Making It Happen: Creating Your Zero-Over-Time (ZOT) Plan

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Introduction

A Zero-Over-Time (ZOT) Plan, based on an ASHRAE Level 2 Energy Audit, serves as a detailed roadmap to transition affordable housing properties to zero-carbon emissions. This process starts with Phase 1: a foundational project designed to achieve a minimum 30% reduction in carbon emissions. By addressing energy efficiency, electrification, renewable energy integration, and climate resilience, the ZOT plan lays out verifiable steps for achieving zero emissions while balancing affordability, safety, and resident comfort.

Crafting a Zero-Over-Time (ZOT) Plan

A zero-carbon transition plan aligns with the Department of Energy's (DOE) definition of zero-emission buildings and 1. identifies specific leverage points within the affordable housing development lifecycle, and 2. prioritizes upgrades that optimize emissions reduction, energy efficiency, and cost savings.

As envisioned, this guide suggests a Zero-Over-Time Plan with three distinct phases:

- Phase 1 (Years 1-5): Immediate Impact Measures
- Phase 2 (Years 6-12): Deep Electrification
- Phase 3 (Years 13-20): Optimization and Resilience

This guide helps project teams develop a Zero-Over-Time Plan that includes all three phases outlined above, with an enhanced focus on Phase 1: Immediate Impact Measures. This will ensure that projects will be able to achieve early, meaningful reduction in carbon emissions while maintaining flexibility for future renovations.

It is also worth noting: this tool uses a sample timeline of 20-years for the execution of a Zero-Over-Time Plan. However, a Zero-Over-Time Plan can range from 5-20 years and should be developed in close coordination with the developer, development team and energy raters / auditors to ensure it matches the timeline for system replacement and major capital improvements.

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Order of Operations to Developing a Zero-Over-Time (ZOT) Plan

1. Review of ASHRAE Level 2 Audit Findings
2. Define Clear ZOT Objectives
3. Stakeholder Engagement
4. Assess Technological Options and Phasing
5. Financial Analysis and Funding Mechanisms
6. Risk Management and Contingency Planning
7. Phase 1 (Immediate Impact Measures): Achieving 30% Emissions Reduction
8. Zero-Over-Time Overview (Maximum 20-year plan)

1. Review of ASHRAE Level 2 Audit Findings

a. Energy Use and Efficiency
   i. Energy Consumption Profiles: Review detailed energy consumption data, including electricity, natural gas, heating, and cooling.
   ii. High-Impact Areas for Energy Savings: Prioritize opportunities for energy efficiency improvements in HVAC systems, lighting, insulation, and windows.
   iii. Baseline Electrification Scope: Identify the capacity and equipment required to transition from combustion-based systems to electric systems during emergency replacements. Highlight upgrades needed to achieve this transition (e.g., panel capacity, wiring, and load management).

b. Baseline Carbon Footprint
   i. Current Emissions Baseline: Establish Scope 1 (direct emissions from on-site combustion) and Scope 2 (indirect emissions from electricity use).
   ii. Path to Electrification: Quantify potential carbon reductions from transitioning key systems to electric alternatives, identifying necessary preparatory work (e.g., grid readiness, infrastructure upgrades)

c. Equipment and System Condition
   i. Condition Assessment: Analyze the age, efficiency, and maintenance needs of existing equipment and systems

ii. Retrofit vs. Replacement: Evaluate the feasibility of retrofits versus full system replacements, with emphasis on enabling future electrification
iii. Electrification-Ready Systems: Identify existing systems that are electrification-ready and those requiring upgrades or replacement to accommodate electric alternatives

d. Health and Safety
   i. Indoor Air Quality and Water Quality: Assess indoor air and water quality concerns and propose necessary improvements
   ii. Safety Risks: Review safety risks, including fire hazards from retrofitting electrical systems, and outline corrective actions
   iii. Audit Findings Expansion: Incorporate specific findings from Task 1 related to health and safety into this category, including detailed system vulnerabilities and required mitigations

e. Resiliency
   i. Climate Impact Assessment: Understand the building's resilience to climate impacts, such as extreme weather events and chronic climate conditions, based on a preliminary vulnerabilities assessment
   ii. Response Strategies: Identify strategies to enhance resilience, including infrastructure upgrades, backup power solutions, and system redundancies.
   iii. Electrification and Resilience: Evaluate how electrification aligns with climate resilience objectives, focusing on systems that ensure operational continuity during extreme events (e.g., backup battery systems or grid-independent solutions)
   iv. Audit Findings Expansion: Integrate specific findings from Task 1 related to resilience, ensuring all vulnerabilities and proposed responses are addressed in detail

