U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Federal Existing Buildings Handbook for Net Zero Energy, Water, and Waste

Prepared for the U.S. Department of Energy
Federal Energy Management Program

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Abbreviations and Acronyms

AD	Anaerobic digestion
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
BMP	best management practice
Btu	British thermal unit
CFR	Code of Federal Regulations
DHW	domestic hot water
DOE	U.S. Department of Energy
EERE	Energy Efficiency and Renewable Energy
EISA	Energy Independence and Security Act of 2007
FEMP	Federal Energy Management Program
GSF	gross square feet
HVAC	heating, ventilation, and air conditioning
LED	light-emitting diode
LFG	landfill gas
MMBtu/sf	Million British thermal units per square foot
MSW	Municipal Solid Waste
O&M	operations and maintenance
PNNL	Pacific Northwest National Laboratory
REC	Renewable energy certificates
U.S.	United States
WTE	waste-to-energy

Contents

1 Introduction

Net zero energy buildings have been a growing target in the federal and private sector. For the commercial and residential building sectors the International Living Future Institute has developed a building certification system for net zero buildings called the Living Building Challenge. Over 300 buildings have been registered in 29 countries, and 43 case studies of certified buildings are available to the public.[1] The World Green Building Council and Architecture 2030 launched a project in 2016 focused on net zero carbon buildings with the goal of all buildings being net zero carbon by 2050.[2] And non-profit organizations, such as the Zero Energy Project, are focused on increasing the number of residential properties that achieve net zero goals along with the federal and private sectors.[3]

In 2015, the Department of Energy's (DOE) Energy Efficiency and Renewable Energy (EERE) office defined zero energy buildings as "*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*." The definition was developed through the survey of existing publications, interviews with subject matter experts (SMEs), and a public comment period. The definition report emphasized that zero energy buildings use all cost-effective energy efficiency measures and then include renewable energy systems that address the power needs, noting that reduced energy consumption makes it less expensive to achieve the zero energy goal. The goal of reducing energy consumption includes integrated design, energy efficiency measures, reduced plug load, and occupant behavior change programs.[4]

This handbook is focused on applying the EERE definition to existing buildings in the federal sector. The Pacific Northwest National Laboratory (PNNL), commissioned by DOE's Federal Energy Management Program (FEMP), prepared the handbook incorporating inputs from the Department of Defense, General Services Administration, and the National Renewable Energy Laboratory.

In the federal sector, the net zero efforts go beyond zero energy buildings to include net zero **energy**, **water**, and **waste** buildings. The federal buildings being addressed in this handbook are owned by the federal government and the occupants are federal employees, and thus do not have an equivalent to building owners or consumers in the commercial and residential building sectors. Federal energy, water, and waste management has a strong history of focusing on minimizing use first and then looking for alternatives to achieve the net zero target. Many

[1] For information on the Living Future Institute net zero building certification system see: https://living-future.org/net-zero/

[2] For more information on the World Green Building Council see: https://www.environmentalleader.com/2016/07/net-zero-green-building-certification-coming-soon/

[3] For more information on residential net zero energy activities see: http://zeroenergyproject.org/, https://energy.gov/eere/buildings/zero-energy-ready-home, and https://www.wsj.com/articles/builders-new-power-play-net-zero-homes-1421794129

[4] *A Common Definition for Zero Energy Buildings* available online at http://energy.gov/sites/prod/files/2015/09/f26/bto_common_definition_zero_energy_buildings_093015.pdf

energy, water, and waste regulatory requirements and mandates exist that drive the federal sector toward reducing consumption first, then encouraging alternative paths to reducing resource use, impact, and costs. This document offers strategies that are in support of, but are not intended to replace, substitute, or modify any statutory or regulatory requirements and mandates. Following the federal culture of promoting reduction and efficiency first, the recommended strategies for net zero energy, water, and waste federal buildings are outlined below.

- A net zero energy federal building (constructed, renovated, or existing) is operated to maximize energy efficiency, implement energy recovery opportunities where feasible, and balance the actual annual source energy consumption with on-site renewable energy generation.

- A net zero water federal building (constructed, renovated, or existing) is operated to minimize total water consumption, maximize alternative water sources, minimize wastewater discharge from the building, and return water to the original water source such that the annual water consumption is equivalent to the alternative water use plus water returned to the original source over the course of a year.

- A net zero waste federal building is operated to reduce, reuse, recycle, compost, or recover solid waste streams (with the exception of hazardous and medical waste) thereby resulting in no waste disposal to landfills or incinerators.

Net zero energy, water, or waste will not be feasible for all federal buildings as it may not be life-cycle cost-effective. Activities that may not be applicable for net zero include:

- An intelligence activity of the United States, and related personnel, resources, and buildings;

- Law enforcement activities of the agency, and related personnel, resources, and buildings;

- Law enforcement, protective, emergency response, or military tactical vehicle fleets of the agency;

- Particular agency activities and buildings where it is in the interest of national security; and

- Buildings outside of the United States are excluded unless the head of an agency determines otherwise.

Federal agencies should look to pursue net zero where it helps achieve statutory or regulatory requirements and mandates.

2 Federal Building Boundaries

Net zero efforts begin with identifying the federal building boundary. A building boundary delineates the area that is functionally part of the building. Simply stated, the boundary is at or within the legal property boundary, ideally including the point of utility interface. For existing federal buildings, the boundary can include contiguous property that hosts space, technologies, or systems that contribute to the building's ability to achieve net zero energy, water, or waste. This property should be under the control of the federal agency.

The following figures represent net zero energy, water, and waste boundaries. Figure 1 offers a net zero energy boundary condition. The net zero energy boundary could include energy use, on-site renewable energy production, energy storage, delivered energy, and exported energy. The renewable energy certificates (RECs) for the on-site renewable energy must be retained. If the RECs for the on-site renewable energy are sold, they must be replaced.

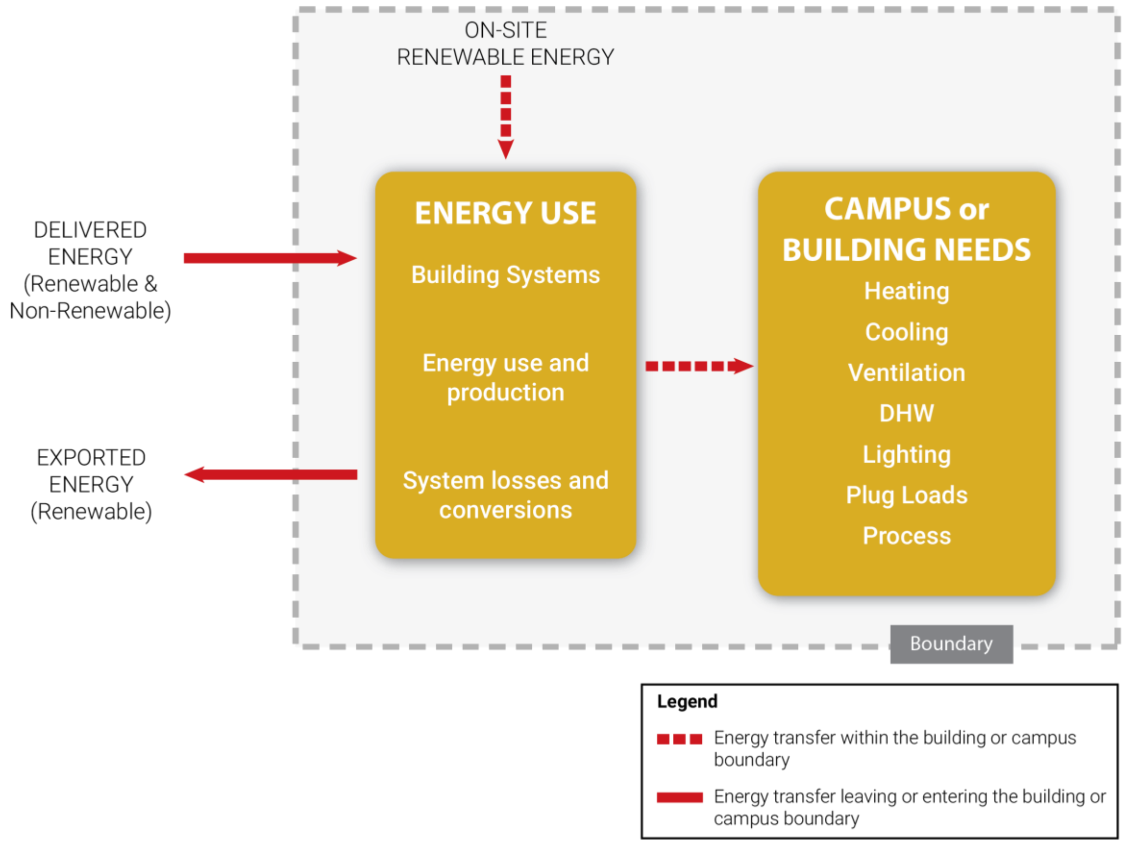

Figure 1. Conceptual depiction of site boundary for energy balance. [5]

[5] Figure was adapted from *A Common Definition for Zero Energy Buildings* available online at http://energy.gov/sites/prod/files/2015/09/f26/bto_common_definition_zero_energy_buildings_093015.pdf

DHW refers to domestic hot water

Figure 2 offers a net zero water boundary condition. The net zero water boundary could include potable and non-potable water use, on-site alternative water sources, freshwater supply, alternative water supply, and water returned to the original water source. If the building is not within the watershed or aquifer of the original water source, then returning water to the original water source will be unlikely. In those cases, achieving net zero water would depend on alternative water use.

