Deep Decarbonization of New Buildings

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Summary

New buildings constructed today can be expected to remain in use well beyond 2050. As a result, thoughtful decisions now can have a significant impact on reducing the carbon footprint of buildings for decades to come. Buildings use about 40% of energy produced in the United States and are responsible for about 30% of the nation's carbon dioxide emissions, making carbon emissions from buildings a priority for reduction. Substantial progress has been made in making new buildings more energy efficient, and technology is available that would allow for major additional reductions. But much more needs to be done in the new building sector to reach the Deep Decarbonization Pathways Project (DDPP) goals for carbon reduction. This Article discusses the changes that need to occur and sets out recommendations to help accomplish the DDPP's carbon reduction goals.

I. Introduction

New buildings present an especially important opportunity to advance energy efficiency and achieve decarbonization in the building sector, as compared with existing buildings, because of the ability to incorporate efficiency and decarbonization approaches directly into new building design. However, new buildings present a particular challenge to decarbonization. If energy-efficiency measures or electrification opportunities are not incorporated into the building design, it may be years before these measures are employed for the existing building. Further, carbon emissions from production of building materials become locked in. As a result, it is critical to focus now on new building design, construction, and operation to achieve decarbonization of new buildings.

This Article explores the rapidly changing landscape related to decarbonization of new buildings, and recommends ways to accelerate this effort. Part II addresses some of the current issues in building construction and design in terms of energy use and carbon intensity. Part III sets out the specific decarbonization goals for new buildings in the United States by 2050. Part IV defines and discusses zero-energy buildings (ZEBs), as they represent an overarching concept that unites many of the steps that will need to be taken in new building design and construction to achieve decarbonization; Part V discusses passive buildings. Next, the Article considers action being taken in the United States (Part VI) and the European Union (EU) (Part VII) to facilitate new building energy performance. Part VIII discusses recommendations designed to meet the new building decarbonization goals, and Part IX concludes.

II. Background

Commercial and residential buildings in the United States consume a significant amount of energy, and new buildings raise important questions about energy use and efficiency over the course of their useful lives. This part will provide background information on U.S. building stocks, building life expectancy, energy usage in buildings, and energy-efficiency efforts in the building sector.

Based on 2013 census data, the median year that houses in the United States were built was 1976, and the largest percentage of residences is between 35 and 64 years old.[1] The life expectancy of commercial buildings ranges from just over 50 years for wood buildings to more than 87 years for concrete buildings.[2] These data indicate that today's

1. U.S. Census Bureau, 2013 Housing Profile: United States (2015) (AHS/13-1), *available at* http://www2.census.gov/programs-surveys/ahs/2013/factsheets/ahs13-1_UnitedStates.pdf.
2. Jennifer O'Connor, Survey on Actual Service Lives for North American Buildings, Presentation at Woodframe Housing Durability and Disaster

new residential and commercial buildings are likely to still be in use well beyond 2050. As a result, near-term action is required to prevent lock-in of building stock that produces significant carbon emissions.

Buildings are major sources of these emissions. In 2015, energy use by buildings made up 40% of all energy use in both the United States[3] and worldwide,[4] as well as 30% of all greenhouse gas (GHG) emissions,[5] with U.S. buildings responsible for 9% of the world's GHGs by themselves.[6] Natural gas is the source of one-half of the energy used for heating houses and heating water in houses.[7]

However, there is good news in the trends on energy use. For example, between 2003 and 2012, energy intensity for commercial buildings declined by 12% and energy intensity for government buildings declined by 23%.[8] Still, to achieve deep decarbonization goals, new buildings must be much more energy efficient, must increasingly utilize low-carbon sources of energy, especially for heating and hot water, and should acquire or generate zero-carbon energy to offset energy used in the buildings.

Among the factors that have led to energy-efficiency improvements, the commercial building market's uptake of Leadership in Energy and Environmental Design (LEED) and Energy Star® standards for new buildings has been notable. Both LEED and Energy Star for buildings are discussed later in this Article. However, the focus for achieving significant reductions in building energy use, particularly fossil fuel consumption, has increasingly been on the concept of ZEBs.[9]

Several strategies are emerging to drive increased decarbonization of new buildings. These strategies for the most part do not need to rely on new or untested technologies. Utilizing the best technology available today could lower energy demands by 61% for residential buildings and 78% for commercial buildings.[10] Important work has already occurred in conceptualizing a much lower carbon future for new buildings. For example, the American Institute of Architects' (AIA's) 2030 Challenge envisions all new buildings and major renovations resulting in carbon-neutral operation by 2030.[11]

In addition to operational energy use, new buildings raise one other important energy question—embodied energy—which is the energy contained in the materials used to construct new buildings. Embodied energy includes emissions from resource extraction, processing, material production, building construction, building deconstruction, and disposal, as well as transportation for those activities.[12] Of the total energy consumed in a building's life cycle, embodied energy accounts for 10%-38% of total energy use for conventional buildings and 9%-46% for more energy-efficient buildings.[13] Embodied energy is receiving more attention, and it is a complex issue that requires consideration of trade offs and diminishing returns. For example, at what point does the embodied energy in manufacturing, transporting, and installing large amounts of insulation materials exceed the energy savings achieved with the additional insulation?

III. Pathways to Deep Decarbonization in the United States

The Deep Decarbonization Pathways Project (DDPP) technical report established three primary goals that affect new buildings: (1) an 80% reduction in GHG emissions from 1990 levels; (2) 90% of final energy from decarbonized electricity in both (existing and new) residential and commercial buildings[14]; and (3) highly efficient end use of

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Issues Conference 1, 5 (Oct. 2004), http://cwc.ca/wp-content/uploads/2013/12/DurabilityService_Life_E.pdf.

3. U.S. Energy Information Administration (EIA), *Frequently Asked Questions—How Much Energy Is Consumed in U.S. Residential and Commercial Buildings?*, http://www.eia.gov/tools/faqs/faq.cfm?id=86&t=1 (last updated May 10, 2017).
4. United Nations Environment Programme, Buildings and Climate Change: Summary for Decision-makers 1, 3 (2009), *available at* https://europa.eu/capacity4dev/unep/document/buildings-and-climate-change-summary-decision-makers.
5. *Id*.
6. U.S. Department of Energy, Energy Efficiency Trends in Residential and Commercial Buildings 11 (2008), *available at* http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/bt_stateindustry.pdf.
7. *See* EIA, *Everywhere but Northeast, Fewer Homes Choose Natural Gas as Heating Fuel*, Today in Energy, Sept. 25, 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=18131.
8. *See* EIA, *Recent Energy Intensity Decline in Government Buildings Exceeds Commercial Sector Average*, Today in Energy, Sept. 16, 2016, http://www.eia.gov/todayinenergy/detail.cfm?id=27972.
9. Also called a net zero-energy building or zero net-energy building. This Article will use the term "zero energy building" due to the U.S. Department of Energy's (DOE's) adoption of it after determining it concisely describes the concept and resonates with building owners "in striving for simplicity, consistency and to accentuate the core objective." *See* Roger Grant et al., National Institute of Building Sciences et al., A Common Definition for Zero Energy Buildings 2 (2015), *available at* https://energy.gov/sites/prod/files/2015/09/f26/bto_common_definition_zero_energy_buildings_093015.pdf.
10. DOE, *Increasing Efficiency of Building Systems and Technologies September 2015*, *in* Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities 143, 155-56 (2015), *available at* http://energy.gov/sites/prod/files/2015/09/f26/QTR2015-05-Buildings.pdf.
11. Architecture 2030, *The 2030 Challenge: All New Buildings, Developments, and Major Renovations Shall Be Carbon-Neutral by 2030*, http://architecture2030.org/2030_challenges/2030-challenge/ (last visited Nov. 1, 2017).
12. Søren E. Lutken & Per Harry Wretlind, UNEP DTU Partnership, Working Paper Series No. 13, City Based Carbon Budgets for Buildings 3 (2016), http://www.unepdtu.org/-/media/Sites/Uneprisoe/Working%20Papers/Working-Paper-13_LCD_final.ashx?la=da.
13. Cassandra L. Thiel et al., *A Materials Life Cycle Assessment of a Net-Zero Energy Building*, 6 Energies 1125, 1127 (2013), *available at* http://www.mdpi.com/1996-1073/6/2/1125/htm.
14. James H. Williams et al., Energy and Environmental Economics, Inc. et al., US 2050 Report, Volume 2: Policy Implications of Deep Decarbonization in the United States 1, 22 (2015) [hereinafter Policy Implications of Deep Decarbonization], *available at* http://deepdecar-

energy in buildings—all by 2050.[15] This part will discuss the specific actions described in the DDPP policy report as necessary to achieve DDPP's overall deep decarbonization target for 2050 for buildings: to maintain the same level of final energy use in commercial and residential buildings as a whole, despite a projected increase by 2050 of 40% in commercial floor space and 36% in population.[16]

The DDPP report suggests that policymakers need to make an early decision on the fate of using natural gas in buildings.[17] In order to meet decarbonization goals, natural gas use in buildings would have to be almost completely eliminated by 2050 and replaced by decarbonized pipeline gas or electricity. However, the natural gas phaseout is not a simple process. Natural gas is predominantly used in buildings for three purposes: space heating, water heating, and cooking.

The most recent data for all building types and sizes across the United States showed that annual consumption of natural gas for space heating was 1,307 billion cubic feet (bcf).[18] Natural gas overshadows electricity as a primary space-heating energy source by 1,240 bcf to 51 bcf.[19] There are nearly 320,000 miles of interstate and intrastate gas transmission pipelines.[20] Natural gas-fired power generation increased 19% in 2015, and growth is expected to continue as 18.7 gigawatts of new capacity comes online between 2016 and 2018.[21] Additionally, in the short term, switching space heating, water heating, and cooking to electricity is likely to mean that the electricity is provided by a significant amount of coal- or gas-fired generation.

Thus, it is important for policymakers and builders to develop a strategy for simultaneously phasing out fossil fuel use in space heating, cooking, and water heating while phasing in electrification of these functions so that the transition progresses at the same time the grid is being decarbonized. This switch alone will create most of the 20% decrease in total building final energy use, reducing final energy use even as floor space increases.[22] Decarbonized electricity will then be poised to make up 90% of the final energy in buildings, up from 50% electricity and 50% natural gas today.[23] Fuel switching on the scale anticipated by the DDPP is a long-term project that will require a concerted effort to accomplish.[24]

In discussing policy approaches for new buildings, the DDPP report asserts that "from the deep decarbonization perspective, some of the fundamental paradigms that have made these [energy-efficiency] programs successful in the past will need to be reoriented going forward, requiring significant policy innovation in both state and federal codes and standards."[25] The DDPP report sets out five major ways that building energy policy should change, but the ideas center on the importance of fuel switching and increased electrification of buildings in tandem with decarbonization of electricity generation[26] to achieve final energy use of more than 90% decarbonized electricity in all buildings.[27]

For new buildings in particular, the DDPP's overall deep decarbonization target for 2050 is to maintain the same level of final energy use in commercial and residential buildings as a whole, despite a projected increase by 2050 of 40% in commercial floor space and 36% in population.[28] This target is proposed to be attained by achieving three goals:

- Maximize energy efficiency to highly efficient end use in new buildings by requiring:
  - Improved building shells/envelopes.
  - Highly efficient electric end-use equipment.[29]
  - Widespread use of sensors and data analytics to regulate energy use, including increased installation and use of smart meters.
- Facilitate, encourage, and/or require the construction of ZEBs, which requires the following:
  - Increase the decarbonized electrification of the building sector, including space and water heating.[30]
  - Develop incentives for fuel switching to electricity and other low-carbon fuels, particularly for space and water heating from fuel oil and natural gas combustion to decarbonized electricity.[31]

bonization.org/wp-content/uploads/2015/11/US_Deep_Decarbonization_Policy_Report.pdf.