2. Define Clear ZOT Objectives

a. Carbon Reduction Goals
   i. Specific Targets: Define carbon reduction targets for the 20-year life of the ZOT plan:
      1. Initial Project - 30% Emissions Reduction (Phase 1)
      2. Energy Star Score of 75
      3. Elimination of Onsite Fossil Fuel Combustion by the end of the 20-year plan

b. Emergency Equipment Replacement Considerations
   i. Capacity Planning for Electrification:

1. Upgrading Electrical Panels: Existing electrical systems may not be designed to handle the increased power demands of renewable energy systems (e.g., solar photovoltaic (PV) panels, battery storage). In this case, electrical panels, circuits, or transformers may need to be replaced or upgraded, which can be a significant capital expense
    a. Identify the electric capacity required to replace combustion-based systems with electric systems during emergency replacements
    b. Ensure sufficient panel space is allocated for new electric equipment

2. Grid Connection: The integration of renewable energy or microgrid systems often requires an upgraded grid connection. In some areas, utility companies may require a new connection agreement, or there may be fees for the grid connection, which should be accounted for

3. Incorporate planning for electrical readiness, including conduit space, wiring upgrades, and load management capacity, to allow for rapid deployment of electric systems when emergency replacements are needed
    a. Dedicated Circuits: Plan for dedicated circuits for each HVAC unit or system to ensure safety and avoid overloading the electrical system.
    b. Power Supply Considerations: Evaluate if the building's power supply is sufficient to accommodate the additional demand of electrified HVAC systems, considering both current and future needs (e.g., additional electrical appliances, EV chargers).
    c. Back-Up Power: Consider integrating battery storage or a backup generator to ensure HVAC systems remain functional during power outages, especially in areas prone to grid disruptions.

ii. Coordination with Electrification Goals: Ensure emergency replacement strategies align with the overarching electrification objectives of the ZOT plan, facilitating smooth transitions without disruption to operations.

iii. Building System Readiness: Identify and implement preparatory measures needed to support electrification of emergency

replacements, including backup power compatibility, battery storage integration, and connections to renewable energy source.

iv. Smart Meters and Energy Management Systems: To fully realize energy savings and integrate renewable systems, smart meters and energy management systems (EMS) are increasingly required. These systems monitor energy consumption in real-time and allow for dynamic energy management. The integration of these technologies may require additional electrical infrastructure or a complete system overhaul, especially in older buildings or facilities.

c. Health and Safety Goals
   i. No Compromises on Health, Safety, or Comfort: Decarbonization efforts must maintain or improve occupant health and safety, addressing air quality, noise, and fire safety
   ii. Energy Burden Mitigation: Consider energy burden implications and reference the accompanying policy document for conditions under which energy burden is a concern. Evaluate potential measures for both benefits and unintended consequences related to affordability and equity
   iii. Example Benefits Table: Include a table summarizing health and safety benefits of proposed measures, such as improvements to air quality, reductions in noise, or enhanced thermal comfort
   iv. Sample Table listing benefits of potential measures:

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Table 1. Benefits Summary

Description of Upgrade	Thermal Comfort	Indoor Air Quality	Odor, Pest, Noise Control	Durability	Site Energy Savings	Utility Cost Savings
PRIORITY PROJECTS (HEALTH & ENERGY)						
Masonry Wall Insulation	✓	✓	✓		✓	✓
Attic Air Sealing & Insulation	✓	✓	✓	✓	✓	✓
Compartment Air Sealing	✓	✓	✓		✓	✓
Foundation Wall Insulation		✓	✓		✓	✓
Electrification of Ranges		✓			✓	
In-Unit ERVs		✓				
NON-ENERGY PROJECTS						
Replace Carpet with Tile		✓				
Add Roof Downspouts, Grade Land Away from Building, Clean Landscape Drains				✓		
FUTURE UPGRADES						
Clothes Washers & Dryers					✓	✓
Common Area Lighting					✓	✓
Windows & Storefront Entries	✓	✓	✓	✓	✓	✓
ES Dishwashers					✓	✓
ES Refrigerators					✓	✓
Air Source Heat Pumps	✓				✓	✓
Heat Pump Water Heaters					✓	
NON-ENERGY PROJECTS						
In-Wall Dehumidifiers	✓	✓		✓		
ON-SITE RENEWABLE ENERGY						
Solar PV						✓

d. Resilience and Climate Adaptation
    i. Climate Resilience Integration: Incorporate strategies to enhance building resilience to future climate impacts, such as:
        1. Energy System Redundancy: Ensure critical systems remain functional during outages, with emphasis on electrified backup systems (e.g., battery storage, microgrids).

