A Report from
American Society of Heating, Refrigerating and Air-Conditioning Engineers

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ASHRAE Vision 2020

Providing tools by 2020 that enable the building community to produce market-viable NZEBs by 2030.

Producing Net Zero Energy Buildings

Prepared by ASHRAE Vision 2020 Ad Hoc Committee

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Producing Net Zero Energy Buildings

On December 1, 2007, ASHRAE President Terry Townsend, P.E., drew from the building design, research, owning, and supplier communities to appoint an ad hoc committee with the following charge:

Develop guidance and strategy for the development of energy-related products, the conducting of research in renewable energy systems, and the sequencing of the various identified activities that will produce net zero energy usage for all types of facilities by 2020.

The membership of the committee was as follows:

Ronald E. Jarnagin, Committee Chair, Pacific Northwest National Laboratory

Thomas E. Watson, P.E., Committee Vice-Chair, McQuay International

Lee W. Burgett, P.E., Trane

Dale E. Carter, Dec Design Mechanical Consultants Ltd

Dr. Donald G. Colliver, P.E., University of Kentucky

Hugh D. McMillan, III, P.E., ccrd partners

Mark S. Menzer, Air Conditioning, Heating and Refrigeration Institute

John Montgomery, Public Building Commission of Chicago

Victor Olgyay, A.I.A., Rocky Mountain Institute

Dr. Andrew K. Persily, National Institute of Standards and Technology

Thomas H. Phoenix, P.E., Moser Mayer Phoenix Associates PA

Dr. Paul A. Torcellini, National Renewable Energy Laboratory

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Introduction

To create and recreate the world's building stock in a manner that sustains the well being of humanity requires planning, concerted effort, and bold action. Formed from our imagination, a single vision must be shared by all who design, build, and operate the structures that house life on our planet and that foster the productivity that defines our civilizations.

This report describes the vision held by members of the American Society of Heating, Refrigerating and Air-Conditioning Engineers. This vision is of a future when buildings will produce as much energy as they use. These are net zero energy buildings (NZEBs). We believe such buildings can be market-viable by the year 2030.

Our vision can be realized only if ASHRAE, working within the framework of the building community, provides to its members by 2020 the tools necessary to design, construct, and operate NZEBs. To achieve this critical milestone, now is the time to plan strategically and to act decisively.

NZEB Technology

Buildings consume 40% of the primary energy and 71% of the electrical energy in the US. Driven by economic expansion and population growth that require more and more facility space each year, energy use in the US commercial sector is expected to grow by 1.6% per year. This is resulting in an energy impact that is increasing faster than all of the energy conservation measures being taken and retrofits being made to buildings.

ASHRAE's vision, as articulated in this report, is that the building community will produce market- viable net zero energy buildings (NZEBs) by the year 2030.

The concept of NZEBs includes only the energy flows of the building, not the overall sustainability of the building. It is a critical step toward achieving the objectives of building sustainability as articulated in *ASHRAE's Sustainability Roadmap*. The quality of the indoor environment must not be sacrificed in the pursuit of NZEBs. And while new buildings are the focus of ASHRAE's NZEB vision, existing buildings must be addressed as NZEB strategies are implemented.

Defining NZEBs

What qualifies a building as a NZEB can be determined using different metrics.

A **net zero site energy building** produces as much energy as it uses when measured at the site. Applying this definition is useful because verification can be achieved through on-site metering. This tends to encourage energy-efficient designs; however, it does not distinguish between fuel types or account for inefficiencies in the utility grid.

A **net zero source energy building** produces as much energy as it uses compared to the energy content at the energy source on an annual basis. The system boundary is drawn around the building, the transmission system, the power plant, and the energy consumed in getting the fuel source to the power plant. This tends to be a better representation of the total energy impact compared to a site definition. It is challenged, however, by difficulties in acquiring site-to-source conversions and by the limitations of these conversions.

Building owners are typically most interested in **net zero energy cost buildings** because they tend to use energy efficiency and renewable energy as part of their business plan. This definition, like the site NZEB definition, is easy to verify with utility bills. Market forces provide a good balance between fuel types based on fuel availability. Costs also tend to include the impact of the infrastructure. Getting to zero, however, may be difficult or even impossible because of utility rate structures. Many rate structures will give credit for energy returned to the grid but will not allow this number to go below zero on an annual basis. As a result, there is no way to recover costs incurred by fixed and demand charges.