15. James H. Williams et al., Energy and Environmental Economics, Inc. et al., Pathways to Deep Decarbonization in the United States, US 2050 Report, Volume 1: Technical Report 1, 24 (2015) [hereinafter Technical Report], *available at* http://deepdecarbonization.org/wp-content/uploads/2015/11/US_Deep_Decarbonization_Technical_Report.pdf.
16. *Id.* at 1, 25-26.
17. Policy Implications of Deep Decarbonization, *supra* note 14, at 1, 91-92.
18. *See* EIA, *Commercial Buildings Energy Consumption Survey (CBECS)—Table E8* (414 bcf for water heating, 384 bcf for cooking, and 89 bcf for other), https://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/e8.cfm (last released May 2016).
19. *Id.*
20. *See* Pipeline 101, *Why Do We Need Pipelines?*, http://www.pipeline101.com/why-do-we-need-pipelines (last visited Nov. 1, 2017). *See also* EIA, *Estimated Natural Gas Pipeline Mileage in Lower 48 States, Close of 2008* (finding a total of 305,954 miles), https://www.eia.gov/naturalgas/archive/analysis_publications/ngpipeline/mileage.html (last visited Nov. 1, 2017).
21. *See* EIA, *Many Natural Gas-Fired Power Plants Under Construction Are Near Major Shale Plays*, Today in Energy, May 19, 2016, http://www.eia.gov/todayinenergy/detail.cfm?id=26312.
22. Policy Implications of Deep Decarbonization, *supra* note 14, at 22.
23. *Id.* at 22-23.
24. Major infrastructure investments in natural gas transmission and distribution lines as well as natural-gas power generating facilities have lifespans of 40 or more years. Accordingly, the country needs to make decisions in the short term about current and future construction of natural gas facilities and infrastructure. The longer decisions are delayed about the fate of natural gas usage, the more infrastructure will be built and the concern about stranded assets becomes more significant.
25. Policy Implications of Deep Decarbonization, *supra* note 14, at 1, 91.
26. *Id.* at 92-93.
27. *Id.* at 22.
28. Technical Report, *supra* note 15, at 1, 25-26.
29. DOE Office of Energy Efficiency and Renewable Energy, *Appliance and Equipment Standards Program*, http://energy.gov/eere/buildings/appliance-and-equipment-standards-program (last visited Nov. 1, 2017).
30. These are the two primary residential energy end uses. *See* Technical Report, *supra* note 15, at 1, 25.
31. Fuel switching of space and water heating from fuel oil and natural gas combustion to decarbonized electricity will be responsible for most of a

- ○ Increase distributed generation of renewable energy on-site and encourage the purchase of off-site renewable energy or renewable energy credits.
- Consider embodied energy in new buildings and reduce the use of carbon-intensive products, like concrete, steel, and aluminum, by substituting innovative building materials made from recycled materials and wood.[32]

In the United States, individual states and local governments have authority over building construction standards, including energy-efficiency requirements, materials requirements, performance standards, and incentive programs for energy use. States also have most of the authority over infrastructure investment decisions that could facilitate fuel switching.

The federal government's authority over relevant areas includes: energy-efficiency standards for appliances, certain infrastructure projects including interstate natural gas pipelines and electric transmission lines, policies regarding federal buildings, and schemes that guide the allocation and spending of federal funds. This is not insignificant; the U.S. government owns or leases 273,000 buildings, totaling 2.8 billion square feet.[33] The federal government can also play a role in broader areas like tax policy, biofuel development, and regulation of electric and natural gas wholesale markets through the Federal Energy Regulatory Commission. The federal government can also demonstrate new, efficient construction methods in its new buildings.

In the parts that follow, each goal is discussed along with its associated legal issues, and co-benefits like cost savings, job creation, economic development, and reduced pollution. For each goal, there are examples of how federal action could be taken to advance it and how states and local governments, as well as the private sector, could make progress on achievement of the goal.

IV. Green Building Approaches

A. LEED and Energy Star for Buildings

LEED and Energy Star for buildings are the two leading voluntary certification programs for buildings in the United States. This section will explain how these schemes encourage the adoption of energy-efficiency measures for commercial and institutional buildings as well as homes.

The U.S. Green Building Council, which manages the LEED program, describes LEED as providing "independent verification of a building or neighborhood's green features, allowing for the design, construction, operation and maintenance of resource-efficient, high-performing, healthy, cost-effective buildings."[34] Building owners can seek "certification" of their building as meeting a LEED standard (Certified, Gold, Silver, or Platinum, with Platinum being the highest standard), or specify in their construction contract that a new building be constructed in a manner that would achieve a particular LEED level but not require certification. Energy Star for buildings is a voluntary program run by the U.S. Environmental Protection Agency (EPA) that allows building owners to benchmark their buildings against standards for energy efficiency. If the building meets the standards, it can display an Energy Star logo. Energy Star for buildings benchmarking is incorporated into the factors for LEED certification.[35]

LEED and EPA's Energy Star for buildings certification programs have become the two leading voluntary standards for "green buildings," with LEED increasingly being adopted by cities as a mandatory requirement for new buildings. The prominence of the LEED system for certifying green buildings might lead to the conclusion that a LEED building will be highly energy efficient. The number of points achieved by the building's design and features allow it to be certified as attaining one of the LEED standards.

However, LEED certification points can be earned by adopting a wide range of practices, including recycled building materials, water-efficiency techniques, low-volatile organic compound paints, and many other attributes of a green building beyond energy efficiency and renewable energy. The LEED certification prioritizes and assigns the most points in the category Energy and Atmosphere, which encompasses energy efficiency, renewable generation on-site, green power, and carbon offset credit purchasing.[36] Pursuing points in this area is not mandatory, but ignoring it amounts to a penalty. Ignoring energy efficiency and renewable energy also would not make sense economically when seeking to achieve the higher levels of certification, particularly LEED Platinum.[37]

Although LEED is not a guarantee that a building will employ specific strategies to increase energy efficiency or minimize resource consumption, there are some new offerings in LEED's menu of features to earn credits that address energy efficiency. For example, credits are now available for demand-response sensitivity and an alternate compliance

projected 20% decrease in total building final energy use. *See id.* at 22.

32. The White House, United States Mid-Century Strategy for Deep Decarbonization (2016), *available at* https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf.

See also ClimateTechWiki, *Carbon Sink and Low-Carbon Building Materials*, http://www.climatetechwiki.org/technology/carbon-sink-and-low-carbon-building-materials (last visited Nov. 1, 2017).

33. Fiscal Year 2015 Federal Real Property Profile Tool Open Data Set, Table 5 FY 2012-FY 2015 U.S. and U.S. Territories—Office Square Footage Trend by Agency, https://www.gsa.gov/cdnstatic/FY_2015_FRPP_Open_Data_Set_20160531.xlsx.

34. *See* U.S. Green Building Council, *This Is LEED*, http://leed.usgbc.org/leed.html (last visited Nov. 1, 2017).

35. ENERGY STAR, *ENERGY STAR Certification for Your Building*, https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/earn-recognition/energy-star-certification (last visited Nov. 1, 2017). *See* ENERGY STAR, *Green Buildings and ENERGY STAR*, https://www.energystar.gov/buildings/about-us/how-can-we-help-you/energy-star-action/green-buildings-and-energy-star (last visited Nov. 1, 2017).

36. Interview With Brendan Owens, LEED Fellow, Chief of Engineering, U.S. Green Building Council, in Washington, D.C. (Aug. 16, 2016).

37. *Id.*

path of optimized accounting for energy use according to carbon rather than cost (which is the current standard for that credit). LEED also cycles in pilot credits that allow testing of new ideas, like an upcoming emphasis on peak load factor to encourage building energy usage that does not coincide with peaks in electricity demand. Additionally, LEED standards also address embodied carbon in new buildings through the Materials and Resources credit category in LEED Version 4.[38]

Both Energy Star and LEED have specialized programs for residential buildings, Energy Star-Certified Homes[39] and LEED for Homes,[40] which certify homes in the same way that the programs certify commercial buildings, but use criteria developed for single-family homes and multifamily buildings.

B. ZEBs

ZEBs provide an endpoint or ultimate goal toward which green building can and should be directed. The federal government has encouraged the construction of commercial ZEBs and provided a common definition for the ZEB. In the Energy Independence and Security Act (EISA) of 2007,[41] the U.S. Congress set a goal of zero net-energy use for all new commercial buildings by 2030 and for one-half of the existing commercial building stock by 2040, and established the Zero Net Energy Commercial Buildings Initiative to achieve those goals.[42] ZEBs rely on efficiency, fuel switching, and on-site renewable energy generation to operate buildings without fossil fuel energy resources.

ZEB definitions vary depending upon the organization involved and the different rules and accounting methodologies used, but all definitions agree on the ultimate goal of net-zero fossil-fuel energy consumption.[43] The U.S. Department of Energy (DOE) has produced a proposed common definition for a ZEB: "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."[44] Energy-efficiency measures that reduce building energy use are a fundamental requirement for ZEBs. Connection to the electric grid (or other energy networks) is another crucial requirement in order to transfer surplus energy generated on-site to the grid. DOE states that any "delivered energy" used by the building, including "grid electricity, district heat and cooling, [and] renewable and non-renewable fuels," must be offset by equal or greater "exported energy" generated from renewable sources on-site[45] and sent to the grid or other energy network.[46]

The most commonly referenced way to generate renewable energy to offset delivered energy is photovoltaic (PV) solar, generated with panels on the top or sides of the building.[47] DOE's ZEB definition allows combustion of fuels on-site, but requires that such fuel consumption be offset by excess renewable energy generation. DOE's ZEB definition maintains strict divisions between on-site renewable energy and delivered energy, stating:

> Renewable fuels delivered to the *site boundary* are not included in this term [on-site renewable energy], because they are treated as *delivered energy* to the *building*. . . . For example, wood chips or biofuel harvested on-site would be considered *on-site renewable energy*, while wood or biofuel/biomass delivered to the site would not be considered on-site renewable energy.[48]

Accordingly, the DOE ZEB definition would require on-site generation to offset even renewable fuels that were generated off-site but delivered to a building.

DOE's requirement of on-site generation may unnecessarily constrict the sources of renewable generation as the effort to move away from carbon-based fuel sources expands. On-site generation can suffer from problems of scale because of insufficient land or building space to accommodate some forms of renewable energy or generate sufficient energy. On-site generation can also suffer from problems of efficiency because urban density may limit sunlight and installation size, and because larger-scale renewable energy facilities may be more cost effective.[49]

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38. U.S. Green Building Council, *LEED V4 Building Design + Construction Guide, MR Overview* ("focuses on minimizing the embodied energy and other impacts associated with the extraction, processing, transport, maintenance, and disposal of building materials . . . [and is] designed to support a life-cycle approach that improves performance and promotes resource efficiency." For example, the "building life-cycle impact reduction" credit provides four options for compliance that generate anywhere from two to five points for the building and involve reuse of existing materials, preservation of existing buildings for incorporation into the new structure, and a whole-building life-cycle assessment.), http://www.usgbc.org/guide/bdc#mr_overview (last visited Nov. 1, 2017); *see also* U.S. Green Building Council, *Building Life-Cycle Impact Reduction*, http://www.usgbc.org/node/2614363?return=/credits/new-construction/v4/material-%26amp%3B-resources (last visited Nov. 1, 2017).
39. *See* ENERGY STAR, Energy Efficient New Homes, https://www.energystar.gov/newhomes (last visited Nov. 1, 2017).
40. U.S. Green Building Council, *Guide to Certification: Homes*, https://new.usgbc.org/cert-guide/homes (last visited Nov. 1, 2017).
41. EISA, 42 U.S.C. §17001.
42. *Id.* §17082.
43. Focusing solely on operational energy usage, there is a continuum that spans from the "on-site ZEB" generating "enough renewable energy on-site to equal or exceed its annual energy use," to the "off-site ZEB," which uses "renewable energy from sources outside the boundaries of the building site." Paul Torcellini et al., National Renewable Energy Laboratory, Zero Energy Buildings: A Critical Look at the Definition 2-3 (2006) (NREL/CP-550-39833).
44. Grant et al., *supra* note 9, at 1, 4.
45. Either generated within the building footprint or on the building site (on the property or contiguous to the property where the building is located) and connected to the building's energy distribution infrastructure. *Id.*
46. The DOE definition takes a hard stance on the issue of on-site generation; whereas, previous definitions included off-site energy supply options, like use of renewable energy resources imported from off-site to the building to generate energy on-site, or purchase of renewable energy generated off-site, whether in the form of certified credits, or a power purchase agreement for a newly installed renewable system. *Id.*
47. Grant et al., *supra* note 9, at 5; Shanti Pless & Paul Torcellini, National Renewable Energy Laboratory, Net-Zero Energy Buildings: A Classification System Based on Renewable Energy Supply Options 1, 6 (2010) (NREL/TP-550-44586), *available at* http://www.nrel.gov/docs/fy10osti/44586.pdf.
48. Grant et al., *supra* note 9, at 1, 7.
49. *See, e.g.*, John Farrell, *Report: Is Bigger Best in Renewable Energy?*, Inst. for Loc. Self-reliance, Sept. 30, 2016, https://ilsr.org/report-is-bigger-best/.

DOE also defined specialized forms of ZEBs,[50] including the renewable energy certificate zero-energy building (REC-ZEB). The premise is that "[m]ulti-story *buildings* that occupy entire lots located in dense urban areas, or *buildings*, such as hospitals with high process loads, may not be able to balance *annual delivered energy* with *on-site renewable energy* simply because the site is not large enough to accommodate all the *on-site renewable energy* required."[51] The REC-ZEB is defined as "[a]n 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* plus acquired *Renewable Energy Certificates* (RECs)."