        2. Flood Resistance and Infrastructure Durability: Upgrade infrastructure to withstand flooding and other extreme weather events.

    ii. Electrification and Resilience Alignment: Evaluate how electrified systems can contribute to resilience, focusing on uninterrupted operations during emergencies and extreme climate conditions

e. Regulatory Compliance
    i. Alignment with Codes and Standards: Ensure the ZOT plan complies with local, state, and federal regulations related to energy efficiency, carbon emissions, and building codes. Key considerations include:

1. Local building energy performance standards and electrification mandates
2. Renewable energy integration requirements
3. Compatibility with future regulatory trends, ensuring proactive compliance over the plan's lifecycle

3. Stakeholder Engagement

a. Internal Stakeholders: Involve all project team members, building residents and or community members, property managers, and operations teams in the planning process to ensure an inclusive and holistic predevelopment process.

b. External Stakeholders: Engage with local utilities, energy service providers, government agencies, and community groups to understand local assets, ensure alignment with community priorities, including climate goals, and to access support services.

c. Education and Training: Provide training for building managers and staff on new systems, energy management practices, and the importance and benefits of carbon reduction efforts, health, safety and resilience building updates. Provide awareness of properties' potential climate vulnerabilities and encourage development of an emergency management plan.

d. Educating Residents: Provide education on the benefits of electric HVAC systems, including energy savings, comfort, and sustainability. Help tenants understand how to use new building systems including thermostats, control settings, and optimize their energy use, as well as the importance and benefits of carbon reduction efforts, health, safety and resilience building updates and programmatic implementation

e. Incentives for Energy-Efficient Use: Identify and implement programs to encourage adoption of energy-efficient behaviors (e.g., setting thermostats at optimal temperatures or using fans instead of AC).

f. Monitoring and Feedback: Offer energy monitoring tools that allow residents to track their electricity usage, especially related to HVAC, and consider their behavior to lower costs and energy consumption.

g. HVAC Maintenance and Support
    i. Ongoing Maintenance: Plan for regular maintenance schedules for electric HVAC systems, including checks on heat pump performance,

refrigerant levels, and filter replacements. This will ensure optimal system performance over time.

ii. Training for Maintenance Personnel: Provide training for maintenance staff to ensure they are familiar with the specific needs of electric HVAC systems and are prepared for any troubleshooting or system upgrades.

4. Assess Technological Options and Phasing

a. Energy Efficiency Measures (EE): Implement energy conservation measures identified in the audit, such as lighting retrofits, HVAC system upgrades, insulation, and building envelope improvements.

i. Identify System Inefficiencies: Identify areas where the current HVAC system is inefficient or costly (e.g., high fuel consumption, poor performance) and prioritize them for electrification.

1. Proper Sizing: Ensure the new electric HVAC systems are properly sized to meet the specific heating and cooling requirements of the building. Oversizing or under-sizing can lead to inefficiencies.

ii. HVAC Load Analysis: Conduct a load analysis to determine the heating and cooling needs of the building and assess how these needs can be met with electric systems.

iii. Identify sources of waste energy for potential capture and reuse: drain-water, ventilation, etc.

b. Electrification Pathways: Identify areas for electrification, such as heating, cooling, and hot water systems. This could include heat pump installation or electric boilers, particularly where fossil fuel systems (e.g., natural gas) are currently in use

i. Consider Hybrid Systems: In areas with extreme temperatures, a hybrid system combining heat pumps with electric backup (e.g., electric resistance heaters) can ensure year-round performance while reducing peak electricity demand.

c. Renewable Energy Integration: Evaluate the feasibility of on-site renewable energy systems (e.g., solar panels, wind turbines, geothermal) and/or purchasing renewable energy (e.g., renewable energy certificates, power purchase agreements).

d. Carbon Capture and Offsets: Explore options for carbon offsetting if direct emissions reductions are challenging to achieve (e.g., purchasing credits, carbon capture technologies).

e. Smart Building and Energy Management Systems: Implement advanced energy management and building automation systems to optimize energy usage, improve real-time monitoring, and integrate renewable energy sources efficiently.

f. Phasing – Age, Integrating ECMs (Penetrations though recently improved envelope, etc.).

g. Consideration for Future Technological Advancements
    i. Emerging HVAC Technologies: Stay informed about emerging electric HVAC technologies, such as advanced heat pump systems, geothermal energy, or liquid desiccant systems, that may offer better efficiency, lower environmental impact, or lower operational costs in the future.
    ii. Flexibility for Future Upgrades: Design systems with flexibility in mind, allowing for easy upgrades or replacements as more efficient technologies become available.

