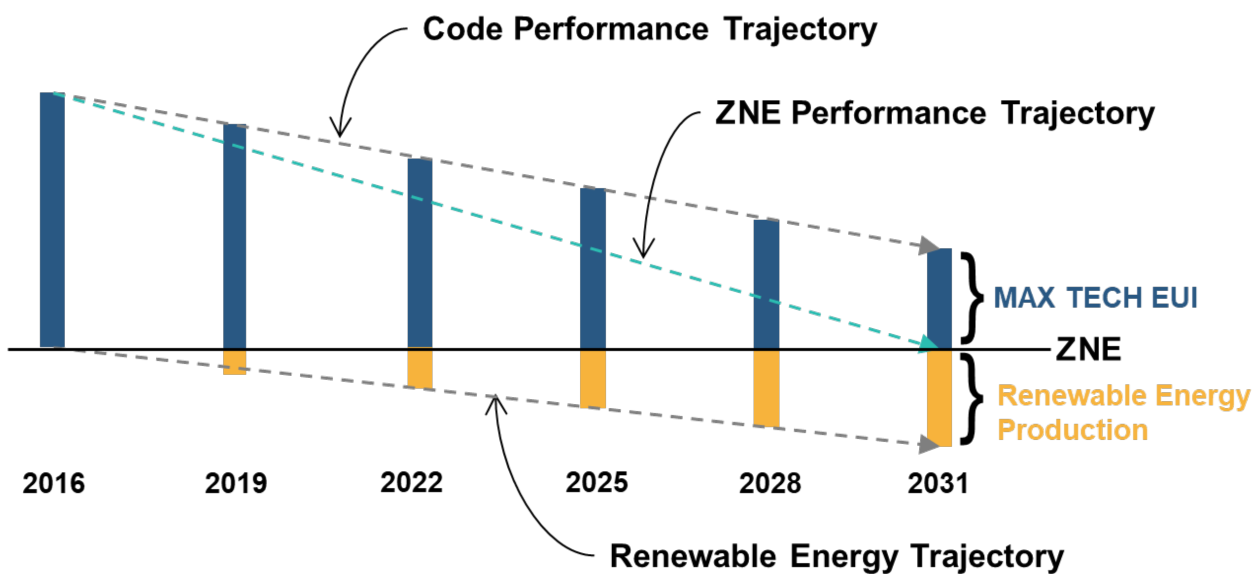

Figure 1: Code Path to ZNE

Based on research done for the Zero Cities Project, here is a summary of the steps in the process:

Incrementally improve efficiency requirements in every code cycle in order to achieve maximum technical ("Max Tech") levels of performance by the targeted year of the policy. Max tech targets are specific to a type of building and climate zone, and they may decline over time with advancing technology. A number of data sources can help inform incremental improvements from current performance to max tech in code. Some of these include: building energy disclosure data, code determination studies (i.e. modeled energy savings estimates) by Pacific Northwest National Labs, research studies, New Buildings Institute's Getting to Zero list of verified building performance, or other modeled performance studies such as the ASHRAE Advanced Energy Design Guide for Zero Energy schools.

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performance, namely HVAC equipment, are regulated at the federal level and states are barred from requiring increased stringency due to federal preemption requirements.

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435 Indio Way | Sunnyvale, CA *Credit: Bruce Damonte*

Cities with disclosure and transparency data can compare modeled data to design predictions submitted during design and permitting.

Energy targets will continuously improve from current code until they achieve max tech by 2031 or whatever year the year the policy should be fully implemented. Analysis of existing data suggests that Energy Use Intensity (EUI) values in the low to mid-20 kBtu/square foot per year represent the anticipated max tech performance target for many building types (for example, schools and office buildings) before accounting for renewables. It should be note that some building types, such as those with few data sources and high range of performance prediction, may not be good candidates for specific energy targets.

Introduce Energy Use Intensity (EUI) building performance metrics and connect design predictions to measured performance. Cities with disclosure and transparency data can compare modeled data to design predictions submitted during design and permitting. Changes in weather, tenants, occupant density, or building use may mean that a building uses more energy than predicted. Energy models can be normalized for these factors. The simple act of going back to update and understand energy modeling accuracy closes an important feedback loop for the design community and pushes the industry toward more accountability on predictive modeling. Over time with this enhanced feedback loop, the discrepancy between predicted performance and outcome performance will lessen and accuracy of models will improve.