An REC is "a market-based instrument that represents the property rights to the environmental, social and other non-power attributes of renewable electricity generation. RECs are issued when one megawatt hour of electricity is generated and delivered to the electricity grid from a renewable energy resource."[52] The REC-ZEB only allows use of RECs as a supplement after on-site renewable energy sources have been employed. In addition, the building's owner must demonstrate through actual measurements that its delivered energy consumption is less than or equal to renewable energy generated on-site plus RECs.[53]

Beyond reductions in energy consumption from carbon-intensive sources, ZEBs could provide numerous benefits, including lower operating costs, better resiliency to power outages, improved energy security, reduced air pollution, new business opportunities, increased demand for renewable energy, and ancillary benefits for building users, like increased productivity[54] and improved health.[55] Yet ZEBs also raise issues that may affect their implementation as well as their incorporation into law, including varying and conflicting definitions, questions about the use of offsets to qualify in meeting the zero emissions standard,[56] the technology and systems required to operate ZEBs,[57] up-front costs,[58] problems that ZEBs may pose for the operation of the electric grid,[59] and lack of energy storage requirements.[60] The bottom line, though, is that ZEBs are playing and likely will play a growing role in decarbonization of new buildings.

V. Energy-Efficiency Technologies for Deep Decarbonization of New Buildings

A wide range of energy-efficiency technologies are available today that can be utilized in new building construction to

50. Two others are the zero-energy campus and the zero-energy community, which are groupings of buildings where renewable energy resources are shared. Grant et al., *supra* note 9, at 1, 4, 7.
51. *Id*. at 10.
52. U.S. EPA, *Green Power Partnership—Renewable Energy Certificates (RECs)*, https://www.epa.gov/greenpower/renewable-energy-certificates-recs (last updated Sept. 8, 2017).
53. Grant et al., *supra* note 9, at 1, 10; *see also* Drury Crawley et al., National Renewable Energy Laboratory, Getting to Net Zero 1, 4 (2009) (NREL/JA-550-46382) (describing ZEBs that employ off-site energy supply options and "[p]urchase recently added off-site [renewable energy] sources, as certified from Green-E (2009) or other equivalent REC programs [and] [c]ontinue to purchase the generation from this new resource to maintain [net-zero energy building] status"), *available at* https://www.nrel.gov/docs/fy09osti/46382.pdf.
54. Nationally, improvements to indoor environmental conditions are estimated to have generated $20 to $160 billion from workforce productivity gains. William J. Fisk, *Health and Productivity Gains From Better Indoor Environments and Their Relationship With Building Energy Efficiency*, 25 Ann. Rev. Energy & Env't 537 (2002); *see also* Lawrence Berkeley National Lab, *Indoor Air Quality Scientific Findings Resource Bank: Human Performance*, https://iaqscience.lbl.gov/performance-summary.7 (last visited Nov. 1, 2017).
55. Poor indoor environmental quality resulting from insufficient air circulation, poor lighting, mold, temperature variances, carpeting and furniture materials, pesticides, toxic adhesives and paints, and high concentrations of pollutants contribute widely to respiratory problems and allergies. *See* U.S. EPA, *Introduction to Indoor Air Quality*, https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality (last updated Jan. 26, 2017); *see also* Marco Ferreira & Manuela Almeida, *Benefits From Energy Related Building Renovation Beyond Costs, Energy, and Emissions*, 78 Energy Procedia 2397-402 (2015), *available at* http://www.sciencedirect.com/science/article/pii/S1876610215019311#.
56. The REC-ZEB category recognizes the challenges of urban density and energy-intensive building uses for on-site generation and takes into account the potential for off-site generation in more optimum areas, which might reduce the cost and increase the attainability of ZEBs. However, DOE missed an opportunity to create a hierarchy of priorities between the purchase of RECs and a power purchase agreement (PPA) for renewable energy from a local utility or an arrangement where the building's owners finance or own generation equipment (e.g., solar PV panels, wind turbines) and pay a utility to operate and maintain them. Use of a PPA would provide direct investment into the utility to support the construction, maintenance, and operation of the means of producing renewable energy. Depending on what is preferable for the utility serving the building, a potential hierarchy would have a PPA or ownership of means of generation at the top, because it involves a contractual relationship (often long-term) that the utility can rely on. Next would be purchase of RECs, because it provides no direct investment and no guaranteed revenue stream for the utility.
57. Experts have written extensively about the simulation models, sensors, actuators, and building optimization and control technologies needed for effective ZEB operation and have expressed concerns about the harmony required between these technologies and the building's users to achieve a ZEB. Complex systems, high-tech components, and diverse users must all work together in real time on a daily basis for a building to succeed as a ZEB. *See* Denia Kolokosta et al., *A Roadmap Towards Intelligent Net Zero- and Positive-Energy Buildings*, Solar Energy 3 (2010).
58. Some studies indicate that a ZEB, whether residential or commercial, can be constructed for approximately 0%-10% more than the same type of traditional building. *See* New Buildings Institute, Getting to Zero 2012 Status Update: A First Look at the Costs and Features of Zero Energy Commercial Buildings (2012), *available at* http://newbuildings.org/sites/default/files/GettingtoZeroReport_0.pdf. *See* Paul Torcellini et al., *A Pathway for Net-Zero Energy Buildings: Creating a Case for Zero Cost Increase*, 43 Building Res. & Info. 25-33 (2015) (demonstrating how an office building was constructed as a ZEB at no incremental cost increase over a traditional building of that size in that location).
59. ZEB models assume that excess energy generated on-site can always be sent to the grid to be used; however, the grid may not always need this energy and on-site storage would be needed to maintain the building's ZEB status. Pless & Torcellini, *supra* note 47, at 2. The electric grid (which is and may remain for some time heavily reliant on fossil fuels) needs to provide backup generation for the ZEB, even though the ZEB will not need energy from the grid on an annual net basis. *See* Mark MacCracken, *The Flaw of "Zero Energy Buildings" Without Energy Storage*, CleanTechnica, Mar. 16, 2016, http://cleantechnica.com/2016/03/16/the-flaw-of-zero-energy-buildings-without-energy-storage/.
60. Most grid-connected ZEB models use the grid for storage and/or consider on-site electric vehicle charging to be energy storage. Mark MacCracken, *The Flaw of "Zero Energy Buildings" Without Energy Storage*, CleanTechnica, Mar. 16, 2016, http://cleantechnica.com/2016/03/16/the-flaw-of-zero-energy-buildings-without-energy-storage; *see also* Karsten Voss et al. *Nearly-Zero, Net Zero, and Plus Energy Buildings—How Definitions & Regulations Affect the Solutions*, REHVA J. 23 (2012). Then, as electric vehicles drive away from the building and use the energy stored in their batteries, the charging becomes a means of transmission for exporting that energy. Grant et al., *supra* note 9, at 7.

satisfy the fundamental ZEB requirement of extraordinary energy efficiency, as well as to meet the DDPP goals. The following approaches and measures can be employed in residential, commercial, and industrial buildings. "Passive" building design represents the high end of the spectrum of energy efficiency and includes features that can be included into less comprehensive but still quite efficient buildings.

Passive building is "both a set of design principles . . . and a quantifiable performance standard that can be implemented in all building types. . . ."[61] The major principles of passive building include superinsulation; airtightness; high-performance components such as windows; solar gain through building orientation, building floor plans that reduce the need for lights ("daylighting"), and heating/cooling with solar shading designed to reduce thermal loads and save energy; natural ventilation; and use of materials that absorb and store heat energy.[62] The use of passive technologies can play a key role in reducing energy demand and is a significant element in designs that help meet AIA's 2030 Challenge.[63]

For example, new residential buildings that adhere to standards for passive construction may not even need to use electricity or very efficient heating technologies, such as ground-source heat pumps,[64] because little additional heating may be required to maintain desired comfort levels. Instead, small electric heating appliances can be used to provide supplemental heating. This approach reduces electric demand and the associated carbon emissions from the portion of the grid that remains reliant on fossil fuels, as well as building costs that would typically be related to space heating.

Additional energy-efficiency measures that are often implemented in construction of ZEBs include innovative heating, ventilating, and air conditioning (HVAC) strategies that decouple ventilation from space conditioning and reduce fan energy; energy-efficient appliances, electronics, and equipment; use of the most efficient lighting technology (light-emitting diodes (LEDs)); and intelligent building technologies that automatically adjust features to maintain a consistent temperature and minimize HVAC-related energy losses.

One question that highly engineered designs raise is the issue of embodied energy, particularly embodied carbon. If superinsulation of the building envelope and triple pane windows are used to increase energy efficiency, there should be some consideration of the balance between the emissions produced to create the extra insulation and glass and the building's reduced energy consumption over its life cycle. There are three main ways to minimize embodied energy in new buildings: (1) increase material efficiency (i.e., use less material by changing the design or increasing the strength of materials), (2) use the same materials with less embodied carbon (i.e., manufactured more efficiently or with low-carbon energy),[65] or (3) substitute materials.[66]

Incorporating into the design energy-efficiency strategies that have manageable up-front costs and positive life-cycle value is one way to move the building sector away from carbon-based fuel dependence and toward ZEBs.

VI. U.S. Approaches to Improve the Energy Performance of New Buildings

A. *Federal Approaches to Improving Energy Performance in New Buildings*

Over the past decade or so, the United States has taken a range of actions on a federal level that support decarbonization goals by improving energy efficiency and promoting increased use and generation of renewable energy. These actions have been taken in accordance with a variety of federal laws, standards, and mandates, including the Energy Policy Act of 2005 (EPAct 2005), EISA, General Services Administration (GSA) 2016 Facilities Standards, President Barack Obama's Executive Order No. 13693, and DOE's 2008 "Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings."

The EPAct 2005 provides several examples of the federal government's authority and willingness to take action on energy efficiency in new buildings.[67] The EPAct mandated that the Secretary of Energy "establish, by rule, revised Federal building energy efficiency performance standards. . . ." The Act requires that, "if life-cycle cost-effective for new Federal buildings," the buildings are to "be designed to achieve energy consumption levels that are at least 30 percent below the levels established in the version of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard or the International Energy Conservation Code, as

61. Katrin Klingenberg & Mike Knezovich, *An Introduction to Passive House Principles and Policy*, 26 Envtl. L. N.Y. 39 (2015), *available at* http://www.phius.org/Releases/Environmental-Law-In-NY-March-2015.pdf.
62. Autodesk Sustainability Workshop, *Thermal Mass*, http://sustainabilityworkshop.autodesk.com/buildings/thermal-mass (last visited Nov. 1, 2017).
63. Architecture 2030, *supra* note 11.
64. Ground-source heat pumps, also called geothermal heat pumps, use the constant temperature of the earth, a few feet below the surface, as the exchange medium instead of the outside air temperature. "Like a cave, this ground temperature is warmer than the air above it during the winter and cooler than the air in the summer." By exchanging heat with the earth, a ground-source heat pump is able to heat, cool, and, if so equipped, supply the house with hot water. *See* DOE, *Geothermal Heat Pumps*, https://energy.gov/energysaver/geothermal-heat-pumps (last visited Nov. 1, 2017).
65. If fuel switching to renewable and low-carbon sources occurs, as laid out in the DDPP, then embodied carbon in building materials would also be reduced.
66. An example of a substitute material is a new type of laminated wood, cross-laminated timber, being produced that is as strong and fire-resistant as steel and concrete. Trees also absorb carbon dioxide from the air as they grow, in sharp contrast with the carbon-intensive production of concrete and steel, making this new material very attractive from an embodied carbon perspective. *See* Nexus Media, *Wooden Skyscrapers—Coming to a City Near You*, Sci. Am., June 16, 2016, http://www.scientificamerican.com/video/wooden-skyscrapers-coming-to-a-city-near-you; *see also* Lutken & Wretlind, *supra* note 12, at 8.
67. EPAct 2005, H.R. 6, 109th Cong. §109 (2005) (enacted), https://www.gpo.gov/fdsys/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf.

appropriate."[68] The implementing regulations were adopted in December 2006.[69]

EISA took energy efficiency further. For new federal buildings and major renovations, the Act required that fossil fuel energy use, including natural gas—relative to the 2003 level—be reduced 55% by 2010 and be eliminated (100% reduction) by 2030.[70] In order to continue these initiatives and others, EISA required GSA to establish the Office of Federal High-Performance Green Buildings to coordinate green building information and activities within GSA and with other federal agencies.[71] With regard to specific features in buildings, the Act directed GSA to review the current use of, and design a strategy for increased use of, cost-effective lighting, ground-source heat pumps, and other technologies in GSA facilities.[72]

The GSA 2016 Facilities Standards (P100) also contain energy-efficiency strategies and energy performance standards.[73] The GSA has addressed energy efficiency and sustainability by requiring LEED certification in its standards.

GSA's Facilities Standards for public buildings also require new buildings be designed to comply with the energy performance requirements of the EPAct 2005 (designed to be at least 30% more efficient than the design required by ASHRAE 90.1) and EISA (designed to reduce fossil fuel-generated energy use by 80% reduction in 2020, 90% in 2025, and 100% by 2030).[74] From concept design through each design phase, the project must demonstrate that it meets its energy targets by using energy modeling that includes the building enclosure systems in concert with mechanical systems and provides documentation showing that systems were chosen based on a life-cycle cost analysis.[75] All buildings must meet minimum levels of performance. Energy cost and its effect on life-cycle cost is an essential consideration in the design of GSA buildings.[76] The GSA requirement that new GSA buildings achieve the LEED Version 4 Gold standard encourages smart grid-connected demand response capability by providing points for that capability.