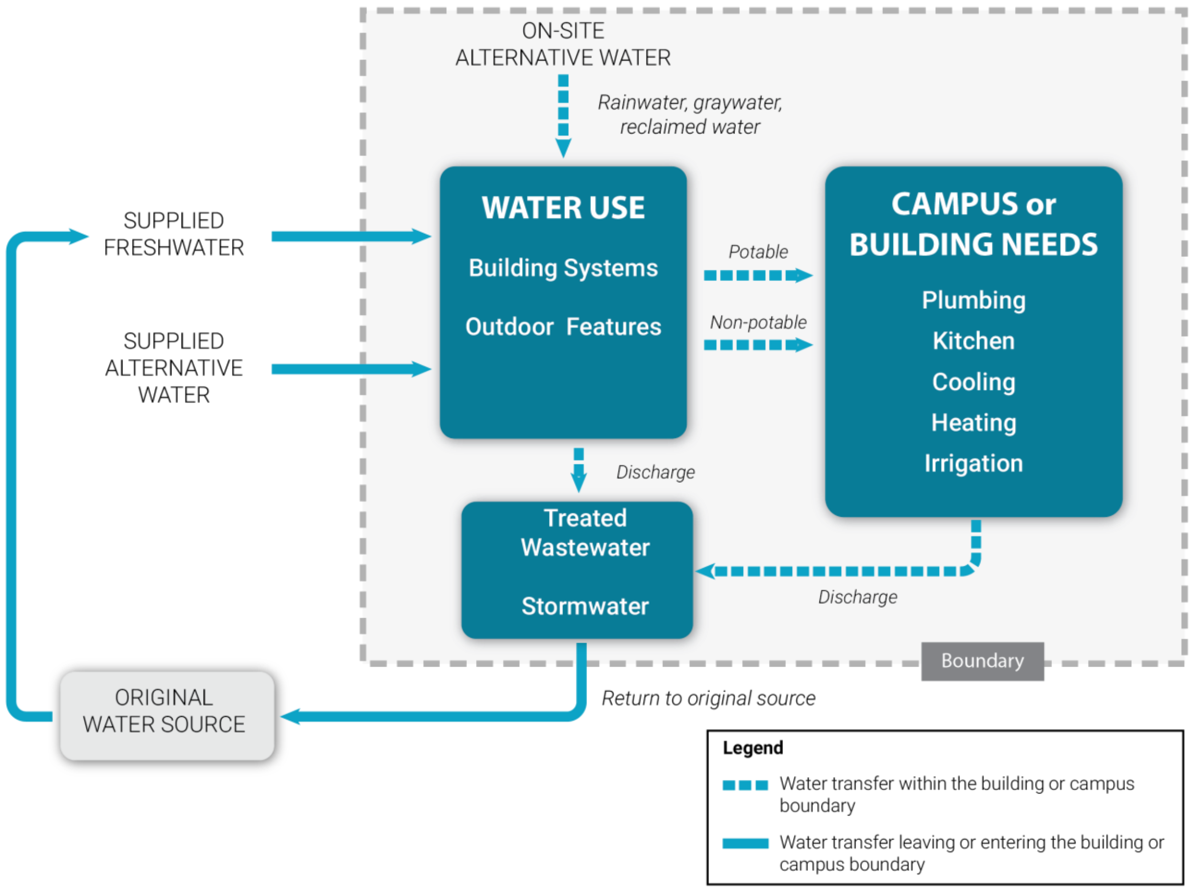

Figure 2. Conceptual depiction of site boundary for water balance.

Figure 3 offers a net zero waste boundary condition. The net zero waste boundary could include material use and waste generation, on-site reuse and compost centers, green procurement, and partnerships with entities to recycle, compost, reuse, and generate energy through waste-to-energy (WTE) plants.

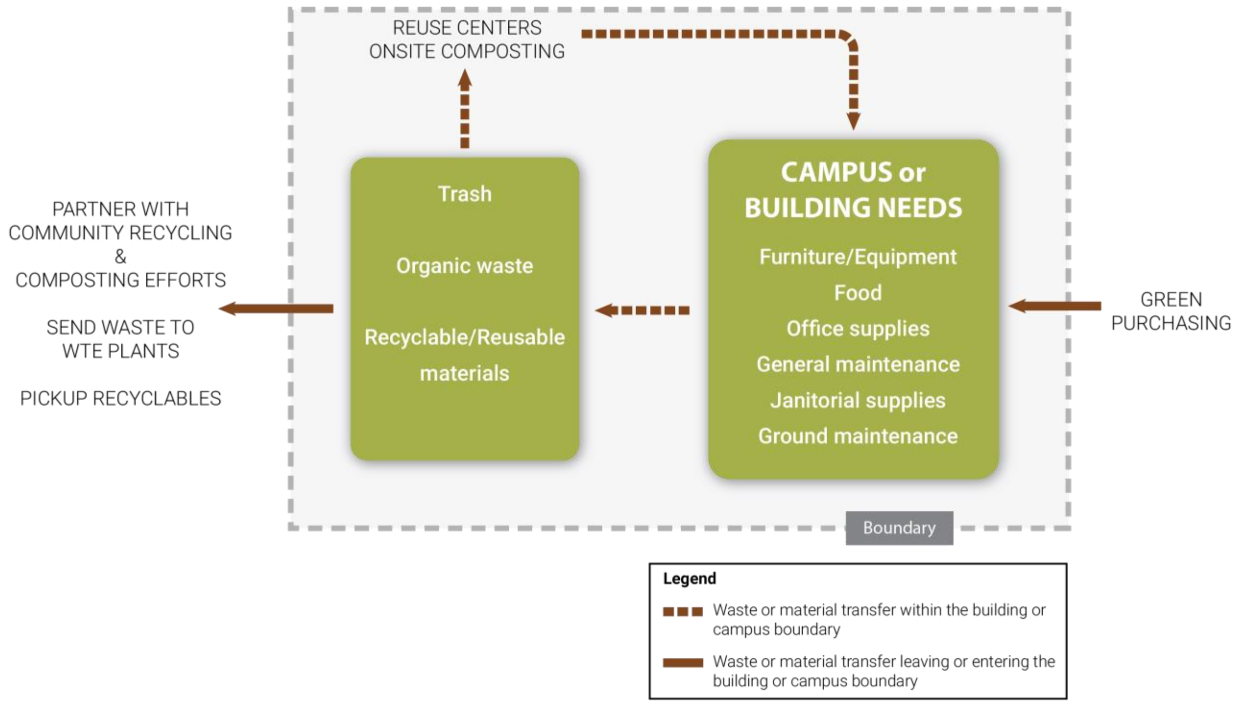

Figure 3. Conceptual depiction of site boundary for waste balance.

3 Net Zero Applications for Federal Buildings

This guidance document provides the net zero application for renovating existing net zero federal buildings. Separate guidance documents address two other net zero applications: designing new net zero federal buildings and modernizing a federal campus to achieve net zero. Each application provides strategies for achieving net zero energy, water, and waste. The existing building application addresses design, construction, and operations considerations. It is recommended that agencies consider the best application to implementing net zero energy, water, or waste for their particular building or campus project. In other words, agencies can determine the boundary that aligns best with their net zero project. Figure 4 provides a visual of the different applications of net zero.

- If considering a net zero federal building, whether new or existing, the area called "*building boundary*" represents a net zero energy building example. Within the boundary line is the building property and the land needed for the on-site renewable energy generation.
- The area called "*designated campus boundary*" represents a net zero water campus. Within that boundary is the set of buildings and water related infrastructure needed for these buildings to be considered net zero water. There are six buildings inside of that

boundary. Depending on whether an agency chooses the number of buildings or square footage, the agency would count all six of those buildings or their total square footage towards meeting the agency net zero target for existing buildings.

- The area called "*property line/campus boundary*" represents a traditional campus boundary definition as it is the actual boundary of the campus. This example is showing elements of a net zero waste campus. If this entire campus was designated as net zero waste, all 17 buildings and their corresponding square footage would count toward the agency's net zero target for existing buildings.