Incorporate renewable energy systems into compliance strategies, eventually requiring full offset of energy use with renewables. As building performance requirements approach max tech limits, an increasing fraction of building performance goals are anticipated to be provided by renewable energy until full offsets are required for zero energy buildings. Projects may choose to deploy more or less renewables to achieve the targets, with increasing minimums for renewable deployment in subsequent code cycles.

Code backstop requirements should be put in place to prevent inherently inefficient buildings and over-dependence on renewables. A backstop requirement is a minimum efficiency requirement that must be met before the incorporation of renewables. This backstop can be based on minimum performance thresholds in the most current model energy codes.

As renewable deployment increases, energy storage will become increasingly important to support grid operations and decarbonization goals. This roadmap anticipates that building-level storage deployment will become a required element of building performance over time.

Enhance code process and enforcement to address building performance outcomes in order to improve alignment with performance targets and support broader efforts to improve the building stock. The existing submittal process may need to be modified slightly to implement the backstop code, enforce restrictions on modeling assumptions, and review for required renewable energy. This will require new collaboration between the city building department and whomever is enforcing the disclosure ordinance.

A number of scenarios might be considered as enforcement mechanisms for buildings in operation, including:

- Performance bond, collected at the time of permit, that is released back to the project when compliance with actual performance requirements is demonstrated, or invested in additional renewable energy resources to make up for the performance shortfall
- Temporary Certificate of Occupancy, granted at the time of project completion, is not converted to a permanent status until performance is proved
- Tax or utility fee structure for projects that are not in compliance within the specified compliance window
- Detailed audit and retro-commissioning requirements for projects not meeting performance goals

The table below shows the successive approach to the issues described above, planned by a leading jurisdiction to achieve outcome-based code enforcement for zero energy operational performance levels by the 2031 code cycle.

Proposed Code Roadmap

	Existing Code Context	Step One (sample year: 2019)	Step Two (sample year: 2022)	Step Three (sample year: 2025)	Step Four (sample year: 2028)	End Goal (sample year: 2031)
Code Improvement[1]		25%	40%	60%	75%	Max Tech
Renewable Energy Offsets	Not Required	5%	10%	25%	50%	100% (ZNE)
Energy Storage	Not Required	Not Required	Encouraged	Encouraged	Required	Required
Back Stop Code	None	90.1-2016	90.1-2016	90.1-2019	90.1-2022	90.1-2025
Modeling Requirements	Not required	Model to establish EUI target	Model to EUI target	Model to EUI target	Model to EUI target	Model to EUI target
Outcome Requirements	None	Report on discrepancy in disclosure data	Within 15% of target	Within 10% of target	Achieve target	Achieve ZNE
Normalization to Modify Target	N/A	Report on discrepancy	Document use changes in model	Document use changes in model	Document changes in model	Not allowed
Enforcement Mechanism	Certificate of Occupancy	Certificate of Occupancy, Disclosure	Disclosure; Bond or Solar Credit	Disclosure; Bond or Solar Credit	Bond or Solar Credit	Bond or Solar Credit
Prescriptive Path	Small/Remodel Projects only	Small/Remodel Projects only	Add renewables	Add renewables	Not Allowed	Not Allowed

1. Over ASHRAE 90.1-2016

While this code roadmap does not specifically address carbon emissions, it should be noted that a code roadmap could also incorporate carbon metrics in addition to energy metrics. Any code roadmap that includes carbon metrics would need to address fuel source consumed onsite (natural gas and electricity) and may include carbon emissions associated with the electrical grid. Carbon emissions associated with the grid vary dramatically by location as well as time of use.

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New Buildings Institute (NBI) is a nonprofit organization driving better energy performance in commercial buildings. We work collaboratively with industry market players—governments, utilities, energy efficiency advocates and building professionals—to promote advanced design practices, innovative technologies, public policies and programs that improve energy efficiency. We also develop and offer guidance and tools to support the design and construction of energy efficient buildings.

Throughout its 20-year history, NBI has become a trusted and independent resource helping to drive buildings that are better for people and the environment. Our theory of change includes setting a vision and defining a path forward. We then set out to create the research that serves as the basis for tool and policy development necessary to create market change.