President Obama's Executive Order No. 13693, Planning for Federal Sustainability in the Next Decade, signed in 2015, established other energy-efficiency requirements for federal agencies.[77] The head of each federal agency is required to promote building energy conservation, efficiency, and management by submitting monthly performance data to EPA for certain buildings, installing and monitoring smart meters in all data centers by fiscal year 2018, and creating power usage effectiveness targets for new and existing data centers. The agency heads must also ensure that minimum percentages of total building electric and thermal energy are generated from renewable and alternative sources, ranging from not less than 10% in 2016 and 2017, up to not less than 25% by 2025. There are similar targets for renewable energy consumed by agency buildings—not less than 30% of electric energy by 2025.[78]

For all new agency lease solicitations larger than 10,000 rentable square feet, the Executive Order requires that energy efficiency be considered either as a required performance specification or as a source selection evaluation factor in best-value trade off procurements. Beginning in 2016, there have also been requirements for lessor disclosure of carbon emissions or energy consumption data for that portion of the building occupied by the agency in order to facilitate reporting requirements. For new buildings and leases, agencies must also "optimize sustainable space usage and consideration of existing community transportation planning and infrastructure, including access to public transit."[79] Finally, all new construction and major renovations are required to incorporate "climate-resilient design and management elements," which are to be defined in new guiding principles for both new and existing federal buildings that also contemplate employee and visitor wellness.[80]

Federal agencies have shown strong results from their energy management over the years. From 1975 to 2015, the federal government has decreased the energy intensity of its buildings by more than 40%. Furthermore, in 2015, 8.7% of the federal government's electricity use came from renewable sources.[81]

Federal agencies are required by statute, Executive Order, and presidential memorandum to meter electricity, natural gas, and steam in federal buildings with advanced metering. Pursuant to §103 of the EPAct 2005, federal

68. *Id*.
69. Life-cycle costing, 10 C.F.R. §433.8 (2006); Energy efficiency performance standard, 10 C.F.R. §433.100 (2006).
70. EISA, 42 U.S.C. §433. Unfortunately, regulations implementing this provision of EISA were never finalized. *See also* Fossil Fuel-Generated Energy Consumption Reduction for New Federal Buildings and Major Renovations of Federal Buildings, 75 Fed. Reg. 63404 (Oct. 15, 2010). The rule never advanced beyond the notice of proposed rulemaking. *See also* Energy Efficiency Standards for the Design and Construction of New Federal Commercial and Multi-Family High-Rise Residential Buildings, 10 C.F.R. pt. 433.
71. EISA, 42 U.S.C. §17092.
72. *Id*. §17095.
73. *See* GSA 2016 Facilities Standards (P100), ch. 1, §§1.7, 1.8, and 6.5.1.1, https://www.gsa.gov/cdnstatic/P100_2016.pdf.
74. GSA, PBS-P100: Facilities Standards for the Public Buildings Service (2016), https://www.gsa.gov/cdnstatic/P100_2016.pdf.
75. *Id*.
76. *Id*.
77. Exec. Order No. 13693, 80 Fed. Reg. 15871 (Mar. 19, 2015). President Donald Trump has not yet revoked Exec. Order No. 13693. If it is revoked in the future, agencies could withdraw their plans for energy efficiency and renewable energy, except for the U.S. Department of Defense (DOD) because its 25% renewables by 2025 target was codified in the National Defense Authorization Act of 2007. In July 2017, amendments to the National Defense Authorization Act that would have reversed climate change-related activities were all voted down by the U.S. House of Representatives, including an amendment that sought to bar the Pentagon from implementing relevant portions of Exec. Order No. 13693. Bonner R. Cohen, *House Rejects Amendments to Free Pentagon From Climate Change Policies*, Heartland Inst., Sept. 15, 2017, https://www.heartland.org/news-opinion/news/house-rejects-amendments-to-free-pentagon-from-climate-change-policies.
78. *Id*.
79. *Id*.
80. Exec. Order No. 13693, 80 Fed. Reg. 15871 (Mar. 19, 2015).
81. Fact Sheet, DOE Office of Energy Efficiency and Renewable Energy, Federal Energy Management Program, https://energy.gov/sites/prod/files/2016/08/f33/femp_overview%281%29.pdf.

agencies are required to meter electricity used in federal buildings for the purposes of efficient use of energy and reduction in the cost of electricity.[82]

DOE's 2008 "Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings" provided additional requirements for installation of building-level electricity, natural gas, and steam meters in new major construction, renovation projects, and existing buildings.[83] DOE guidance, developed in accordance with a presidential memorandum, Federal Leadership on Energy Management, set a deadline of October 1, 2016, for such metering of natural gas and steam.[84] By the end of 2013, federal agencies collectively reported installing 96% of electricity, 96% of natural gas, and 69% of steam meters at buildings the agencies deemed appropriate.[85] The DOE guidance also provides that "[e]ach agency shall use, to the maximum extent practicable, advanced meters or advanced metering devices that provide data at least daily and that measure at least hourly consumption of electricity in the Federal buildings of the agency."[86] This data, particularly the data on natural gas, can be analyzed and used to support decisions on continued energy-efficiency measures and fuel switching from natural gas to electricity. Further, the fact that the data must be generated likely supports better planning for new buildings to minimize emissions.

EISA also established the Zero Net Energy Commercial Buildings Initiative, with a national goal to achieve zero net-energy use for new commercial buildings built after 2025.[87] The Act also created the Office of Commercial High-Performance Green Buildings at DOE and required that DOE establish a national clearinghouse for information and public outreach about high-performance green buildings.[88]

In 2008, the U.S. Department of Defense (DOD) and DOE began a joint initiative to address military energy use by identifying specific actions to reduce energy demand and increase use of renewable energy on DOD installations. Part of this initiative involved evaluating the potential for net zero-energy military installations. A broad definition used by DOE and DOD in this context included producing as much energy from renewable energy sources as is consumed; limiting the consumption of water to not deplete the local watershed; and reducing, reusing, and recovering waste streams to add zero waste to landfills.[89] Although little-to-no progress[90] has been made thus far, DOD has indicated that it will issue guidance soon on incorporating net zero into planning for new facilities larger than 5,000 gross square feet, among others, in compliance with Executive Order No. 13693.[91]

B. *State and Local Approaches to Improving Energy Performance in New Buildings*

The best way to implement energy-efficiency measures, like those mentioned above, at a state level is through amendments to state building codes. This section will cover how states and cities have developed building and energy codes to encourage energy efficiency, comply with federal mandates, and/or chart their own courses into requiring increased efficiency through the incorporation of LEED compliance into their standards or the creation of their own original codes.

There are two general approaches to building codes among U.S. states. First, state building codes may be adopted and applied statewide. Second, a state-level building code may be adopted to set minimums and guide counties and municipalities in adopting building codes. This second approach may allow local codes at the county and municipal level to be stricter than the state code. A state's code may consist of multiple building codes, including international model codes that may be amended to suit the state's needs.[92]

The state may also have an energy code that interfaces with its building codes. The energy code may be written by and for that state specifically, but there also are model energy codes states can adopt in full and/or tailor to their needs. Two model codes are most commonly used by states and the federal government for energy efficiency in buildings: the International Energy Conservation Code (IECC) and ANSI/ASHRAE/IES Standard 90.1.[93] These two codes address efficiency and energy use comparison. Despite some technical differences in what they allow for various building types over all climatic zones, they are

82. *As amended and codified* at 42 U.S.C. §8253(e), https://www.gpo.gov/fdsys/pkg/USCODE-2008-title42/pdf/USCODE-2008-title42-chap91-subchapIII-partB-sec8253.pdf.
83. DOE, *Guiding Principles for Sustainable Federal Buildings*, http://energy.gov/eere/femp/guiding-principles-sustainable-federal-buildings (last visited Nov. 1, 2017).
84. DOE, Federal Building Metering Guidance (Nov. 2014 Update), http://energy.gov/sites/prod/files/2014/11/f19/metering_guidance.pdf; Presidential Memorandum on Federal Leadership on Energy Management, PUB. PAPERS 833 (Dec. 5, 2013), https://www.fedcenter.gov/admin/itemattachment.cfm?attachmentid=779.
85. *Id*. (The following buildings are excluded from metering: building planned to be sold or razed within the next five years; building leased or owned, but the agency either does not pay the utility bill or does not pay the lessor for utilities based on actual consumption; building does not have an energy-consuming heating or cooling system or significant process loads; building generates electricity that is sold commercially to other parties in the course of regular business, where installing meters would require an impractical shutdown of service.).
86. DOE, *supra* note 84.
87. EISA, 42 U.S.C. §422.
88. *Id*. §§421 and 423.
89. U.S. Government Accountability Office, Report on Defense Infrastructure: DOD Efforts Regarding Net Zero Goals (2016) (GAO-16-153R), http://www.gao.gov/assets/680/674599.pdf.
90. *Id*. at 1.
91. *Id*. at 2.
92. This is a great resource that lists whether a state has a statewide code or a combination of state and municipal building codes. U.S. Department of Energy, Status of State Energy Code Adoption (Dec 15, 2017), https://www.energycodes.gov/status-state-energy-code-adoption (last visited Dec. 20, 2017).
93. There is also a long list of model codes, to name a few: the International Building Code, International Residential Code, International Mechanical Code, International Plumbing Code, International Fuel Gas Code, International Green Construction Code, and International Property Maintenance Code.

"within 1% for both energy use and energy costs" on a national average basis.[94]

States and cities are also increasingly looking to the LEED certification system for ways to improve energy efficiency and lower the environmental impact of buildings, often by incorporating compliance with LEED into their building standards.[95] Sixteen states require new buildings to meet or exceed LEED Silver certification; some of those states require the same for renovated buildings and allow compliance through a somewhat equivalent standard, the Green Globe system.[96] Thirty-two cities require some form of LEED certification for new and/or renovated buildings; some apply this requirement exclusively to municipal buildings and some apply it to all new construction above a specific square footage.[97]

The Energy Policy Act of 1992 required each state to review the energy-efficiency provisions of its residential building codes and to determine within two years whether it should adopt the 1992 Model Energy Code published by the Council of American Building Officials.[98] For commercial building codes, the Act requires states to adopt the current ASHRAE code.[99] Both of these codes are revised periodically. Whenever either code is revised, the Act requires states to consider or adopt updated provisions that DOE determines "would improve energy efficiency" in residential or commercial buildings.[100] To bolster state performance, the EPAct 2005 authorizes DOE to provide $25 million annually to states to improve existing energy-efficiency codes and to improve compliance with such codes.[101]

Three states have adopted energy codes that are more energy efficient than the 2012 or 2015 IECC[102] for their residential building energy codes, eight states and the District of Columbia have adopted the 2012 or 2012 IECC or equivalent, and 28 states have adopted the 2009 IECC or a code between the 2009 and 2012 or 2015 IECC.[103] For commercial building energy codes, seven states have adopted ASHRAE 90.1 (2013) or more efficient codes, and seven states and the District of Columbia have adopted ASHRAE 90.1 (2010) or a code between the 2010 and 2013 versions. Twenty-three states have commercial building codes between 90.1 (2007) and 90.1(2010).[104]

California's 2016 Building Energy Efficiency Standards[105] (effective January 2017) apply to new residential and nonresidential buildings and provide mandatory, prescriptive, and performance standards for building envelopes for buildings with and without air-conditioned environments.[106] The California Energy Commission has estimated that the implementation of the 2016 Building Energy Efficiency Standards will reduce statewide annual electricity consumption by about 281 gigawatt hours per year, natural gas consumption by 16 million therms per year, and GHG emissions by an amount equivalent to 160,000 metric tons of carbon dioxide annually.[107]

The 2016 Building Energy Efficiency Standards will not achieve zero net-energy use, but they will push residential building standards closer to ZEBs. The 2019 standards, effective in January 2020, will take the final step to achieve zero net energy for newly constructed residential buildings, meaning the buildings must use a combination of improved efficiency and distributed renewable energy generation on-site to meet 100% of their annual energy needs. According to the California Public Utilities Commission (PUC), "[t]ypically the Standards' stringency increases at the rate of 12-15% in each cycle. . . ."[108] Areas to be cov-

94. For an in-depth comparison of the two standards, see Jian Zhang et al., Pacific Northwest National Laboratory, Energy and Energy Cost Savings Analysis of the 2015 IECC for Commercial Buildings app. B (2015) (PNNL-24269 Rev. 1), *available at* https://www.energycodes.gov/sites/default/files/documents/2015_IECC_Commercial_Analysis.pdf.