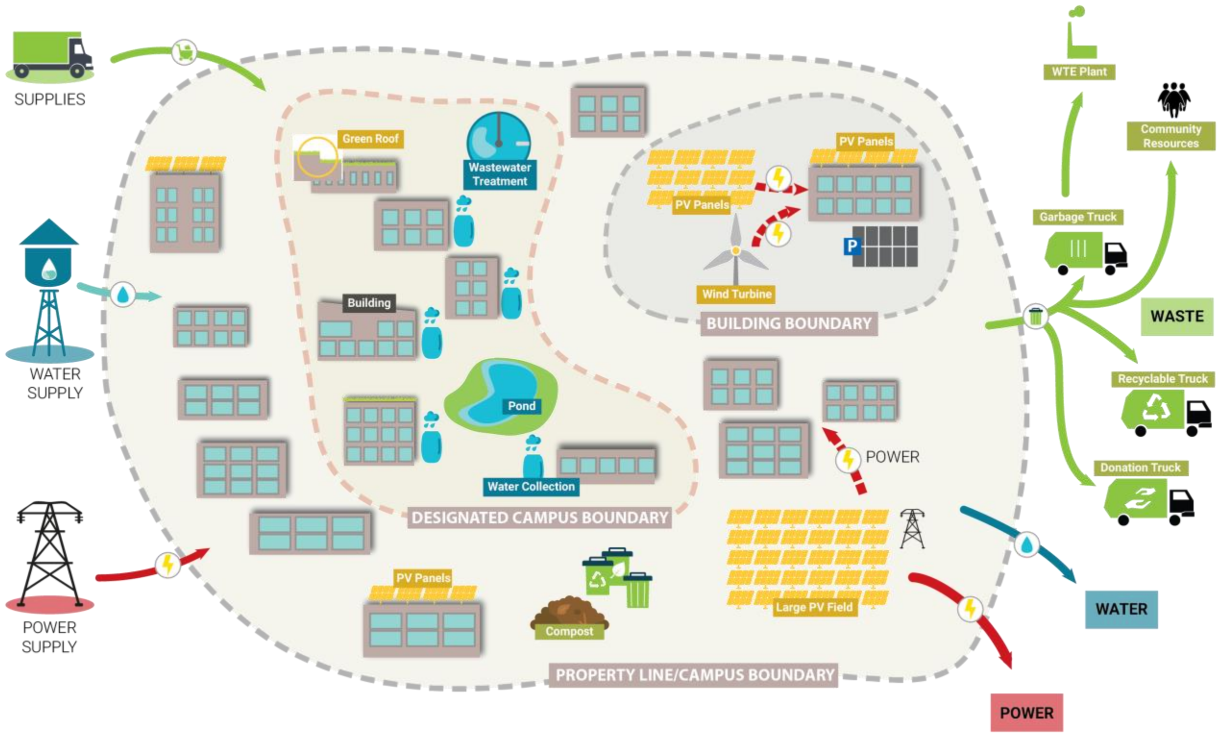

Figure 4. Net Zero Boundary Examples

4 Net Zero for Existing Federal Buildings

This section describes how existing buildings could achieve net zero energy, water, and waste considering the lifecycle of design, construction, and operation (Figure 5).

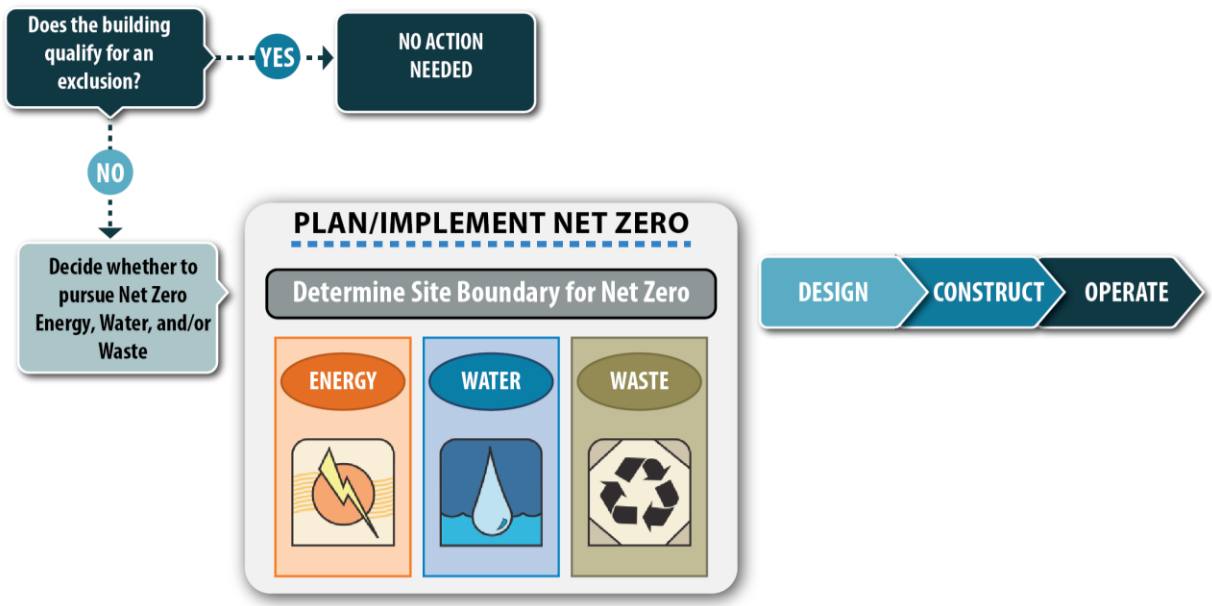

Figure 5. Net Zero Planning for Existing Buildings

This section is organized by net zero area in the following order; energy, water, and waste. Each net zero area includes design, construction, and operation considerations.

ENERGY

A net zero energy building should reduce its load through conservation (use only what is needed) and energy efficiency, then meet the remaining load through on-site renewable energy generation.

ENERGY Net Zero Design Elements for Existing Buildings
EA.D.1 Design the renovation to be a high performance, energy efficient building
EA.D.2 Use metered data to calibrate the renovated building's energy model
EA.D.3 Design renewable energy system to generate the source energy equivalent or greater of the modeled annual energy use
EA.D.4 Minimize the impact of design reviews or value engineering on the net zero target

Design

The key design elements for existing buildings are listed below.

EA.D.1 Design the renovation to be a high performance, energy efficient building

The highest priority for an existing building to become net zero energy should be to aggressively reduce the energy use. The building should be renovated with energy-efficient equipment and a high-performance envelope. Consider how the building boundary may limit the quantity of renewable energy that can be generated. A building energy use intensity renovation goal may need to be set if there are significant renewable energy generation constraints. Approaches to achieve a net zero energy building through renovations are outlined in Table 1.

Table 1. Energy Efficiency Strategies for Existing Buildings

Strategy	Considerations
Energy audit	Conduct detailed energy audits to identify energy conservation and efficiency improvement opportunities. The energy audit should examine key building energy uses such as lighting, heating, ventilation, and air conditioning (HVAC) systems, building control systems, building envelope, hot water use, appliances, plug loads, industrial equipment, food service equipment, and site infrastructure such as street and parking lot lights, considering occupant behavior.
Benchmarking	Benchmark the building's energy performance using ENERGY STAR Portfolio Manager® and use the benchmark information to understand the building's energy performance potential.
Energy modeling	Build an energy model of the building to evaluate the investment value of various conservation and efficiency measures.
Third party financing	Explore a performance contract such as an energy savings performance contract or utility energy services contract where the private sector or utility helps determine potential savings and energy conservation measures.
Control system	Install and use a building automation system to manage building equipment schedules and temperature setting, at a minimum.

Strategy	Considerations
Fuel switching	Consider switching between energy types or sources when selecting efficiency upgrades. For example, heat pumps could be powered with renewable electricity rather than natural gas heating systems.

EA.D.2 Use metered data to calibrate the renovated building's energy model

Building energy modeling is an iterative process where alternative technologies and systems are modeled to determine the optimum solution for the building function and operational goals. A building energy model will be modified throughout the design and construction processes of the renovation to identify the impact of potential design modifications. The model should be calibrated using existing metered energy data. The calibrated building energy model provides an estimate for energy consumption at the building site (site energy).

To convert site energy to source energy, several other factors must be accounted for including: energy consumed in the extraction, processing and transport of primary fuels such as coal, oil and natural gas; energy losses in thermal combustion in power generation plants; and energy losses in transmission and distribution to the building site. The conversion factors listed in Table 2 can be used to:

1) convert site energy to source energy, and

2) develop a source energy equivalent value of on-site renewable energy generation that is exported from the net zero energy site to the electric grid, since it displaces electricity that would otherwise be generated from conventional sources.

Table 2. National Average Source Energy Conversion Factors[6]

Energy Form	Source Energy Conversion Factor
Imported Electricity	3.15
Exported Renewable Electricity	3.15
Natural Gas	1.09
Fuel Oil (1,2,4,5,6)	1.19
Propane & Liquid Propane	1.15
Steam	1.45
Hot Water	1.35
Chilled Water	1.04
Coal or Other	1.05

To estimate the total source energy consumption, the amount of each delivered energy type is multiplied by the conversion factor to determine source energy. For example, a building using electricity and natural gas would multiply each fuel type in British Thermal Units (Btus) by the appropriate conversion faction listed in Table 2**Error! Reference source not found.**. These end use values would be summed to represent the total source energy use for the building. The renewable electric energy generated on-site and exported to the grid would be multiplied by the electricity conversion factor and be subtracted from the sum of the energy use. A building would be considered net zero when the difference between energy use and energy generation is equal to zero or a negative value.