5. Financial Analysis and Funding Mechanisms

a. Capital and Operational Costs: Assess the costs of implementing ZOT measures over 20 years, including capital costs for major retrofits or system replacements and operational savings (e.g., energy savings, reduced maintenance). Include a detailed analysis of the impact on energy burden for residents, particularly in affordable housing projects, to ensure decarbonization does not increase financial strain for marginalized communities. Evaluate pre- and post-retrofit utility costs for both building owners and residents as part of the cost assessment.

b. Payback Periods and ROI: Evaluate the payback period for each proposed measure and assess the return on investment (ROI) for each phase of the ZOT plan. Prioritize investments with short payback periods to maximize long-term savings, while also considering measures that minimize resident energy burden. For projects serving low-income or vulnerable populations, incorporate phased investments that reduce energy costs or maintain a net-zero impact on utility expenses for residents.

c. Incentives and Grants: Identify financial incentives, rebates, and grants for energy efficiency, renewable energy, and decarbonization projects. Investigate local, state, and federal programs (e.g., tax incentives, low-interest loans). Emphasize programs that mitigate energy burden, such as those specifically designed for low-income households or affordable housing developments.

d. Financing Options: Consider financing mechanisms such as green bonds, energy performance contracts (EPCs), or power purchase agreements (PPAs) for renewable energy projects. When evaluating financing options, include provisions for reducing resident energy costs, such as aggregate metering, subsidies, or ensuring equitable access to renewable energy. Incorporate life-cycle financial planning to address energy burden, and develop strategies to subsidize or offset increased resident costs during construction delays or early project phases.

6. Risk Management and Contingency Planning

a. Technology Risks: Address potential challenges with new technologies (e.g., cost overruns, delays in product development, adoption rates).

b. Regulatory Risks: Anticipate regulatory changes that may impact the feasibility or timing of certain actions (e.g., shifts in energy policy, carbon tax policies, grid reliability).

c. Economic Risks: Prepare for potential economic downturns, inflationary pressures, or energy price volatility that could affect the cost and timing of energy projects.

d. Health and Safety Risks: Ensure that retrofitting and construction activities do not compromise worker safety, occupant health, energy burden, or building functionality.

e. Climate Risk:
    i. Assess vulnerability to climate risks (e.g., flooding, heat waves)
        1. Federal Resources
            a. FEMA Flood Maps - https://www.fema.gov/flood-maps
            b. FEMA Resilience Analysis and Planning Tool (RAPT) - https://www.fema.gov/about/reports-and-data/resilience-analysis-planning-tool

        2. State Resources (Review state websites for local hazard info. The following websites are provided as examples.)
            a. Resilient Mass Climate & Hazards Viewer - https://resilientma-mapcenter-mass-eoeea.hub.arcgis.com/
            b. Massachusetts Flood Zone Mapping Tool - https://matracking.ehs.state.ma.us/planning_and_tools/flood-zones/flood-zones-tool.html

ii. Review building structure for disaster preparedness (e.g., seismic, wind).

iii. Output: Data collection report with a detailed assessment of energy use, emissions, and health/safety and climate vulnerability conditions.

7. **Phase 1: Achieving 30% Emissions Reduction**
    a. The first phase is a cornerstone of the ZOT Plan. It prioritizes high-impact measures that can reduce carbon emissions by at least 30% while aligning with ongoing development or maintenance cycles. This foundational step positions the property for deeper emissions reductions in subsequent phases by focusing on immediate improvements in energy efficiency, partial electrification, and renewable energy adoption.

8. **Zero-Over-Time Overview (Maximum 20-year plan)**
    a. The Zero-Over-Time Plan breaks upgrades and activities into manageable phases over a maximum 20-year period, aligning with affordable housing development and maintenance cycles. Phase 1 achieves rapid, impactful reductions (30% emissions reduction), while subsequent phases build on this foundation.