95. *See* Jocelyn Durkay, *Energy Efficiency Requirements for Public Buildings*, Nat'l Conf. St. Legislatures, Nov. 20, 2013 (listing state energy-efficiency requirements that involve LEED certification), http://www.ncsl.org/research/energy/energy-efficiency-requirements-for-public-buildings.aspx; *see also* Everblue Training Institute, *Cities Requiring or Supporting LEED* (listing city ordinances and requirements that involve LEED certification), http://www.everbluetraining.com/blog/cities-requiring-or-supporting-leed-2015-edition (last updated Sept. 21, 2017).

96. *See* Durkay, *supra* note 95; *see also* Green Globes, *About Green Globes*, https://www.greenglobes.com/about.asp (last visited Nov. 1, 2017).

97. *See* Everblue Training Institute, *supra* note 95 (listing city ordinances and requirements that involve LEED certification).

98. 42 U.S.C. §§6832(15), 6833(a).

99. *Id*. §§6832(16), 6833(b).

100. *Id*. §6833(a)(5), (b)(2).

101. *Id*. §6833(e).

102. The most recent version of IECC is 2015 IECC, which can provide a 15% increase in energy savings compared to the 2009 IECC. *See* Ryan Meres, *2015 IECC: What You Need to Know*, Builder, Nov. 18, 2014, http://www.builderonline.com/building/code/2015-iecc-what-you-need-to-know_o.

103. DOE, Status of State Energy Code Adoption (Dec 15, 2017), https://www.energycodes.gov/status-state-energy-code-adoption (last visited Dec. 20, 2017). For a discussion of the difference between the 2009 IECC and the 2012 IECC, see Terry S. Mapes & David R. Conover, Pacific Northwest National Laboratory, Guide to the Changes Between the 2009 and 2012 International Energy Conservation Code (2012) (PNNL-21435), *available at* https://www.energycodes.gov/sites/default/files/documents/Comparison_2009to2012_IECC.pdf.

104. DOE, *supra* note 103.

105. The abstract to the standards states:

> Public Resources Code Sections 25402 subdivisions (a)-(b) and 25402.1 emphasize the importance of building design and construction flexibility by requiring the Energy Commission to establish performance standards, in the form of an **"energy budget" in terms of the energy consumption per square foot of floor space**. For this reason, the Standards include both a **prescriptive option**, allowing builders to comply by using methods known to be efficient, and a **performance option**, allowing builders complete freedom in their designs provided the building achieves the same overall efficiency as an equivalent building using the prescriptive option.

California Energy Commission, 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (2015) (CEC-400-2015-037-CMF) (emphasis added), *available at* http://www.energy.ca.gov/2015publications/CEC-400-2015-037/CEC-400-2015-037-CMF.pdf.

106. *Id*. at 48, §100.0.

107. Additionally, there will be a net reduction in nitrous oxide emissions by about 508 tons per year, sulfur oxides by 13 tons per year, carbon monoxide by 41 tons per year, and particulate matter ($PM_{2.5}$) by 13.75 tons per year. *See* California Energy Commission, Staff Report: Initial Study/Proposed Negative Declaration for the 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (2015) (CEC-400-2015-012), http://www.energy.ca.gov/2015publications/CEC-400-2015-012/CEC-400-2015-012.pdf.

108. California Energy Commission & California PUC, CA Energy Efficiency Strategic Plan: New Residential Zero Net Energy Action Plan 2015-2020, at 20 (2015), *available at* http://www.cpuc.ca.gov/

ered in the 2016 and 2019 standards related to zero-energy policy goals for 2020 include "high performance walls and attics with increased continuous insulation; high efficacy lighting; energy-efficient water heating system requirements; conditions under which solar can be offered as a compliance credit; and defining a [Zero Net Energy] ZNE tier for CALGreen, which implements California's green building standard."[109]

Several zero-energy communities in California have been built over the past few years or are planned for the near future to begin piloting designs and technologies that will soon be required for new single-family homes as well as new multifamily residential buildings.[110] As of early 2016, California already had 1,538 net-zero buildings, more than any other state.[111]

California takes its building standards further in "CALGreen," the California Green Building Standards Code.[112] CALGreen goes beyond the state's Building Energy Efficiency Standards to account for other environmental factors and impacts in new building construction. The first version was created in 2010, the second in 2013, and the newest version in 2016 (effective January 2017). The purpose of this code is "to improve public health, safety and general welfare through enhanced design and construction of buildings using concepts that reduce negative impacts and promote those principles that have a positive environmental impact and encourage sustainable construction practices."[113] The code focuses on five areas: planning and design; energy efficiency; water efficiency and conservation; material conservation and resource efficiency; and environmental quality.[114]

The CALGreen code provides mandatory and voluntary requirements for new residential and nonresidential buildings (including buildings for retail, office, public schools, and hospitals) throughout California. The code applies broadly to "every newly constructed building or structure on a statewide basis unless otherwise indicated."[115] Both sets of mandatory standards—for residential and nonresidential buildings—have requirements for electric vehicle charging, which promotes increased electrification, provides for energy storage/export if the building is a ZEB, and facilitates fuel switching in the transportation sector by making it more convenient to charge electric vehicles.[116] The CALGreen standards miss an opportunity to require highly efficient, electric end-use equipment in the mandatory standards for residential and nonresidential buildings, which would promote increased electrification of new buildings.[117]

In the wake of Hawaii's 2015 law setting a 100% renewable energy goal by 2045,[118] the state has focused on lowering energy consumption as part of the strategy to achieve its goal.[119] Because "[h]omes and buildings account for most of Hawaii's electrical use[,]"[120] the state decided to strengthen its building energy codes and the State Building Code Council unanimously adopted the 2015 IECC with amendments to address the state's specific needs.[121] Once all of the county councils adopt the 2015 IECC, "[h]omes and buildings built to the 2015 IECC [will] use about 30% less energy than those built to the 2006 IECC—Hawaii's prior code . . . [and] Hawaii's amendments reduce energy use by up to another 3%."[122] Some of the specific highlights of Hawaii's new code are that a building's envelope must meet standards tailored to Hawaii's tropical climate and comply with testing requirements.[123] Hawaii requires that HVAC systems meet performance standards laid out in the code.[124] Also, lighting systems in buildings must operate with occupant sensors and time-sensitive controls; these systems must also be tested for functionality.[125]

The 2015 Washington State Energy Code mandates continuous improvement to energy efficiency in buildings, working toward the goal of 70% net annual reduction in energy consumption in newly constructed residential and

uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/EE_and_Energy_Savings_Assist/ZNERESACTIONPLAN_FINAL_060815.pdf.

109. *Id.* (noting that "Codes and Standards are the most important push mechanism available for implementing policy goals"). *See also* California Energy Commission, 2016 Building Energy Efficiency Standards Frequently Asked Questions (2017), http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/2016_Building_Energy_Efficiency_Standards_FAQ.pdf.

110. *See* Jake Richardson, *First Zero Net Energy Community in California Announced*, CleanTechnica, Apr. 28, 2015, https://cleantechnica.com/2015/04/28/first-zero-net-energy-community-california-announced/; *see also* Kerry A. Dolan, *Largest U.S. "Zero Net Energy" Community Opens in California at UC Davis*, Forbes, Oct. 14, 2011, http://www.forbes.com/sites/kerryadolan/2011/10/14/largest-u-s-zero-net-energy-community-opens-in-california-at-uc-davis/#f522d136ad94.

111. Andrew Meyer, *California's SGIP Is Bringing Net-Zero Homes Into the Mainstream*, Swell, Feb. 16, 2016, https://www.swellenergy.com/blog/2016/02/16/california-s-sgip-is-bringing-net-zero-homes-into-the-mainstream.

112. International Code Council, *California*, https://codes.iccsafe.org/public/collections/CA (last visited Nov. 1, 2017).

113. International Code Council & Department of Housing and Community Development, Guide to the 2016 California Green Building Standards Code: Residential 1 (2016), *available at* https://cdn-codes-pdf.iccsafe.org/uploads/bookpdfs/Guide%20to%202016%20CalGreen%20Residential.pdf#viewer.action=download.

114. *Id.* at 2.

115. *Id.*

116. *Id.* ch. 4.

117. *Id.* Additionally, there are no enhanced standards for building envelopes beyond the Building Energy Efficiency Standards, the only equipment standard is an ENERGY STAR requirement for bathroom exhaust fans, there are no requirements around sensors, and HVAC design standards are set according to the American National Standards Institute (ANSI) and ASHRAE.

118. Press Release, Governor David Ige, Governor Ige Signs Bill Setting 100 Percent Renewable Energy Goal in Power Sector (June 8, 2015), http://governor.hawaii.gov/newsroom/press-release-governor-ige-signs-bill-setting-100-percent-renewable-energy-goal-in-power-sector/.

119. Cadmus Group, Inc., Analyses and Proposal of Hawaii Amendments to the 2015 International Energy Conservation Code 3 (2016), *available at* https://energy.hawaii.gov/wp-content/uploads/2016/07/Analyses-and-Proposal-of-Amendments.pdf.

120. *Id.*

121. Hawaii State Energy Office, *2015 IECC Update*, http://energy.hawaii.gov/hawaii-energy-building-code/2015-iecc-update (last visited Nov. 1, 2017).

122. Cadmus Group, Inc., *supra* note 119.

123. Haw. Stat. Code §C402.5; Howard Wigg & Eric Makela, 2015 IECC With Hawaii Amendments (2016), https://energy.hawaii.gov/wp-content/uploads/2016/07/2015-IECC-with-Hawaii-Amendments.pdf.

124. Haw. Stat. Code §§C403.2.2 and C403.2.3.

125. *Id.* §§C405.2.1, C405.2.2, C405.2.3.

nonresidential buildings by 2031.[126] However, the code also states that the State Building Code Council may defer adoption of energy-efficiency measures if "economic, technological, or process factors would significantly impede adoption or compliance. . . ."[127] The city of Seattle's Energy Code goes beyond some of the mandates in the statewide code. For example, solar readiness—the ability to accommodate the installation of a solar PV system and/or a solar hot water system—is mandatory rather than voluntary for new buildings. In addition, the city's building envelope requirement for commercial buildings (effective 2017) is more stringent than the Washington State code.[128] The Seattle Energy Code also has its own standards for HVAC, water heating, lighting, metering, plug load controls, transformers, motors, and renewable energy.[129]

Other cities have taken action on energy efficiency through energy use disclosure laws, often referred to as "benchmarking" laws. Thirty-five jurisdictions in the United States, including 13 states, have laws or executive actions requiring energy use disclosure that vary according to whether they cover commercial, multifamily, public, and/or single-family buildings.[130] New York City's benchmarking law, Local Law 84, requires owners of large buildings to annually measure their energy and water consumption and submit the data to the city using EPA's Energy Star tool. New York City then provides building owners with comparative information on consumption in similar buildings and tracks each building's progress over the years for energy-efficiency planning purposes.[131]

States have also played an important role in decarbonization by authorizing or requiring smart metering technology that allows building owners and operators to closely monitor and adjust energy use. As this Article went to press, 47 states and the District of Columbia had general smart metering legislation or policies.[132] As of 2016, about 70.8 million smart meters were installed, and about 88% were residential customer installations.[133] Data from smart meters can facilitate achievement of DDPP goals by encouraging customers to better monitor energy use, reduce energy use, move energy use to off-peak times, support on-site generation, and monitor the effectiveness of efficiency measures.[134]

There are three main barriers to widespread installation of smart meters across the country: privacy concerns, concerns about inaccuracy, and investment costs. Since smart meters report how much water, gas, and electricity is used by the building or household, as well as when it is used, there are concerns that this data will be sold, used for monitoring, intercepted through hacking, or turned over to law enforcement authorities.[135] Many of the privacy concerns can be eased with the understanding that misuse of the data is likely prohibited under several federal statutes[136] and could also be addressed with state legislation that dictates limits on the use and storage of smart meter data.[137]

Early in California's adoption of smart meters, there were issues with inaccurate, higher bills[138] and, more recently, with underreported usage leading to inaccurate, lower bills.[139] Overall, the number of customers affected by these issues has been low compared to the number of smart meters installed today. Nonetheless, concerns around recording inaccuracies remain a rallying point for opponents of the technology.

Smart meters are a substantial investment. But there are significant savings for utilities and advantages for custom-

126. The 70% net annual reduction is as compared to the 2006 Washington State Energy Code. This goal replaced one set in 2010 of "building zero fossil-fuel greenhouse gas emission homes and buildings by the year 2031." *See* Washington State Building Code Council, 2015 Washington State Energy Code: Progress Toward 2030 (2015), https://fortress.wa.gov/ga/apps/SBCC/File.ashx?cid=6095.

127. Wash. Rev. Code §19.27A.170 (2009), http://app.leg.wa.gov/RCW/default.aspx?cite=19.27A.160.

128. The city of Seattle requires a tightness of 0.3 cubic feet per minute (cfm) per square foot rather than 0.4 cfm in the state code. *See* Fact Sheet, Northwest Energy Efficiency Council, Air Barrier Management (July 2011), http://neec.net/sites/default/files/neec_codes_training/NREC-Air-Barrier-07-2011.pdf.