Total Energy Use = [Site Energy Use by Fuel Type(s) * Source Energy Conversion Factor(s)] – [On-site, Exported Renewable Energy by System* Source Energy Conversion Factor(s)]

If a building uses the renewable energy directly, then the site energy use of the building would be reduced by the site renewable energy used and the remainder of the site energy use would be converted to source energy as described above.

EA.D.3 Design renewable energy system to generate the source energy equivalent or greater of the modeled annual energy use

A net zero energy building minimizes energy use and then generates renewable energy to equal the annual source energy consumption. The optimal mix of renewable energy technologies for a net zero building is site-specific. Renewable energy includes technologies that can harness solar power, wind power, hydropower, geothermal energy (including ground source heat pumps), biomass, and biofuels. To determine which technologies are best for a site, a renewable energy assessment should be performed. An assessment will identify which renewable energy sources could potentially work at the site, how much energy they could generate given site constraints, and which options are cost-effective for the site.

EA.D.4 Minimize the impact of design reviews or value engineering on the net zero target

When renovating a building to achieve net zero energy, it is important to clearly state the net zero energy goals (such as a specific energy use intensity, MMBtu/sf), and identify key stakeholders early in the process, including future occupants and operators. During the value engineering phase of the project, an advocate for the net zero energy design elements needs to be present to communicate the impact of design modifications on the net zero energy goal. Throughout the design stages it is important that the energy model is updated to reflect the impact of design modifications to the estimated annual source energy use and how that might impact the renewable energy systems' design and size.

Construction

During the construction phase, the net zero energy elements identified during the design phase will be put into practice. For existing buildings, net zero construction elements are provided below.

ENERGY Net Zero Construction Elements for Existing Buildings
EA.C.1 Develop contract language to maintain the integrity of net zero
EA.C.2 Commission, recommission, or retrocommission the building energy systems

EA.C.1 Develop contract language to maintain the integrity of net zero

During the construction and operation of a net zero energy building, additional modeling will provide insight into the building's expected performance. These models could be for the 100% as-designed drawings, impacts of design modifications, as-built drawings, and post-occupancy calibrated energy models.

Contract language should ensure the net zero energy elements are installed per the design. This language should include that the equipment specifications identified in the design phase are cross-walked with the contractor's procurement documentation to ensure that the correct equipment is purchased and installed. Furthermore, the contract should be developed to include energy use and power generation performance metrics to ensure the building meets the design expectations. Include a requirement to meter the building's energy use by fuel type, with sub-meters for large end uses as appropriate, as well as the renewable energy generation.

EA.C.2 Commission, recommission, or retrocommission the building energy systems

Contract language should require that all energy technologies and systems and all other features that impact energy consumption, whether energy efficiency or power generation related, are commissioned, recommissioned, or retrocommissioned. New equipment should be commissioned during the construction phase as well as upon completion of renovation of the building. Existing equipment should be recommissioned or retrocommissioned to ensure that the existing equipment is operating as intended. A commissioning plan should be prepared that includes the overall objectives, commissioning strategies, project team, and schedule for future recommissioning efforts.

Operations

Operations and maintenance (O&M) can be one of the most cost-effective ways to reduce energy use. The net zero energy operation elements that contribute to a building meeting its goals are provided below.

ENERGY Net Zero Operation Elements for Existing Buildings
EA.O.1 Develop a building operation plan to address O&M of energy efficiency design features and renewable energy technology
EA.O.2 Meter energy use and production and benchmark performance
EA.O.3 Implement behavior change and training programs to engage occupants in the net zero energy performance goal
EA.O.4 Measure and verify building is operating at net zero over a one-year timeframe

EA.O.1 Develop a building operation plan to address O&M of energy efficiency design features and renewable energy technology

The building operation plan needs to address the key areas of operational efficiency. The plan should include the description of the measure, action items that should be performed, the frequency it should occur, and the personnel that are responsible for the action. Key actions toward the goal of operational efficiency include:[7]

- Tracking O&M activities and reporting on status of O&M investments,
- Using data to identify energy technologies or systems that are operating outside of their expected performance parameters,
- Committing to addressing the identified technology or system performance issues, and
- Documenting changes made and tracking subsequent performance changes.

EA.O.2 Meter energy use and production and benchmark performance

federal buildings are required to have meters collecting data on at least an hourly basis. For new construction and major renovation, advanced meters need to be installed for all building energy use and on-site power generation. Energy use data must be collected and analyzed to identify use trends and potential opportunities for efficiency opportunities.[8] The monthly energy use data must be benchmarked using the Environmental Protection Agency's ENERGY STAR Portfolio Manager®.[9] Sub-meters for large end uses are encouraged to be able to identify operational issues.

EA.O.3 Implement behavior change and training programs to engage occupants in the net zero energy performance goal

To successfully operate a net zero energy building, occupants must be engaged and knowledgeable about the building's net zero elements and functions. A behavior change program

[7] For additional information see the FEMP O&M Best Practices guide at: http://energy.gov/eere/femp/downloads/operations-and-maintenance-best-practices-guide

[8] For additional information see the FEMP Federal Building Metering guidance at: http://energy.gov/eere/femp/metering-federal-buildings

[9] For additional information see the FEMP Benchmarking guidance at: http://energy.gov/eere/femp/eisa-federal-facility-management-and-benchmarking-reporting-requirements

can be an effective approach to training occupants on key net zero features of the buildings.[10] A behavior change program integrates technology, policy, and behavior into the day-to-day operations of a building.[11] Example elements of a behavior change program for encouraging energy conservation and efficiency include:

- training occupants on interactive energy design features such as lighting or plug load controls,
- billing or mock billing of tenants,
- holding competitions to inspire occupant energy conservation efforts,
- informing building occupants about the building's energy use through staff meetings, newsletters, email announcements, and social media announcements, and
- providing awards for occupant-led energy conservation efforts.

EA.O.4 Measure and verify building is operating at net zero over a one-year timeframe

To verify that the building is operating at net zero, energy generation data must be compared to energy use. The steps to follow to calculate net zero energy status are:

- A year of building site energy use is collected for all sources such as electricity, steam, and natural gas.
- Building site energy is converted to source energy using conversion factors offered in Table 2**Error! Reference source not found.**. To estimate the total source energy consumption, the amount of each delivered energy type is multiplied by its respective conversion factor to determine source energy.
- A corresponding year of renewable energy generation data is collected for all renewable energy generated within the building boundary and which was exported to the grid. The exported renewable electricity is converted into a source energy equivalent by using the conversion factor from Table 2**Error! Reference source not found.**.

If the total building source energy use data is less than or equal to the total renewable energy exported (after conversion to a source energy equivalent), the building is considered net zero energy.

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[10] For an example of effective behavior change actions refer to *The Role of Occupant Behavior in Achieving Net Zero Energy: A Demonstration Project at Fort Carson* at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22824.pdf

[11] For more information go to FEMP Institutional Change for Sustainability Website: http://energy.gov/eere/femp/institutional-change-sustainability

WATER

A net zero water existing building has been achieved when the amount of alternative water consumption and water returned to the original water source is equivalent to the building's water consumption. The original water source includes sources within the same local watershed and aquifer of the building's water supply.[12] The goal of net zero water is to preserve the quantity and quality of natural water resources with minimal deterioration, depletion, and rerouting due to the building's water use by utilizing potential alternative water sources and water efficiency measures to minimize the use of supplied freshwater. Ultimately, a net zero water building completely offsets the building's water use with maximized alternative water plus water returned to the original water source, represented by this simple formula (definitions of the terms in the equation can be found in the Glossary):

WATER Net Zero Design Elements for Existing Buildings
WA.D.1 Design the renovation to be a high performance, water efficient building
WA.D.2 Meter water use, develop water balance by end-use
WA.D.3 Maximize alternative water sources
WA.D.4 Treat wastewater on-site and return to the original water source
WA.D.5 Design green infrastructure features to return water to its original water source
WA.D.6 Minimize the impact of design reviews or value engineering on the net zero target

$$\begin{Bmatrix}\text{Total Annual}\\ \text{Water Use}\end{Bmatrix} = \begin{Bmatrix}\text{Total Annual}\\ \text{Alternative Water Use}\end{Bmatrix} + \begin{Bmatrix}\text{Total Annual Water Returned/Discharged}\\ \text{to the Original Source}\end{Bmatrix}$$

Design

The design elements for renovating an existing building to achieve a net zero water target are provided below.

WA.D.1 Design the renovation to be a high performance, water efficient building

The highest priority for an existing building to become net zero water should be to aggressively drive down the water demand. The building should be renovated with water-efficient equipment and landscape. The renovations should include a comprehensive suite of water efficient elements, as shown in Table 3.[13]

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[12] If the building is not located within the watershed or aquifer of the original water source, then returning water to the original water source will be unlikely. The option for net zero water strategy would therefore have to depend on using alternative water to offset the use of freshwater.