Critical Phase 1 (Immediate Impact Measures) Activities:

- **Building Envelope Improvements:**
  - Decision Point: Include air sealing, insulation upgrades, and window improvements to reduce energy demand during regularly scheduled maintenance or capital improvement projects.
  - Impact: Reduces heating and cooling loads, lowering energy use and creating a stronger foundation for future electrification.
- **Energy-Efficient HVAC Systems**
  - Decision Point: Replace end-of-life heating and cooling systems with high-efficiency electric heat pumps or hybrid systems where feasible.
  - Impact: Reduces emissions from fossil fuel-based heating systems and improves thermal comfort for residents.
- **Lighting Upgrades**
  - Decision Point: Retrofit to LED lighting during tenant turnover or common area upgrades.
  - Impact: Achieves quick, measurable reductions in energy use with minimal cost or disruption.
- **Renewable Energy Integration**
  - Decision Point: Evaluate feasibility for installing rooftop solar PV systems, especially if roof replacement is planned.
  - Impact: Reduces reliance on grid electricity and generates clean energy to offset operational emissions.
- **Resident Engagement and Education**
  - Decision Point: Include resident education initiatives on energy-saving behaviors during implementation of energy upgrades.
  - Impact: Supports reductions in energy consumption and builds resident buy-in for decarbonization goals.
- **Health and Safety Enhancements**
  - Decision Point: Address indoor air quality and water quality concerns as part of building system upgrades.
  - Impact: Ensures emissions reductions improve overall living conditions, with co-benefits like reduced allergens and improved thermal comfort.

Timeline Milestones:

- **Phase 1 (Years 1-5): Immediate Impact Measures**
  - Focus: High-impact measures that reduce emissions by at least 30% while preparing for full electrification.
  - Activities: Insulation upgrades, lighting retrofits, initial HVAC system replacements, rooftop solar PV installation, and foundational resident engagement.

- Decision Leverage Points: Maintenance schedules, major capital improvements, and end-of-life equipment replacements.

- **Phase 2 (Years 6-12): Deep Electrification**
  - Focus: Transitioning remaining fossil fuel-based systems to electric alternatives.
  - Activities: Full HVAC system electrification, hot water system replacement, additional renewable energy integration, and grid readiness upgrades.
  - Decision Leverage Points: Equipment end-of-life, utility incentives, and local grid improvements.
- **Phase 3 (Years 13-20): Optimization and Resilience**
  - Focus: Integration of advanced technologies and resilience measures.
  - Activities: Smart energy management systems, backup power solutions (e.g., batteries or microgrids), and future-proofing systems for regulatory and climate trends.
  - Decision Leverage Points: Availability of emerging technologies, additional funding opportunities, and evolving climate risks.

Decision Tree for Upgrades and Activities

To guide affordable housing professionals through the ZOT process, the following decision tree outlines when and why specific upgrades should be implemented:

Upgrade/Activity	Decision Point	Why This Interval?	Impact
Building Envelope Upgrades	During maintenance cycles or roof replacements	Reduces baseline energy use, preparing the property for future electrification.	Immediate load reduction and energy savings; foundational for electrification.
HVAC System Electrification	End-of-life replacement or major renovations	Replaces fossil fuel systems with efficient electric alternatives, reducing emissions.	Significant operational emissions reductions; improved thermal comfort.
Renewable Energy Integration	Roof replacements or capital improvement cycles	Offsets electricity use with clean energy generation.	Reduced grid dependency; long-term operational cost savings.
Smart Energy Systems	Post-HVAC electrification or mid-cycle upgrades	Improves energy management and integrates with renewable systems.	Optimized energy use; real-time monitoring of

			emissions reductions.
Resident Education	During tenant turnover or project rollouts	Encourages resident buy-in and maximizes the effectiveness of energy-saving measures.	Behavioral energy savings; increased satisfaction with new systems.

Verifying Progress

Each phase includes measurable outcomes to ensure activities align with Zero-Over-Time goals:

- Phase 1 (Immediate Impact Measures) Verification:
  - Monitor energy use and emissions reductions post-implementation of early measures.
  - Validate 30% emissions reduction through utility data and ASHRAE Level 2 Energy Audit comparisons.
- Ongoing Monitoring:
  - Use smart meters and energy management systems to track energy use, renewables integration, and emissions reductions in real-time.
  - Regularly evaluate system performance and adjust future phases based on observed results.

Summary

A 20-Year Zero-Over-Time (ZOT) Plan is an ambitious roadmap that requires a deep understanding of existing energy use patterns, carbon emissions, and opportunities for improvement.

Key considerations include:

- Energy efficiency and carbon reduction measures based on the ASHRAE audit,
- Health, safety, and resilience integration,
- Financial analysis to assess the cost-effectiveness of various measures,
- Technology adoption including electrification and renewable energy integration, and
- Risk management to anticipate challenges in implementation

By following a decision-tree structure, stakeholders can methodically craft a comprehensive plan that balances technical, financial, and environmental considerations while achieving long-term decarbonization goals.