129. Seattle Department of Construction and Inspections, *Energy Code,* http://www.seattle.gov/DPD/codesrules/codes/energy/overview/ (last visited Nov. 1, 2017). *See also* Seattle, Wash., Energy Code, Commercial Provisions (2016), http://www.seattle.gov/dpd/cs/groups/pan/@pan/documents/web_informational/p2395485.pdf.

130. *See* Dave Eisenberg, *$2.6 Billion: Potential 2025 Global Revenue From Virtual Reality Use in the Housing Industry*, Urb. Land Inst., Nov. 7, 2016, https://americas.uli.org/research/centers-initiatives/center-for-capital-markets/number-of-the-week-4/.

131. New York, N.Y., Local Law No. 84 (2009), http://www.nyc.gov/html/planyc2030/downloads/pdf/ll84of2009_benchmarking.pdf.

132. Except New Jersey, New Mexico, and New York. State Policy Opportunity Tracker (SPOT) for Clean Energy, Policy Profile: Smart Meter Deployment, https://spotforcleanenergy.org/policy/smart-meter-deployment/ (last visited Dec. 21, 2017). Note that this analysis looked for a statewide policy that is supportive of smart meters generally, not just for or by certain utilities only.

133. EIA, *Frequently Asked Questions—How Many Smart Meters Are Installed in the United States, and Who Has Them?*, http://www.eia.gov/tools/faqs/faq.cfm?id=108&t=3 (last visited Nov. 1, 2017).

134. Policy Implications of Deep Decarbonization, *supra* note 14, at 1, 15.

135. *See* Brandon J. Murrill et al., Congressional Research Service, Smart Meter Data: Privacy and Cybersecurity 3-7 (2012), *available at* https://fas.org/sgp/crs/misc/R42338.pdf.

136. *Id*. (discussing the potential for application of the Electronic Communications Privacy Act, the Stored Communications Act, the Computer Fraud and Abuse Act, and the Federal Trade Commission Act to smart meter data collection, management, and use).

137. *See* Cassarah Brown, *States Get Smart: Regulating and Encouraging Smart Grid Technologies*, Nat'l Conf. St. Legislatures, July 2013:

> Several states are actively working to address and regulate the use of personal energy data provided by smart meters. Both Michigan and Vermont have pending bills (H.B 4728 and H.B 402, respectively) to require utilities to treat customer data confidentially to prevent unintended disclosure of personal information. Texas House Bill 1600 and Kansas House Bill 2128, both enacted, prohibit utilities from sharing or disclosing information collected from a smart metering system. California and Pennsylvania currently have similar bills pending and require customer consent before third party data disclosure.

See http://www.ncsl.org/research/energy/regulating-and-encouraging-smart-grid-technologies.aspx.

138. William Pentland, *Not-So-Smart Meters Overbilling Californians*, Forbes, May 3, 2011, http://www.forbes.com/sites/williampentland/2011/05/03/not-so-smart-meters-overbilling-californians/#7cae347669e8.

139. Alice Walton, *Faulty Readings May Have Led to Incorrect Bills, Says Southern California Gas Co*., L.A. Times, Aug. 9, 2016, http://www.latimes.com/local/lanow/la-me-ln-gas-company-meter-problems-20160809-snap-story.html.

ers with smart meters in their service areas. These include reducing the need to dispatch personnel out on as many calls and decreasing the length of outages by pinpointing affected customers and problems. Federal stimulus money under the 2009 American Recovery and Reinvestment Act's Smart Grid Investment Grant awards and matching industry funds to private companies, utilities, manufacturers, cities, and other partners resulted in a total investment of more than $8 billion for smart grid and smart meter technologies.[140]

VII. EU Approaches to Improve the Energy Performance of Buildings

The EU has long focused on reducing energy demand from new buildings, culminating in efforts around the Energy Performance of Buildings Directive (EPBD) in 2002 and its recast (or revision) in 2010. In coordination with the EPBD, both the Netherlands and Sweden have adopted ambitious energy-efficiency goals, material standards, and energy use disclosure requirements along with complementary regulatory regimes to implement these standards. The United States can learn from the initiatives that are the focus of this part.

The European Parliament and Council of the EU first adopted the EPBD in 2002. The directive established standards for buildings that all EU countries were required to incorporate into their national building regulations and introduced energy certification schemes for buildings.[141] The EU Commission launched the Concerted Action EPBD[142] in 2005 to promote dialogue on implementation of the EPBD, which led to 29 countries exchanging experiences and best practices.

In 2010, a revised version of the EPBD (EPBD recast)[143] was adopted by the European Parliament and Council of the EU. In it, the EU created an intermediate step between a traditional building and a ZEB, called a nearly zero-energy building, or NZEB. This is defined as "a building that has a very high energy performance. . . . The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby. . . ."[144] The EU directive provides factors for Member States to consider in defining what an NZEB is for each category of buildings, but does not specifically define what constitutes nearly zero.[145] The EPBD recast requires that "(a) by 31 December 2020, all buildings are nearly zero-energy buildings; and (b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings."[146] The directive instructs Member States to "draw up national plans for increasing the number of nearly zero-energy buildings . . . [that] may include targets differentiated according to the category of building."[147] Member States are also required to set minimum requirements for both the building envelope and technical systems according to a cost-optimal methodology.

Both the original 2002 EPBD and the 2010 EPBD recast established energy performance certificates (EPCs) as instruments to enhance energy performance in buildings by providing information to building owners, occupiers, and the real estate market to drive market demand for energy efficiency in buildings. The requirements for EPCs, certification, and registration vary by country in accordance with the baselines set in the EPBD and the EPBD recast.[148] EPCs can also be used to determine the impact of building and energy policies, and to document the energy performance of the building stock in a country and the entire EU.[149] The EPBD accounts for the cost of additional materials and technologies needed for NZEBs by suggesting cost-benefit analysis in terms of the economic life cycle[150] of a building to arrive at a cost-optimal level for a building.

A 2016 report tracking the EPBD's implementation progress concluded that "NZEB continues to be a major challenge and it is yet unclear how much progress will be reached by 2020. . . ."[151] There have been some successes as Member States have improved minimum energy-efficiency requirements for buildings, taking into account cost optimality for a long (30-year) life-cycle approach. There have also been some shortcomings, like the lack of demanding NZEB standards. About 40% of the Member States do not

140. Press Release, The White House, President Obama Announces $3.4 Billion Investment to Spur Transition to Smart Energy Grid (Oct. 27, 2009), https://obamawhitehouse.archives.gov/the-press-office/president-obama-announces-34-billion-investment-spur-transition-smart-energy-grid.
141. Council Directive 2002/91/EC.
142. The Concerted Action EPBD is a joint initiative between the EU Member States and the European Commission. It involves representatives of national ministries or their affiliated institutions who are in charge of preparing the technical, legal, and administrative framework for the EPBD (2002/91/EC) and the recast (2010/31/EC) in each EU Member State, plus Norway. The objective is to enhance the sharing of information and experiences from national adoption and implementation of this important European legislation. *See* Concerted Action EPBD, *Home Page*, http://www.epbd-ca.eu/ (last visited Nov. 1, 2017).
143. Council Directive 2010/31/EU.
144. *Id.* art. 2.
145. *Id.*
146. *Id.* art. 9. This includes all residential, commercial, and industrial privately owned buildings.
147. *Id.*
148. Buildings Performance Institute Europe, *Energy Performance Certificates Across the EU: Mapping of National Approaches*, http://bpie.eu/publication/energy-performance-certificates-across-the-eu/ (last visited Nov. 1, 2017).
149. Aleksandra Arcipowska et al., Buildings Performance Institute Europe, Energy Performance Certificates Across the EU: A Mapping of National Approaches (2014), *available at* http://bpie.eu/uploads/lib/document/attachment/81/BPIE_Energy_Performance_Certificates_EU_mapping_2014.pdf.
150. To be "determined by each Member State. It refers to the remaining estimated economic lifecycle of a building where energy performance requirements are set for the building as a whole, or to the estimated economic lifecycle of a building element where energy performance requirements are set for building elements." This definition is important because it affects what is "cost-optimal" under the directive because "[t]he cost-optimal level shall lie within the range of performance levels where the cost benefit analysis calculated over the estimated economic lifecycle is positive." *See* Council Directive 2010/31/EU, art. 3, §14(b).
151. The Concerted Action EPBD, 2016 Implementing the Energy Performance of Buildings Directive 1, 7-8 (2015), *available at* http://www.epbd-ca.eu/outcomes/2011-2015/CA3-BOOK-2016-A-web.pdf.

yet have a detailed NZEB definition in place. About 60% of the Member States have established detailed NZEB definitions in a legal document,[152] but a few of them state that the definition is a draft or that it might be updated later.[153] Countries have differed on how to set requirements for renewable energy supply for new buildings. Some countries have required that a percentage of primary energy use be from renewable sources (up to 50%), and others have set specific minimum renewable energy contributions in kilowatt hours per square meter per year (kWh/m^2/y).[154]

There is a notable, complementary initiative aimed at improving resource efficiency in the building sector in the EU. That initiative is part of the European Commission's Roadmap to a Resource Efficient Europe.[155] It sets out structural and technological changes needed to ensure the European economy is on a path of sustainable growth by 2050, with milestones to be reached by 2020 as it interfaces with the Europe 2020 strategy.[156] One component of the Roadmap focuses on "a decisive move towards a low carbon economy."[157] Under that Roadmap, the EU will use a life-cycle assessment approach to go beyond energy efficiency and primary energy consumption to track the environmental impact of preconstruction materials production and post-demolition disposal in accordance with circular economy objectives focused on resource efficiency, recycling, and waste management.[158] This initiative demonstrates one approach to addressing embodied energy.

A. *Implementation of the EPBD and Building Policies in the Netherlands*

The Netherlands has made significant progress in implementing both the original 2002 EPBD and the recast 2010 EPBD by integrating the policies and goals advanced in the directives with its existing programs.[159] The Netherlands Enterprise Agency (RVO) implements the national EPBD legislation, manages the certification schemes, administers training, accredits experts, performs compliance checks, and serves as a central register for all certificates.[160]

The Netherlands regulates the energy performance of new buildings, both residential and commercial, through its Energy Performance Coefficient program that predates and also complies with the EPBD's EPC. The Netherlands' energy performance coefficient reflects "the estimated total primary energy consumption of a building based on a series of indicators, e.g., heating, ventilation and lighting, adjusted to the useful floor area and the renewable energy produced by the building."[161] To calculate the energy performance coefficient, the building's allowed primary energy performance is divided by its calculated annual primary energy needs.

The calculation of the energy performance coefficient is mandatory for all new buildings and is performed by a certified professional. New buildings also have to meet minimum requirements for building components (insulation value (R-value) of walls, roof, and floor; and insulation value (U-value) of windows and doors).[162] Beyond those minimum requirements, no specific energy-efficiency measures must be installed.

The Netherlands defines an NZEB as meeting an energy performance coefficient of zero, meaning that the building's allowed primary energy performance and annual primary energy needs are both zero.[163] The Netherlands follows a flexible approach; builders and developers have the freedom to choose the most cost-efficient solutions as long as the building reaches the required level of efficiency. The hope is that this freedom will stimulate technical innovation in building design and combinations of technology.[164]

Before construction may begin, a builder must receive a building permit from the local municipality. As part of the application process for this permit, a project developer must demonstrate compliance with the energy performance requirements. Dutch regional environmental services perform monitoring and enforcement. However, local municipalities are responsible for compliance checks during construction. In case of noncompliance, they issue a "cease-work" order that halts construction until applicable requirements are met, but there are no separate financial penalties. The RVO annually audits a pool of permits to ensure they are in compliance with requirements, and reports cases of noncompliance to the local municipality for legal action.[165]

The Netherlands has adopted a law to address the problem of the split incentive, where energy-efficiency improvements are not made because the costs of installing energy-efficiency measures fall on the building's owner while the tenants experience the benefit of lower energy bills. This law ("Energieprestatievergoeding") allows an owner to collect an energy performance fee from tenants to

152. The relevant legal documents are found in building regulations, energy decrees and official guidelines, or the national NZEB plans. *Id.* at 1, 59.
153. *Id.*
154. *Id.*
155. European Commission, *Environment—The Roadmap to a Resource Efficient Europe*, http://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm (last updated June 8, 2016).
156. European Commission, *Europe 2020 in a Nutshell*, ec.europa.eu/eurostat/web/europe-2020-indicators (last visited Dec. 20, 2017).
157. European Commission, *supra* note 156.
158. *Id.*
159. Hans van Eck, Implementation of the EPBD in the Netherlands: Status in November 2015, at 1, 2 (2015), *available at* http://www.epbd-ca.eu/outcomes/2011-2015/CA3-2016-National-NETHERLANDS-web.pdf.
160. *Id.* at 1.
161. *Id.* at 1, 2-3 (the minimum energy performance coefficient is set according to the Energy Performance Standard that sets energy-efficiency requirements for new buildings).
162. R-value measures resistance to heat transfer, and U-value measures the rate of heat transfer. The lower its U-value, the better the product's ability to resist heat conduction. *See* van Eck, *supra* note 159, at 1, 3.
163. Factsheet, Buildings Performance Institute Europe, Nearly Zero-Energy Building Definitions Across Europe (Apr. 2015), http://bpie.eu/uploads/lib/document/attachment/128/BPIE_factsheet_nZEB_definitions_across_Europe.pdf.
164. van Eck, *supra* note 159, at 6.
165. *Id.* at 2.