[13] For information, go to FEMP Water Efficiency BMPs: http://energy.gov/eere/femp/best-management-practices-water-efficiency

Table 3. High Performance Design Considerations

End-Use	High performance design options	Considerations
Plumbing	High efficiency and WaterSense-labeled equipment[14]	Retrofit with the most efficient equipment available; consider non-water using equipment such as composting toilets and non-water urinals to dramatically reduce water demand as well as reducing wastewater discharge, however ensure that the existing building's plumbing configuration and materials are conducive for non-water toilets and urinals
Commercial Kitchen	WaterSense and ENERGY STAR-labeled equipment	Install the most efficient equipment available; look for equipment like dishwashers that recycle water
Landscape	Low-water using landscaping	Remove high-water consuming landscape and retrofit with low-water using landscape such as xeriscape, native plants, and plants that do not require supplemental irrigation into the landscape design
Cooling and Heating Systems	High efficiency system design	For water cooling and heating, install control and water treatment systems that manage water systems to efficiency targets

WA.D.2 Meter water use and develop water balance by end-use

When renovating a building for net zero water, the building should be metered as a whole to measure total water use. Water-intensive applications and alternative water systems should be sub-metered. Metered data can be used to estimate a water balance, which compares the building's total water consumption to equipment water use. The comparison provides the breakout of water consumption by end-use. A water balance uncovers the high-water uses and can help to focus water efficiency and conservation of the building's renovation.[15]

WA.D.3 Maximize alternative water sources

A net zero water building minimizes the use of potable freshwater and maximizes alternative water. Freshwater is sourced from surface or groundwater such as lakes, rivers, or aquifers. Alternative water is sustainable sources that are ***not*** derived from freshwater, including harvested rainwater and stormwater, sump pump water, graywater, air cooling condensate, reclaimed wastewater, or water derived from other water reuse strategies (Table 4). During a renovation of a net zero water building, alternative water sources should be investigated. Choose alternative

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[14] For information, go to EPA's WaterSense website: https://www.epa.gov/watersense

[15] For information, go to FEMP BMP on Water Management Planning: http://energy.gov/eere/femp/best-management-practice-1-water-management-planning; FEMP guidelines on Prioritizing Building Water Meter Applications: http://energy.gov/eere/femp/prioritizing-building-water-meter-applications

water sources that provide the best potential for offsetting freshwater consumption in major water uses such as flushing toilets and urinals, irrigation, and cooling towers.[16]

Table 4. Alternative Water Sources Examples

Alternative Water Source	Potential Applications	Considerations
Rainwater	Irrigation, toilet and urinal flushing	Minimal treatment is needed for irrigation
Stormwater	Irrigation, cooling tower make-up, industrial uses	Foundation drain water can be reused similarly to stormwater
On-site Reclaimed Wastewater	Irrigation, cooling tower make-up, industrial uses	Substantial filtration and disinfection is required
Graywater	Toilet and urinal flushing, irrigation	Toilet and urinal flushing with alternative water requires a dual plumbing system, which can be an expensive retrofit for an existing building; subsurface irrigation is the most appropriate use of graywater unless water is disinfected
Air Handling Condensate	Cooling tower make-up, industrial uses	Condensate water can be corrosive to metals because condensate can be slightly acidic; water may absorb copper from cooling coils

A building that captures alternative water may require a dual plumbing system, which has two separate distribution networks to deliver potable water and alternative non-potable water to separate end-uses. However, to retrofit an existing building with a dual plumbing system can be expensive. It may be more appropriate for an existing building to use alternative water in systems that do not require a dual plumbing system such as irrigation systems and cooling towers.

WA.D.4 Treat wastewater on-site and return to the original water source

A net zero water building closes the water system loop by returning water to the original water source. The original water source is considered fresh surface water and groundwater sources that are within the same local watershed or aquifer as the building's supply water. Investigate opportunities for on-site wastewater treatment systems such as septic systems or small packaged systems if the building is located within the same watershed or aquifer as the original water source. Land area, permitting requirements, and environmental effects should be used in determining if treated wastewater on-site is possible for an existing building. Treated wastewater can also be reclaimed as an alternative water source and reused within the building.[17]

[16] For information, go to FEMP BMP on Alternative Water Sources: http://energy.gov/eere/femp/best-management-practice-14-alternative-water-sources

[17] https://www.epa.gov/septic and Decentralized Wastewater Treatment Systems: https://www.epa.gov/septic/decentralized-wastewater-systems-technology-fact-sheets

Treating wastewater on-site may not be a viable solution for many buildings due to space and cost constraints. If this is the case, then the building will have to depend on using alternative water to offset the use of freshwater and/or infiltrate water back to the original source through green infrastructure.

WA.D.5 Design green infrastructure features to return water to its original water source

Another option for returning water to the original water source is through green infrastructure (also referred to as low impact development). Green infrastructure includes features that retain stormwater on-site and infiltrate it back to groundwater. These features minimize water loss due to runoff and allow infiltration of water through soil into the water table. While this process preserves the natural flow of water, it also helps prevent flow on hardscape where water may be more exposed to contaminants (affecting water quality) and may more readily be lost into the atmosphere (through evaporation). Examples of such green infrastructure include bioswales, raingardens, and permeable pavement.[18]

If the building is not located within the watershed or aquifer of the original water source, then returning water via green infrastructure to the original water source will be unlikely. The option for net zero water strategy would therefore have to depend on using alternative water to offset the use of freshwater.

WA.D.6 Minimize the impact of design reviews or value engineering on the net zero target

When retrofitting a building for net zero water, it is important to incorporate these elements early in the process. Clearly lay out the net zero water goals of the building's renovation at the onset of design. Specify net zero water equipment and elements at the initial design charrette. Bring stakeholders to the table at the beginning of the process, including future occupants and operators, to ensure everyone is in agreement on the net zero water goals.

[18] For information, go to Environmental Protection Agency's Green Infrastructure website: https://www.epa.gov/green-infrastructure

Construction

During the construction phase, the net zero water elements identified during the design phase will be put into practice. For existing buildings the recommended construction elements are provided below.

WATER Net Zero Construction Elements for Existing Buildings
WA.C.1 Develop contract language that requires approval before changing net zero related features
WA.C.2 Commission, recommissioning, or retrocomissioning the building water and wastewater systems

WA.C.1 Develop contract language that requires approval before changing net zero related features

Language should be incorporated into the contract that ensures the net zero water elements are installed per the renovation design. Equipment specifications should be cross-walked with the contractor's procurement to ensure that the correct equipment is purchased and installed. Add language to the contract that includes performance metrics on water use that requires the building meets the water reduction goals compared to the water balance.

WA.C.2 Commission/recommissioning/retrocommissioning the building's water and wastewater systems

Language should be incorporated into the contract that ensures all net zero water equipment and features are commissioned, recommissioned, or retrocommissioned. New equipment should be commissioned during the construction phase, as well as upon completion of construction of the building. This will ensure that the building's new water systems are installed and tested to perform per the specifications of the design. Existing equipment should be recommissioned and retrocommissioned which ensures that the existing equipment is operating to the original design criteria.

A commissioning plan should be developed that includes:

- Overall objectives
- Commissioning, recommissioning, and retrocommissioning strategies
- Project team

The plan should include the required tests to be performed to commission each major water system. Tests may include flow rate monitoring to ensure that equipment meets the manufacturer's specified flow rate. This measurement can be done through a flow meter or spot flow measurement. In addition, all equipment should be tested to ensure the connections are not leaking. For alternative water and wastewater systems, it is recommended that the commissioning plan includes a requirement for water quality testing to confirm that the treatment system is producing the desired level of filtration and/or disinfection.[19]

[19] For information, go to FEMP Commissioning website: http://energy.gov/eere/femp/commissioning-federal-buildings

Operations

Good O&M practices are key to meeting the designed performance of a net zero water building. The net zero water operation elements that contribute to an existing federal building meeting its goals are provided below.

WATER Net Zero Operation Elements for Existing Buildings
WA.O.1 Develop a building operation plan to address O&M of water efficient design features, alternative water systems, wastewater treatment systems, and perform leak detection and water quality assessments
WA.O.2 Meter water use and monitor for leaks and operational issues
WA.O.3 Ensure that occupants are aware of the net zero design features and are actively engaged with achieving the expected water performance
WA.O.4 Measure and verify building is operating at net zero over a one-year timeframe

WA.O.1 Develop a building operation plan to address O&M of water efficient design features, alternative water systems, and wastewater treatment systems, and perform leak detection and water quality assessments

Ensure the building operation plan includes specific O&M measures of water equipment. The plan should include the description of the measure, action items that should be performed, the frequency it should occur, and the personnel that are responsible for the action. Table 5 provides examples of O&M measures for water equipment that could be included in the building operation plan.

Table 5. Example O&M Measures for Water Equipment

End-Use	O&M Measure	Frequency	Responsible Party
Plumbing	Inspect for leaks, long toilet/urinal flush cycles, and broken or missing aerators	Bi-annually	Plumber/building manager
Commercial Kitchen	Ensure that manufacturer specified use and care instructions are being followed, inspect for broken components, loose connections, and leaks	Bi-annually	Commercial kitchen maintenance staff
Landscape/ Irrigation	Aerate turf, alternate turf mowing height, add mulch to landscaped areas, and keep landscaped areas weed free Review irrigation schedule, inspect emitter components for broken heads and leaks, verify system pressure	At the beginning and mid-point of growing season	Grounds maintenance personnel
Rainwater Harvesting System	Inspect the system for leaks and loose connections, test for water quality, change or clean the filter and screens, inspect motors and pumps to ensure they are fully operational	Bi-annually (or per the manufacturers' recommendations)	Building engineer

WA.O.2 Meter water use and monitor for leaks and operational issues

Metered data provides critical information on a building's water use to ensure that the building is performing as designed. The building should be metered as a whole to monitor total water use. Water-intensive applications such as irrigation and cooling towers should be sub-metered.

Alternative water systems should be metered to monitor water production and use separately. It is recommended that on-site wastewater is metered so that the total amount of treated wastewater returned to the original water source can be monitored and measured. Water infiltration of green infrastructure features can be monitored with flow sensors and/or simple mass balance.

All meters should be advanced meters that have the ability to download data at least in hourly intervals. The interval data can be used to monitor the building and equipment for unusual spikes in water use that can pinpoint leaks or operational issues. [20]

WA.O.3 Ensure that occupants are aware of the net zero design features and are actively engaged with achieving the expected water performance

To successfully operate a net zero water federal building, occupants must be engaged and knowledgeable about the building's net zero elements and functions. An outreach program should be implemented to help building occupants become engaged in the building's net zero water features. Example elements of a behavior change program for encouraging water conservation include:

- training occupants on how to identify plumbing leaks,
- providing an easy mechanism for reporting leaks,
- setting periodic goals for building water use,
- billing or mock billing of tenants,
- informing building occupants on water performance through staff meetings, newsletters, email announcements, and social media announcements,
- holding competitions to inspire occupant water conservation efforts, and
- providing awards for achieving water reduction targets.

WA.O.4 Measure and verify building is operating at net zero over a one-year timeframe

To verify if the building is operating at net zero, collect annual data on water use and water discharges considering each specific water pathway, flow, and use within the boundary of the building. These pathways will include the following estimates:

- Building's total annual water use for all sources including purchased potable water and on-site alternative water
- Total annual alternative water use (e.g., amount of rainwater captured from the roof and reused within the building)
- Total annual on-site treated wastewater returned to original water source
- Total annual stormwater infiltrated to original water source through green infrastructure.

[20] For more information, go to FEMP Metering Best Practices: http://energy.gov/sites/prod/files/2015/04/f21/mbpg2015.pdf

Sum alternative water, on-site treated wastewater, and stormwater returned via green infrastructure to the original water source. If this sum is equal to or greater than the annual total water use, then the building is considered net zero water.

WASTE

Agencies that seek to meet the net zero waste goal for an existing building may need to incorporate net zero waste considerations during the design phase. A net zero waste building should integrate methods to handle the expected waste streams produced by renovation through to operation of the building, including physical space considerations, local or regional waste disposal programs, green procurement, and any permitting or regulatory requirements that may be needed to support waste diversion and treatment.

Design

During the design phase, the following elements may assist in laying the groundwork for a net zero waste building.

WASTE Net Zero Design Elements for Existing Buildings
WS.D.1 Assess waste stream composition of existing building and the impact on waste for the renovated building
WS.D.2 Develop green procurement program that minimizes waste generation
WS.D.3 Design reuse, recycling, and compost programs to minimize waste generation
WS.D.4 Identify alternative path for remaining waste streams (e.g., waste-to-energy)

WS.D.1 Assess waste stream composition of existing building and the impact on waste for the renovated building

The first step toward designing a net zero waste building is to fully define the waste stream expected during the renovation as well as the current waste stream produced during normal operation of the building. In planning for the renovation, consider the materials to be used and evaluate where decisions can be made to use materials that are more environmentally preferable. Additionally, understanding the building function will identify potential unique material and waste impacts that may need special handling. Table 6 summarizes some of the net zero waste renovation considerations.

Table 6. High Performance Design Considerations for Existing Net Zero Waste Buildings

High performance design elements	Considerations
Waste Generation	Office recyclables (e.g., white paper, cardboard, mixed paper, glass, plastic) Compostable waste (e.g., food, landscaping) Other reusable/recyclable items (e.g., appliances, pallets, scrap metal) Municipal solid waste (MSW) for use in WTE
Materials Used	Environmentally preferable materials Recycled/reclaimed materials Materials that enable easy diversion Locally/regionally made products
Building Function	Office building Laboratory Data center Housing Manufacturing Vehicle Maintenance

In defining the expected waste streams early in the process, options to reduce the amount of solid waste generated, reuse or re-purpose items, and recycling and composting opportunities will be more readily identifiable.

WS.D.2 Develop green procurement program that minimizes waste generation

Once an assessment of the anticipated waste streams has occurred, agencies should consider methods by which waste generation can be reduced. Agencies should have green procurement programs in place that can be applied to individual buildings. Green procurement programs should be developed to consider recycled content, energy and water efficient products and services, and bio-based products. Consideration should also be given to supply chain greenhouse gas management.

Within the design phase, it is helpful to understand which products are easily obtained in the region to help with product selection, and also whether there are community programs that facilitate the reuse of excess materials. Designers may also determine the types of service contractors available in the area that may be able to provide additional services that eliminate waste, such as furniture leasing, rag washing, and entry mat services. Additionally, designers and/or operators should check that all service contracts include applicable requirements and clauses to ensure that contractors adhere to the same level of compliance. Example service contracts to be considered include custodial, pest control, landscape maintenance, and building maintenance contracts. The type of contracts used could have an effect on design if there are special requirements needed to support the contractor (e.g., area for compost, roll off container for landscape waste).

WS.D.3 Design reuse, recycling, and compost programs to minimize waste generation

During the design phase, the net zero waste advocate should become familiar with community programs that facilitate the reuse, recycling, and composting of solid waste, as well as the design, purpose, and plan for regular building operations (Table 7). The design team should also become familiar with and adhere to any permitting or regulatory requirements within the local area that pertain to waste management, recycling, or composting. Although construction waste and debris are not part of the net zero waste building, best management practices would include a construction waste plan that outlines the method of construction, supplier considerations for packaging and delivery of construction supplies, environmentally preferable materials specifications, and construction waste stream management.

Once an understanding of the available programs and building layout has been achieved, designers can work to integrate the necessary spaces needed to manage waste generated on-site any expected renovations. In designating spaces, designers should consider that bins are best located in areas that are easily accessible to staff and determine whether there are enough common areas to accommodate collection areas for all staff, or whether other spaces, such as hallways will be needed (and whether those areas are wide enough to place collection bins).

- Compost areas should be sized based on type of collection unit and need identified (traditionally, these are located in kitchens and break rooms). Designers should evaluate the location and accessibility to occupants in determining whether current dumpster areas are sufficient to contain both MSW containers and recycle collection, and whether there are other areas that may be needed to accommodate multiple dumpsters and be accessible from different sides of the building.

- Designers should also consider potential holding areas, either within the building or next to the dumpster area to process bulky items (e.g., pallets, cardboard). An additional area may need to be designated within the buildings to collect items that cannot be accepted in the MSW recycling service, such as lamps, batteries, solvents/paints, and toner cartridges. Designers should also consider space for storing items identified for reuse or sharing; depending on the building size, more than one space may be needed.
- Designers should develop a reuse advertising method so that all building tenants are aware of items available for reuse.
- Designers may also wish to identify and partner with community programs for reuse of items, particularly if items in the reuse areas are not re-utilized within a certain period of time.
- A separate slab/power/water source area may be needed for compost, anaerobic digestion (AD), driers, and/or used cooking oil collection, depending on local services available and methods chosen for managing food and landscape debris.

Table 7. Net Zero Waste Program Considerations for Existing Buildings

Program Areas	Considerations
Reuse	Within the building: Location of reuse center space(s) and a process to educate staff to check these areas before purchasing Beyond the building: Identify potential opportunities for donating to local charities for items that are no longer useful to the agency
Recycling	Within the building: Location of recycling containers and process to educate staff on what can be recycled Beyond the building: Type of service offered (e.g., single stream versus sorted, commodities collected) and the pickup schedules
Composting	Within the building/site: Pest management considerations for the placement of composting containers, availability of compostable materials, and on-site needs for compost Beyond the building: Type of composting services available in the community and local need for compost
Waste Recovery	Availability of MSW for use in a WTE plant

WS.D.4 Identify alternative path for remaining waste streams (e.g., waste-to-energy)

To achieve net zero waste, any remaining waste streams must be managed through other methods, including WTE. Designers should identify what disposal facilities the building is currently utilizing and if regional facilities are available in the area, including WTE, AD, and landfill gas (LFG), and determine the distance between the building location and the waste management facility, whether the agency's location is within the jurisdiction of the alternative disposal facility (or what it would cost to be added into their service domain), whether haulers will deliver collected material to their facility, what materials are accepted, how they are collected, and whether there are any special collection requirements.