recoup investment costs that lead to a reduced energy bill or, in the case of a ZEB, the lack of an energy bill.[166]

With regard to national goals for NZEBs, the Netherlands currently plans to make all new public buildings NZEBs after 2019 and all nonpublic buildings NZEBs after 2021.[167] The Netherlands' National Plan Toward Nearly Zero-Energy Buildings involves a wide range of national programs and activities on energy efficiency, renewable energy, innovation, information-sharing, smart metering, and smart grids.[168] A range of financial support and incentive mechanisms are in place for achievement of the plan, including incentives for sustainable energy production, better lending terms for loans to be spent on energy-saving measures, and subsidies for sustainable heating and energy performance.[169] The Netherlands has also adopted a plan to introduce smart meters to all homes and small businesses by 2020 in order to encourage customers to use energy as efficiently as possible and contribute to a future smart grid system.[170]

B. Implementation of the EPBD and Building Policies in Sweden

Sweden has also made remarkable progress incorporating the requirements of the EPBD into its national energy code. Sweden's energy performance regulations are based on "measured delivered energy, including energy performance requirements for heating, cooling, hot water and other general uses of the building . . . divided by the area intended to be heated to more than 10°C [50°F]."[171]

In 2009, Sweden set the goal of increasing energy efficiency in new and existing buildings undergoing renovation by 20% in 2020 and 50% in 2050 as part of its Integrated Climate and Energy Policy.[172] Measures addressing new building energy performance include the planning and building codes,[173] energy taxes, education programs, training courses, and mandatory and voluntary labeling schemes.[174] Sweden passed new climate legislation in June 2017 (effective January 2018) that drastically increases Sweden's emissions reduction goals.[175] Sweden's proposed goal for 2019 is for all public buildings (new and existing) to be zero-energy, and for 2021, all buildings are to be zero-energy.[176]

New buildings in Sweden must be designed to limit energy use through low heat losses, low cooling demands, efficient use of heating and cooling, and efficient use of electricity. Swedish regulations require that a building's primary energy use be in accordance with residential and nonresidential limits established per the climatic zone where it is located.[177] A building's energy performance is expressed using an indicator of primary energy in kWh/m^2/y. The limit ranges for NZEBs are 30-75 kWh/m^2/y for new residential buildings and 30-105 kWh/m^2/y for new nonresidential buildings, depending on the climate.[178] Buildings must also comply with a maximum electric power rating for heating and an average thermal transmission level for the building envelope.[179]

A compliance check occurs during the second year of the building's operation. Similar to the Netherlands, Sweden is focused on ensuring that the building's energy performance meets the limits set out in the building code. Sweden does not require individual parameters to be measured for their contribution to the building's energy usage; the building is only evaluated as a whole. Thus, the building's developer and/or owner is responsible for compliance with the standards, which are supervised by the municipality building board.[180]

In compliance with the EU EPBD, Sweden requires production of an EPC whenever a building is built, sold, or rented.[181] An EPC provides, at a minimum, the energy performance of a building and may include the percentage of energy consumed from renewable sources.[182] In addition, there are several voluntary labeling schemes on top of the EPC that involve established standards for three categories of houses in Sweden: NZEB, "Passivhaus" (passive house), and "Minienergihus" (low-energy house) for

166. van Eck, *supra* note 159, at 1, 5; *see also* SBRCURnet, *Energiesprong 02: Wetgeving Energieprestatievergoeding [Energy Leap 02: Energy Performance Fee Legislation]* (providing the circumstances under which such a fee can be collected, the standards for relevant calculations, and limits to the fee), http://www.sbrcurnet.nl/producten/infobladen/wetgeving-energieprestatievergoeding (last visited Nov. 1, 2017).
167. van Eck, *supra* note 159, at 1, 5. *See also* Buildings Performance Institute Europe, *supra* note 163.
168. *See* Hans van Eck, National Plan Towards Nearly Zero-Energy Buildings in the Netherlands, Webinar (Nov. 13, 2013), https://cleanenergysolutions.org/sites/default/files/documents/Presentatie-Webinar-14-November_Hans-Van-Eck.pdf.
169. *Id.*
170. van Eck, *supra* note 159, at 1, 6.
171. Hans-Olof Karlsson Hjorth et al., Implementation of the EPBD in Sweden: Status in December 2014, at 1 (2014), http://www.epbd-ca.eu/outcomes/2011-2015/CA3-2016-National-SWEDEN-web.pdf.
172. Government Offices of Sweden, *An Integrated Climate and Energy Policy*, http://www.government.se/information-material/2009/03/an-integrated-climate-and-energy-policy/ (last updated May 17, 2015); *see also* Global Buildings Performance Network, *Sweden*, http://www.gbpn.org/databases-tools/rp-detail-pages/sweden (last visited Nov. 1, 2017).
173. Swedish Code of Statutes, *Plan-och Byggförordning (2011:338) [Planning and Building Regulation (2011: 338)]*, http://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/plan--och-byggforordning-2011338_sfs-2011-338 (last visited Nov. 1, 2017).
174. Global Buildings Performance Network, *supra* note 172.
175. Government Offices of Sweden, *The Climate Policy Framework*, http://www.government.se/articles/2017/06/the-climate-policy-framework/ (last updated June 15, 2017); *see also* Åsa Romson, Report to Centre International de Droit Comparé de l'Environnement, Sweden's New Climate Policy Framework: Sets the World's Most Ambitious Climate Goals and Puts Climate Policies in National Law (2017), https://cidce.org/wp-content/uploads/2017/01/report-CIDCE-climate-policy-framwork-1.pdf.
176. Global Buildings Performance Network, *supra* note 172.
177. Hjorth et al., *supra* note 171, at 1.
178. Delia D'Agostino et al., European Commission, Synthesis Report on the National Plans for Nearly Zero Energy Buildings (NZEBs): Progress of Member States Towards NZEBs (2016) (EUR 27804 EN), *available at* http://publications.jrc.ec.europa.eu/repository/bitstream/JRC97408/reqno_jrc97408_online%20nzeb%20report%281%29.pdf.
179. Hjorth et al., *supra* note 171, at 1.
180. *Id.* at 1, 3.
181. An EPC is also required for large buildings occupied by public authorities or institutions that supply public services.
182. Council Directive 2010/31/EU, arts. 11-18, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF.

heating depending on the climatic zone where the house is located.

VIII. Recommendations

To achieve the DDPP goals to maximize energy efficiency to create highly efficient new buildings, to facilitate the construction of ZEBs or NZEBs that rely heavily on carbon-free electricity, and to take into account embodied energy in the new building construction process, several steps should be taken by the federal, state, and local governments, and by the private sector.

A. Federal Government

One of the most effective ways to drive decarbonization of new building would be to place a national price on carbon that applies to both building energy use and embodied carbon in building materials. Such a pricing mechanism could significantly accelerate the adoption of low- and zero-carbon energy sources, thus allowing further electrification of new buildings for heating, cooking, and water heating. It should also encourage designers, architects, builders, building managers, and building owners to find innovative ways to reduce carbon. The prospects of federal legislation that would price carbon, however, are not good as this Article goes to press, given the current makeup of Congress and the views of the president. Still, the idea of pricing carbon should remain on the table, awaiting a sympathetic environment in Congress and the executive branch.

Current laws, Executive Orders, and initiatives by federal agencies have made significant progress in reducing the carbon impact of new buildings. Preserving these laws, orders, and initiatives is critical for a variety of reasons beyond carbon reduction, including national security, cost and resource efficiency, productivity, and worker health. Specifically:

1. Congress should preserve the tax incentives for investing in renewable energy sources to maintain progress toward decarbonization of the grid, thereby allowing progress in electrification of new buildings.
2. GSA and federal agencies should fully implement the requirement in EISA that federal buildings reduce fossil fuel use measured against a 2003 benchmark by 100% by 2030, and meet the goal that all new commercial buildings achieve zero net energy by 2030. These are ambitious goals that support the new building decarbonization effort.
3. The president should retain within the GSA the Office of Federal High-Performance Green Buildings that was mandated by EISA and that is the focal point for federal building energy-efficiency efforts through such mechanisms as the Sustainable Facilities Tool.[183]
4. The president should preserve the energy-efficiency and renewable energy requirements of Executive Order No. 13693.
5. GSA should retain its 2016 Facilities Standards that require all new federal buildings to attain LEED Gold (Version 4) certification, as a minimum.
6. Federal agencies should continue implementing the "Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings" adopted pursuant to Executive Order No. 13423, which requires advanced energy monitoring that provides at least daily data on energy use.
7. DOD should complete the guidance document called for under Executive Order No. 13693 that requires it to incorporate net zero into planning for new facilities larger than 5,000 square feet.
8. DOE should continue setting leading-edge energy-efficiency standards for heating, cooling, lighting, and other energy-consuming equipment used in new buildings.
9. EPA and DOE should continue providing guidance to consumers by maintaining updated versions of programs such as Energy Star for appliances and electrical equipment, and Energy Star for buildings.
10. Based on the authority provided to DOE under EISA and DOE's previous work on ZEBs, the agency should encourage the use of the most efficient sources and location of renewable energy rather than emphasizing only on-site generation.
11. DOE should fund research of innovative ways for buildings to capture as much wind and sunlight as possible within the confines of urban environments to generate decarbonized electricity.[184]
12. DOE should encourage through its work on ZEBs direct investment in the means of production of

183. *See* Sustainable Facilities Tool, *Home Page*, https://sftool.gov (last visited Nov. 1, 2017) (The Sustainable Facilities Tool "is an interactive online resource created by the Office of Federal High-Performance Green Buildings that shows users how to build, buy and operate green. SFTool assists project managers, procurement professionals, facility managers and others to identify, understand and integrate sustainable strategies into their projects.").

184. A similar hierarchy was created by the National Renewable Energy Laboratory—the "NZEB RE Supply Option Hierarchy"—and for off-site supply options, they prioritized using renewable energy resources off-site to generate energy on-site above buying generation from off-site renewable energy sources. The system requires all off-site purchases to be certified, and suggested:

> A building could also negotiate with its power provider to install dedicated wind turbines or PV panels at a site with good solar or wind resource off site. In this approach, the building might own the hardware and receive credits for the power. The power company or a contractor would maintain the hardware.

See Pless & Torcellini, *supra* note 47, at 4.

renewables or power purchase agreements as preferable to purchase of RECs.[185]

The previous set of recommendations addresses implementation of existing law and policy. However, the federal government should take additional steps beyond existing law and policy to help achieve DDPP goals:

1. In the absence of a national energy code[186] that would result in the construction of ZEBs or NZEBs, Congress should establish a national ZEBs or NZEBs goal for a specific date such as 2030, much as the EU, the Netherlands, and Sweden have done. Such a national goal would help focus on the need to address carbon emissions from new buildings. It could also stimulate state and local regulatory efforts and lend support to voluntary programs such as the AIA 2030 Challenge and newer versions of LEED.
2. Congress should provide tax incentives to encourage wider adoption of zero-emissions energy and passive buildings.
3. Congress should provide grants to community colleges and other organizations for training of building professionals to facilitate the design, construction, and management of high-efficiency, ZEB, LEED, and passive buildings.
4. Congress should, as the EU has done for buildings in Europe, require federal agencies to use a life-cycle assessment to track the environmental carbon impact of construction materials in accordance with circular economy objectives focused on resource efficiency, recycling, and waste management.[187]
5. DOE should produce a model ZEB-focused energy code. Such a model code could also address issues related to embodied energy. Additionally, a model code could deal with large-scale fuel switching by addressing issues such as the use of heat pumps and solar water heating. Such a model code could provide support for a national ZEBs goal discussed in the previous recommendation.

B. State Governments

States can have a significant impact on reaching the DDPP goals in several ways, including updating their building codes, providing incentives for energy-efficient buildings, and providing policy support for the installation of renewable energy facilities for new buildings.