Construction

During the construction or renovation phase, the net zero waste management elements identified during the design phase will start to be put into practice. Although construction waste and debris are not part of the net zero waste building, it is a best management practice for the construction company contracts to have specific clauses to ensure that all debris is handled according to established criteria. Materials used should follow the design, and all debris should be appropriately diverted. A report should be provided that shows total weight of all materials diverted from construction activities. The net zero waste elements for renovating existing buildings are provided below.

WASTE Net Zero Construction Elements for Existing Buildings
WS.C.1 Establish contracts with local entities to support purchasing, reuse, recycling, compost, and other waste management efforts
WS.C.2 Put systems in place to enforce green procurement and waste management
WS.C.3 Make available containers for reuse, recycling, compost and other waste management

WS.C.1 Establish contracts with local entities to support purchasing, reuse, recycling, compost, and other waste management efforts

Building managers should work with the community programs and suppliers identified in the design phase to establish or modify the contracting network necessary for implementation of green procurement programs and management of identified waste streams through reuse, recycling, composting, and other methods. The renovation contracting officer should include net zero waste targets as a key contractor selection criterion when soliciting and selecting contractors.

WS.C.2 Put systems in place to enforce green procurement and waste management

During the renovation phase, building managers should implement the systems designed to enforce the green procurement and waste management methods. Contracts should include specifications and clauses that promote the net zero waste goals, along with penalties for non-compliance. Product and material specifications may be written to minimize waste generation and allow for return/reuse of packaging and excess materials. It is a best management practice for the construction companies to document removal of materials from the construction site, and to track and monitor waste disposition.

WS.C.3 Make available containers for reuse, recycling, compost and other waste management

As building renovation proceeds, ensure that the necessary containers are available, correctly labeled, utilized, and serviced in a timely manner to effectively manage the waste created.

Operations

WASTE Net Zero Operation Elements for Existing Buildings
WS.O.1 Building operation plan addresses O&M of waste conversion programs, such as waste-to-energy, and O&M of reuse, recycling, compost and other waste diversion programs
WS.O.2 Implement Reuse/Recycle Program
WS.O.3 Green procurement requirements and waste diversion options are enforced
WS.O.4 Occupants are actively engaged in achieving the net zero waste targets
WS.O.5 Measure and verify building is operating at net zero over a one-year timeframe

As a building enters day-to-day operations, the designed net zero waste elements will be put into place. The programs identified during the design phase may need to be revisited to ensure that they remain current and allow for the addition of new or unforeseen waste streams and program offerings. Net zero waste operation elements are provided below.

WS.O.1 Building operation plan addresses O&M of waste conversion programs, such as waste-to-energy, and O&M of reuse, recycling, compost and other waste diversion programs

Ensure the building operation plan includes specific net zero waste elements. The plan should include the description of the measure, action items that should be performed, the frequency it should occur, and the personnel that are responsible for the action. The building operation plan should be reviewed annually to make sure that all components of the plan for waste management are functioning correctly. Table 8 provides examples of waste management measures that could be included in the building operation plan.

Table 8. Example Waste Management O&M Measures

Area	O&M Measure
Custodial Services	Ensure that custodial service contracts include clauses for transporting recyclables to the hauler collection point or internal collection area for pickup (including food and cooking oil, if applicable)
Compost	Ensure service contracts for passive compost units include transporting food scraps to the unit, as well as intermittent cleaning of the unit area (e.g., hose off the pad)
Recycling	Monitor use of the recycle bins to ensure that either liners are appropriately used, or that the bins are cleaned when needed
Occupants	Occupants are informed of how and where to place items for reuse, recycling, and composting, and informed about green procurement programs

WS.O.2 Implement Reuse/Recycle Program

Reuse, composting, and recycling areas should be clearly labeled and monitored to ensure that only items suitable for reuse, composting, and recycling are placed in the area. Building signage should be placed in common areas explaining the program and providing information regarding location and use of collection bins and areas. Responsible parties (or building points of contact) should be identified to assist staff with questions and suggestions for improvement. An annual assessment of the reuse, composting, and recycling programs should be conducted regarding location and functionality, and adjustments should be made to allow for optimum implementation of the programs.

WS.O.3 Green procurement requirements and waste diversion options are enforced

Policies and procedures regarding green procurement and waste diversion should be relayed to staff, and all staff involved in the day-to-day operations regarding purchasing and waste management should be trained to provide an understanding of the requirements. The agency should put a tracking system in place to monitor that green procurement principles are used at each purchase; this information should be reviewed annually to ensure that the principles are being implemented. Additional materials, such as “quick guides” should be provided to purchasing card holders to aid them in their decision-making process. Finally, items that are delivered to the building should be verified that they are in compliance with green procurement requirements.

WS.O.4 Occupants are actively engaged in achieving the net zero waste targets

Occupant engagement will be required to achieve the net zero goal. Training and awareness materials and guidance should be developed and provided to assist both contracting professionals and building occupants in understanding the net zero waste goals, and their role in meeting those goals. One method is to institute an aggressive education and motivation program that may include new occupant briefings, annual trainings, occupant meetings, newsletters, and social media announcements. These communications may also include information about building progress toward waste minimization and diversion goals. Competitions may be held to encourage waste minimization and diversion efforts, and periodic goals may be set for building waste targets. Incentive and award programs motivate and acknowledge occupant contributions to a successful net zero waste program.

WS.O.5 Measure and verify building is operating at net zero over a one-year timeframe

To verify if the building is operating at net zero, the following steps should be taken on an annual basis:

- Review procurement records to verify that they are in compliance with green procurement requirements.
- Verify that applicable net zero waste clauses within service contracts are being honored by the contractor, and that they are managing waste as stated.
- Review recycle/reuse/compost records (e.g., invoices, weight) to verify that waste diversion took place as expected, and that material streams were handled as expected.
- Review WTE records to determine whether any materials were included that should have been diverted through other means.

If waste was reduced or diverted properly through reuse/recycling/composting/WTE/other methods, contractors appropriately handled diverted materials, and no waste was landfilled or incinerated, the building is considered net zero waste.

5 Summary

FEMP and PNNL recognize there are more strategies and lessons learned from on-going net zero energy, water, and waste efforts on federal buildings and campuses. In 2010 Army launched a net zero energy, water, and waste pilot initiative that involved 17 installations. As of October 2015, this initiative documented an energy reduction of 307 MMBtus and generated nearly 28,700 megawatt-hours of renewable energy; documented a water reduction of 636 million gallons and produced 89 million gallons of alternative water; and documented a waste reduction of 9,400 tons and diverted 58% of the waste from landfill disposal. The Army's net zero energy, water, and waste hierarchy is considered a key element to the initiative's success. The first item on the hierarchy is reducing resource use with the final item being renewable energy generation, groundwater recharge, and waste disposal.[21] The General Services Administration has renovated the Wayne Aspinall Federal Building in Grand Junction, Colorado, a building on the National Registry of Historic Places, to achieve net zero objectives. Some of the energy efficiency features include advanced metering and controls, high-efficiency lighting systems, an improved building envelope, and techniques to manage occupant plug load. Photovoltaic roof panels were installed to generate enough renewable energy to meet the building's electricity needs.[22]

FEMP is eager to learn more about federal agency net zero energy, water, and waste efforts in order to share those strategies and lessons learned with the federal sector. Contact FEMP at: https://www4.eere.energy.gov/femp/assistance/ with your experiences with net zero efforts.

6 Glossary

Terms used in this handbook are defined below. Existing federal or publicly available definitions are referenced. Additional zero energy buildings terms can be found in the EERE *A Common Definition of Net Zero Buildings* report.[23]

Alternative water – A sustainable water source not derived from fresh, surface or groundwater sources. Alternative water can include harvested rainwater, harvested stormwater, sump pump water harvesting, graywater, air cooling condensate, reject water from water purification systems, reclaimed wastewater, or water derived from other water reuse strategies.

British thermal units – Standard unit of energy.

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[21] U.S. Army, prepared by PNNL. October 2016. *2015 Progress Report: Army Net Zero Initiative*. U.S. Army Office of the Assistant Secretary of the Army (Installations, Energy and Environment).

[22] To learn more about the Wayne Aspinall Federal Building go to: https://sftool.gov/plan/422/net-examples#wayneaspinall

[23] U.S. DOE's *A Common Definition for Zero Energy Buildings* available online at http://energy.gov/sites/prod/files/2015/09/f26/bto_common_definition_zero_energy_buildings_093015.pdf

Boundary – Line that is at or within the legal property boundary that marks the limits of the building or campus across which delivered energy and exported energy are measured.[24]

Cogeneration – The simultaneous production of electric and thermal energy in distributed energy systems; typically, waste heat from the electricity generation process is recovered and used to heat, cool, or dehumidify building space. Neither generation of electricity without use of the byproduct heat, nor waste-heat recovery from processes other than electricity generation is included in the definition of cogeneration.[25]

Commissioning – A systematic process of ensuring that all building systems in a new building perform interactively as intended in the design.