1. State legislatures should adopt a price for carbon either through a carbon tax or through cap-and-trade systems that include new buildings. This step would encourage developers of new buildings to minimize carbon emissions to avoid the costs associated with buying allowances or paying the tax. For example, Tokyo's cap-and-trade system applies to1,300 commercial and industrial facilities with the goal of reducing carbon dioxide emissions by 25% by 2020 from a 2005 baseline.[188]
2. State legislatures should follow the lead of states like California, Hawaii, and Washington in developing advanced building and energy codes that significantly reduce the energy used by new buildings.
3. State legislatures should adopt building or electrical code standards that support the use of on-site energy storage to allow more-efficient usage of renewable energy generated on-site at new buildings.
4. If a state's utility regulation does not allow power purchase agreements for supplying new buildings with renewable energy, state legislatures should amend the utility regulation to authorize such purchases to facilitate movement to low-carbon electrification for heating and hot water as part of the net-zero building process.
5. State legislatures should require that a minimum percentage of energy for large new buildings be derived from renewable energy, either generated on-site, obtained through a power purchase agreement, or evidenced by certified RECs, unless the building meets stringent low-energy usage criteria such as that for certified passive buildings.[189]
6. State legislatures should require new buildings to obtain a construction permit or obtain a certificate of occupancy before construction can begin, and, as a condition of obtaining the permit or certificate, require them to meet an "energy-efficiency coefficient," as mandated in the Netherlands.

185. By encouraging building operators to make a capital investment in the means of renewable energy generation, this takes the burden off the power provider to bear those up-front capital costs. PPAs also provide some certainty for power providers as they invest in renewable means of generation; they know they have a customer who will purchase, and perhaps pay a premium for, the power they will generate over the term of the agreement.
186. States have historically resisted a national building or energy code. Section 324 of the American Clean Energy and Security Act of 2009, H.R. 2454, would have established a National Energy Efficiency Building Code. Although the legislation passed the House, it never proceeded further.
187. European Commission, *supra* note 155. The approach that GSA currently uses to comply with EPAct 2005 requires a life-cycle cost analysis that could be expanded into a life-cycle impact analysis that goes beyond cost alone to consider embodied carbon. Federal legislation would be necessary to direct GSA to broaden its analysis and include embodied energy, but this would be a crucial step in raising awareness and lowering levels of embodied carbon in new federal buildings. *See* GSA, *supra* note 73.
188. *See* Yuko Nishida et al., *Alternative Building Emission-Reduction Measure: Outcomes From the Tokyo Cap-and-Trade Program*, 44 Building Res. & Info. J. 5-6 (2016), *available at* http://www.tandfonline.com/doi/abs/10.1080/09613218.2016.1169475?journalCode=rbri20.
189. The Passive House Institute has a passive house certification program. *See* Passive House Institute, *Accredited Building Certifiers*, http://www.passiv.de/en/03_certification/02_certification_buildings/03_certifiers/01_accredited/01_accredited.php?sort=organsiation (last visited Nov. 1, 2017).

7. State legislatures should allow owners of net-zero buildings to charge an energy-efficiency fee that reflects the prorated additional building cost of achieving net-zero status for the building, similar to the Dutch Energieprestatievergoeding system.[190]

8. State legislatures should maintain or adopt laws such as renewable portfolio standards, net metering, cost of solar tariffs, and renewable energy tax credits that encourage more rapid integration of renewable energy into the grid, thereby facilitating the goal of low-carbon electrification of new buildings.

9. States should revise building and energy codes to provide developers of a new building with a significant head start on LEED certification by specifying energy performance requirements that will lead to LEED points.

10. State legislatures or governors should establish state ZEB goals, such as California's goals under the California Building Standards Code that all new residential buildings be zero-energy by 2020 and all new commercial buildings be zero-energy by 2030.[191]

11. State education agencies should provide training opportunities to builders, architects, developers, and others through community colleges, universities, vocational technical schools, and other educational institutions on high-efficiency and ZEB construction practices, as well as passive solar techniques, to significantly expand the capacity of the building industry to design and build low-energy demand buildings, as has been done in Sweden.

12. State PUCs should authorize utilities to install smart meters. Data from smart meters can play a number of roles in meeting the DDPP goals, including stimulating customers to better monitor and reduce use of energy, allowing energy use to be moved to off-peak times, facilitating on-site generation, and monitoring the effectiveness of efficiency measures.

13. State energy, commerce, or other appropriate agencies should provide information on methods of minimizing the cost of ZEBs, as has been recommended by the National Renewable Energy Laboratory to help stimulate the market for ZEBs.[192]

14. State energy, commerce, or other appropriate agencies should promote voluntary programs, such as LEED for Homes and Energy Star for homes,[193] that recognize buildings for meeting energy-efficiency goals.

190. SBRCURnet, *supra* note 166.
191. California PUC, *Energy Efficiency Strategic Plan*, http://www.cpuc.ca.gov/General.aspx?id=4125 (last visited Nov. 1, 2017).
192. *See* Torcellini et al., *supra* note 58, at 32.
193. *See* ENERGY STAR, *supra* note 39.

C. Local Governments

Local governments typically have substantial authority in dealing with buildings within their boundaries through building codes and energy use disclosure requirements.

1. Within the authority granted to them under state law and state building code requirements, local legislative bodies should adopt advanced building and energy codes that drive down carbon use in buildings, such as Seattle's Energy Code.[194]

2. Local legislative bodies should require energy use disclosures for larger commercial buildings (e.g., buildings larger than 50,000 square feet and multifamily buildings). They should require benchmarking information to be made publicly available in a format that is easy to understand so that it can be readily used in rental and purchase decisions.[195] Benchmarking requirements would encourage developers of new buildings to more carefully consider energy usage in the design process in order for their buildings to stand out in the benchmarking reports.

3. Local legislative bodies should mandate that new commercial buildings over a specified size achieve the equivalent of at least the latest version of LEED Gold certification.[196] Cities such as Portland under its Green Building Policy,[197] New York pursuant to Local Law 86 (which applies to new buildings that have city financial support),[198] and Washington, D.C., under its Green Buildings Act (which applies to city-owned, -funded, or -financed buildings)[199] require LEED Gold certification as a minimum.

4. Local legislative bodies should switch when feasible to district heating and cooling.

194. Wash. Rev. Code §19.27A.020, http://app.leg.wa.gov/rcw/default.aspx?cite=19.27A.020. In Washington, except for requiring new buildings to meet a certain level of energy efficiency, "the Washington state energy code for residential structures shall preempt the residential energy code of each city, town, and county in the state of Washington."
195. New York City makes the information about water and energy usage gathered under Local Law 84 available online, but the energy information is presented as a score of Weather Normalized Source Energy Use Intensity (kilo-British thermal unit/square feet (kBTU/ft^2)), which is not straightforward for a layperson to understand. NYC Energy and Water Benchmarking, *New York City Energy & Water Performance Map*, https://serv.cusp.nyu.edu/projects/evt/ (last visited Nov. 1, 2017).
196. Acknowledging that it could be considered an impermissible delegation of government power to incorporate LEED standards by reference into a local ordinance or regulation and, thus, provide that the LEED system become law, local governments should still rely on LEED certification to set standards for new buildings. In order to avoid the issue of improper delegation of setting building standards, local governments should undertake regular review of changes to the LEED certification system and adopt revisions on a case-by-case basis rather than providing that the most current version of LEED should be used at all times, even as it changes.
197. *See* DOE, *City of Portland—Green Building Policy and LEED Certification*, https://energy.gov/savings/city-portland-green-building-policy-and-leed-certification (last visited Nov. 1, 2017).
198. *Id.*
199. *Id.*

5. Local legislative bodies should decarbonize their own utility systems, where they own or operate such systems. Palo Alto's gas and electric utilities have been 100% carbon-neutral for electricity since 2013 through the use of renewables and offsets, and carbon-neutral for natural gas since July 2017 through the use of efficiency measures, offsets, and encouragement of switching to electric appliances.[200]

6. Local legislative bodies should adopt a citywide carbon budget that includes the carbon impact for new buildings. The carbon budget adopted by the city of Oslo, Norway, aims for a carbon emissions reduction of 50% by 2020 and carbon neutrality by 2030. Such a budget may require new buildings to acquire offsets so as to not exceed the carbon budget ceiling. The Oslo carbon budget anticipates phasing out the use of fossil fuel for home heating.[201] City carbon budgets could also take into account embodied energy to encourage materials substitution in circumstances where substitution is appropriate.

7. Finally, local legislative bodies should consider or expand the use of district heating systems. These systems can play an important role in reducing carbon emissions. Connecting new buildings to district heating systems can significantly reduce energy demand from new buildings compared to scattered site heating systems that typically have relied upon fossil fuel for heating and single building cooling systems. District energy heating and cooling is a long-standing strategy for energy efficiency in some cities like St. Paul, Minnesota, and is a growing strategy for other cities in reducing carbon emissions. The city of Vancouver, British Columbia, is employing district energy as a key strategy for reducing carbon emissions by 33% by 2020 from a 2007 baseline.[202] Paris is converting its existing district energy system and expanding the system to achieve both heating and cooling energy efficiencies by utilizing 60% renewable or recovered energy sources for 2020.[203] District cooling in Paris results in one-half of the carbon dioxide emissions that would occur with traditional cooling.[204]

D. Private Initiatives

The private sector has increasingly assumed a more active role in pursuing environmental goals that are not required by law—an approach that has been referred to as "private environmental governance." Companies are pursuing environmental goals for a wide range of reasons, including building and protecting their reputation, saving money, responding to individual customer demands and to business customers who have initiated green supply chain programs, taking advantage of government green procurement requirements, and mitigating liability.

The commercial buildings market provides a good example of this situation. Green buildings, including LEED properties, represented around 33% of all commercial and institutional construction in America in 2015 and are expected to make up 60% of new construction in 2018.[205] A more limited 2017 study focusing only on 30 markets within the United States found that 38% of commercial office space has been certified by LEED or Energy Star.[206] Much of this demand for green buildings is coming from customer desires and better building performance rather than from government mandates.

1. Consistent with the AIA's 2030 Challenge, building developers and purchasers should commit to building only ZEBs by no later than 2030.[207]

2. Building developers and owners should construct new buildings that meet the Silver, Gold, and Platinum levels of LEED certification and that focus on earning many of the LEED points through energy strategies.

3. Building owners should take full life-cycle costs and the carbon impacts of materials into account when deciding on the energy-efficiency measures for new buildings, with the aim of reducing embodied carbon and overall environmental impacts.

4. Building owners should specify that energy for large new buildings must be derived from renewable energy sources through on-site generation, the use of power purchase agreements for off-site renewable energy, or the purchase of certified RECs.

5. Trade associations and other organizations involved in training building professionals should increase

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200. *See* City of Palo Alto, *Home Page*, http://www.cityofpaloalto.org/gov/depts/utl/default.asp (last visited Nov. 1, 2017).
201. *See* Oslo, Norway, *Climate Budget*, https://www.oslo.kommune.no/getfile.php/13166287/Content/English/Politics%20and%20administration/Green%20Oslo/Best%20practices/Climate%20Budget/climate%20budget.jpg (last visited Nov. 1, 2017). The Oslo carbon budget also anticipates raising tolls, reducing parking availability, increasing bicycling, and utilizing carbon capture and storage for the city's waste incinerators, among other measures to reduce carbon emissions.
202. *See Case Study: Reducing Carbon Emissions Through District Energy*, C40 Cities, Dec. 11, 2013, http://www.c40.org/case_studies/reducing-carbon-emissions-through-district-energy.
203. *See* Global Alliance for Buildings and Construction, Putting the Buildings and Construction Sector on a Below *2°C* Path, http://newsroom.unfccc.int/media/544101/building-alliance-common-statement.pdf.
204. *Id.* at 9.
205. Dodge Data & Analytics, SmartMarket Report—World Green Building Trends 2016: Developing Markets Accelerate Global Green Growth 35 (2016), http://fidic.org/sites/default/files/World%20Green%20Building%20Trends%202016%20SmartMarket%20Report%20FINAL.pdf.
206. Jennifer Gunby, *2017 National Green Building Adoption Index Releases Data on Growth*, U.S. Green Building Council, July 20, 2017 (This statistic does not include homes or government and institutional buildings, so the overall number is higher.), https://www.usgbc.org/articles/2017-national-green-building-adoption-index-releases-data-growth.
207. Specifically, new buildings should be fully electric and use only renewable energy, whether generated on-site or off-site.

training opportunities for architects, developers, and builders on passive buildings and ZEBs.

6. In its next update, the U.S. Green Building Council could revise the LEED certification system to better align with deep decarbonization goals. For example, the next version could more heavily prioritize and weight energy-related credits so that LEED buildings more uniformly increase electrification, reduce reliance on natural gas, become extremely energy efficient, purchase renewable energy or renewable energy credits, and install generating capacity on-site.

IX. Conclusion

Although some of the recommendations proposed here may seem complex and politically challenging to implement, the bottom line is that the overall goal for new buildings—maintaining the same level of final energy use in commercial and residential buildings, despite a projected increase by 2050 of 40% in commercial floor space and 36% in population—is attainable.[208] Decarbonization in the new building sector will demand high levels of cooperation among federal, state, and local authorities, as well as architects and the construction industry. Consumer demand in the form of decisions by individuals, companies, and developers will be a driving force in this sector, as it has been in other areas that have progressively become "greener" and more mindful of sustainability. Despite some of the difficulties ahead, there is good reason for optimism as new buildings incorporate cost-effective energy performance measures, moving our building stock toward a zero-energy and decarbonized future.

208. Technical Report, *supra* note 15, at 1, 25-26.