Compost – Degradation of organic waste to form mulch or soil amendment.

Construction – Preliminary planning, engineering, architectural, legal, fiscal, and economic investigations and studies, surveys, designs, plans, working drawings, specifications, procedures, and other similar actions necessary for the construction of a public building. (40 U.S. Code § 3301)

Disposal – Proper disposition of a discarded or discharged material in accordance with local environmental guidelines or laws.

Electric energy – Electric power provided by a utility or generated on-site, usually measured in kilowatt hours (kWh).

Energy conservation measure (ECM) – Life-cycle cost-effective actions or technologies that are applied to an existing federally owned building that improve energy efficiency. ECMs include energy conservation, cogeneration facilities, renewable energy sources, improvements in operation and maintenance efficiencies, or retrofit activities.[26]

Energy recovery – The exchange of energy from one subsystem with another, typically in the form of thermal energy.

Federal building – Any building, structure, or facility, or part thereof, including the associated energy consuming support systems, which is constructed, renovated, leased, or purchased in whole or in part for use by the federal government and which consumes energy; such term also

[24] Adapted from U.S. DOE. September 2015. A Common Definition for Zero Energy Buildings.

[25] Quote from EIA's Commercial Buildings Energy Consumption Survey Terminology: http://www.eia.gov/consumption/commercial/terminology.php#C An alternative definition can be found at: http://energy.gov/eere/energybasics/articles/glossary-energy-related-terms#E – The generation of electricity or shaft power by an energy conversion system and the concurrent use of rejected thermal energy from the conversion system as an auxiliary energy source.

[26] 10 CFR § 436.31

means a collection of such buildings, structures, or facilities and the energy consuming support systems for such collection.[27]

Federal campus – A U.S. government designation associated with a campus or installation owned or leased by the federal government. This designation is used to identify groups of buildings typically in the same geographic location. It could be the name of a federal campus, or it could be an alphanumeric sequence, like the Installation or Sub-Installation Identifier from the U.S. Federal Real Property Profile, the federal government's centralized real property database.[28]

Freshwater – A surface or groundwater source that has a total dissolved solids concentration of less than 1,000 milligrams per liter (1,000 ppm).

Geothermal heat pump renewable energy – Energy generated from systems that use the constant temperature of the earth as the exchange medium for heating and cooling to reduce and replace the equivalent amount of energy otherwise would be generated from an air-source heat pump.[29]

Graywater – Lightly contaminated water generated by lavatory faucets, showers, or clothes washing machines.

Green procurement – The purchase of new materials or products that are made from the most environmentally preferable materials available, including materials that are easily reused or recycled.

Groundwater – Water beneath the surface of the Earth held in porous spaces in soil, sediment, and rock.

Harvested rainwater – Precipitation collected from a roof surface before hitting the ground.

Harvested stormwater – Precipitation collected on the ground level at the building or campus property that has not entered a surface waterway (such as a parking lot).

Hazardous waste – A waste with properties that make it potentially dangerous or harmful to human health or the environment, requiring special handling and disposal techniques.[30]

Landfill – A disposal system in which the waste is buried between layers of earth.

Life-cycle cost-effective – The proposed building or existing building project has a lower life-cycle cost than the life-cycle costs of the baseline building or project, as described by 10 Code of Federal Regulations (CFR) 436.19, or has a positive estimated net savings, as described by 10

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[27] 42 U.S.C. § 8259

[28] https://portfoliomanager.energystar.gov/pm/glossary

[29] The White House Council on Environmental Quality Office of Federal Sustainability. June 10, 2015. Implementing Instructions for Executive Order 13693 Planning for Federal Sustainability in the Next Decade., page 25.

[30] https://www.epa.gov/hw/learn-basics-hazardous-waste#hwid

CFR 436.20, or has a savings-to-investment ratio estimated to be greater than one, as described by 10 CFR 436.21; or has an adjusted internal rate of return, as described by 10 CFR 436.22, that is estimated to be greater than the discount rate as listed in OMB Circular Number A-94 "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.[31]

Measure and verify – Quantifying the performance of energy, water and waste systems compared to expected performance.

Medical waste – Potentially hazardous waste generated at health care buildings that may be contaminated with blood or other potentially infectious material requiring special handling and disposal.[32]

Municipal solid waste – Garbage, refuse, sludge and other waste materials not excluded by federal law or regulation.

New federal building – Any building to be constructed on a site that previously did not have a building or a complete replacement of an existing building from the foundation up, by, or for the use of, any federal agency which is not legally subject to State or local building codes or similar requirements.

On-site renewable energy – Includes any renewable energy collected and generated within the site boundary that is used for building energy and the excess renewable energy could be exported outside the site boundary. The renewable energy certificates (RECs) associated with the renewable energy must be retained or retired by the building owner/lessee to be claimed as renewable energy.

Original water source – Surface water and groundwater sources that are within the same local watershed. Local watersheds are defined as a sub-watershed. Each sub-watershed is assigned a 12 digit hydrologic unit code by the U.S. Geological Survey.[33]

Recycle – When the useful life of a material or product has been reached, the material or product is used as feedstock for new materials or products following some form of physical or chemical processing (e.g., aluminum cans to make new aluminum products).

Recommissioning – For an existing building that has already been commissioned, this is the systematic process of checking that all building systems continue to perform interactively as intended.

Reduce – Decrease the amount of solid waste generated on-site that needs to be considered for diversion including intentionally limiting materials brought on-site.

[31] 10 CFR 435.2

[32] https://www.epa.gov/rcra/medical-waste

[33] Original water source includes sources within the same local watershed and aquifer of the building's (or campus') water supply. For more information on watershed boundaries, go to: https://nhd.usgs.gov/wbd.html

Renewable electric energy – Electric energy produced by solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, geothermal heat pumps, micro-turbines *(powered by renewable fuel)*, municipal solid waste (*including Waste-to-Energy*), or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project.

Renewable energy certificate (REC) – Documentation that represents the generation of one megawatt-hour (MWh) of electricity from an eligible source of renewable energy.[34]

Renovated building – Construction on an existing building that includes replacement or restoration of major systems, interior work (such as ceilings, partitions, doors, floor finishes, etc.), and building elements and features.

Repurpose – Items that are no longer able to be used for their intended purpose are modified for a different purpose (e.g., wood pallets used to make furniture).

Retrocommissioning – For an existing building that has not been commissioned, this is the systematic process of checking that all building systems are operating interactively as intended.

Reuse – Use materials or products for intended purpose for as long as possible. Reuse can include donations to entities outside of the agency (e.g., furniture to a non-profit).

Site energy – Energy consumed at the building site as measured at the site boundary. At a minimum, this includes heating, cooling, ventilation, domestic hot water, indoor and outdoor lighting, plug loads, process energy, elevators and conveying systems, and intra-building transportation systems.[35]

Source energy – Site energy plus the energy consumed in the extraction, processing and transport of primary fuels such as coal, oil and natural gas; energy losses in thermal combustion in power generation plants; and energy losses in transmission and distribution to the building site.[36]

Surface water – Water on the surface of the Earth such as a river or lake. Surface water does not include stormwater collected on-site at the building or campus level.

Thermal energy – All forms of non-electric energy which is primarily the energy delivered as heating or cooling. Examples of thermal energy are fuels used in furnaces and solar water heaters and British thermal units of energy received from ground sourced heat pumps.[37]

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[34] U.S. DOE FEMP http://www.energy.gov/sites/prod/files/2013/10/f3/rec_guide.pdf

[35] U.S. DOE. September 2015. A Common Definition for Zero Energy Buildings.

[36] U.S. DOE. September 2015. A Common Definition for Zero Energy Buildings.

[37] The White House Council on Environmental Quality Office of Federal Sustainability. June 10, 2015. Implementing Instructions for Executive Order 13693 Planning for Federal Sustainability in the Next Decade., footnote 18 on page 20.

Thermal renewable energy – Energy generating technologies and approaches that use renewable heat sources, including biomass, solar thermal, geothermal, waste heat, and combined heat and power from renewables.

Total Annual Water Use – The amount of water consumed within the boundaries of a building from all sources (potable and non-potable including freshwater and alternative water) over the course of a year.

Total Annual Alternative Water Use - The amount of water consumed within the boundaries of a building from sustainable water sources not derived from fresh, surface or groundwater sources over the course of a year. In a net zero building, the total annual water use should be offset by alternative water in part or completely.

Total Annual Water Returned/Discharged to the Original Source – The amount of water collected from the building systems (e.g., green infrastructure and on-site treated wastewater) and is discharged back to the original water source over the course of a year. In a net zero building, the total annual water use should be offset by water returned to the original source in part or completely.

Waste-to-energy – The waste treatment process that creates energy in the form of electricity, heat, or transport fuels (e.g., diesel) from a waste source.

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