The fourth definition, a **net zero energy emissions building**, looks at the emissions that were produced by the energy needs of the building. This is probably a better model for "green" energy sources; however, like the source NZEB definition, it can be difficult to calculate.

A Single Definition for NZEB

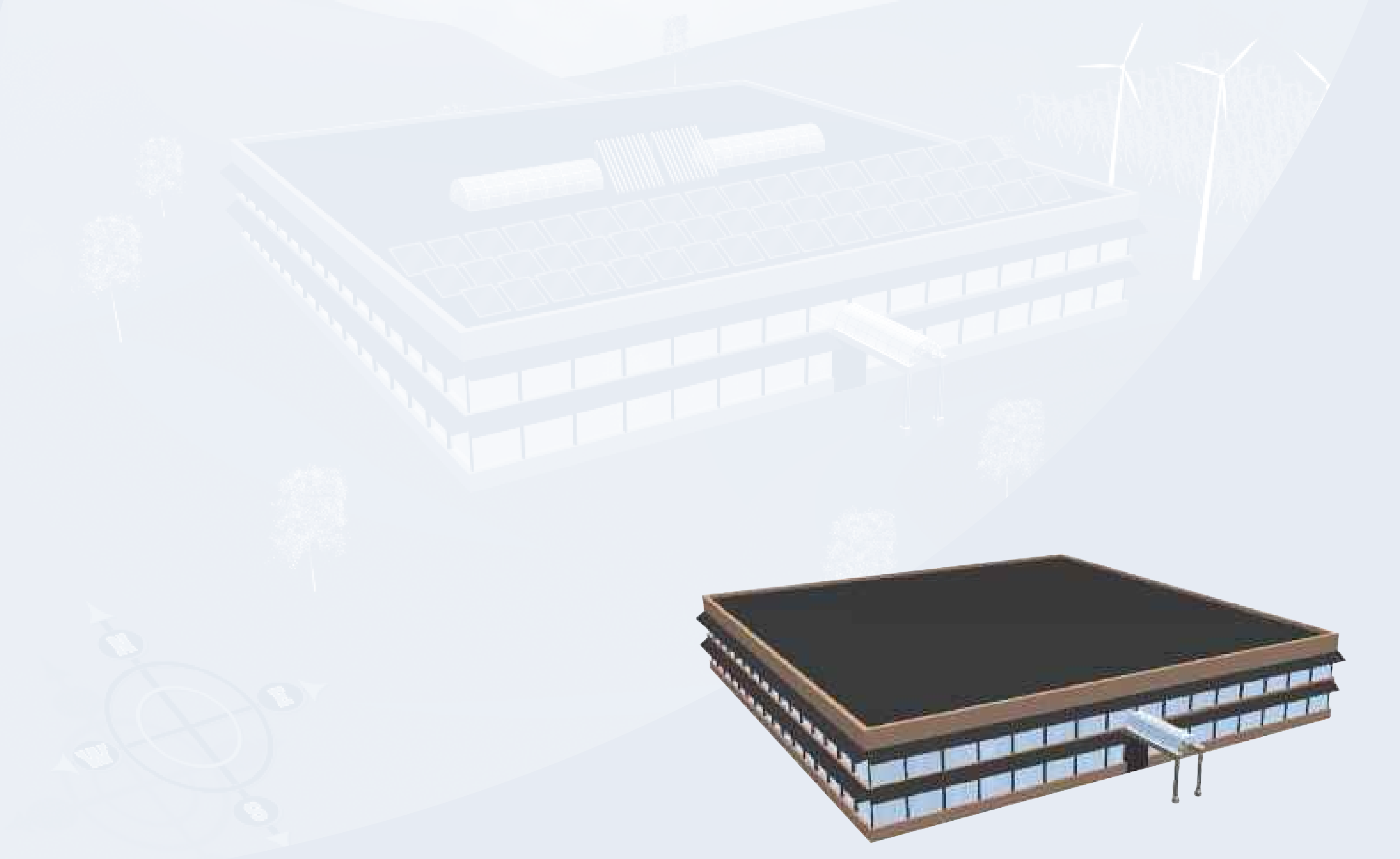
Based on today's building stock, each metric represents a positive direction toward achieving buildings that lessen their environmental impact and conserve nonrenewable resources.

There is still a need to create a single definition, however. Without this, there is a vacuum that leaves questions as to whether a building can be universally considered a NZEB.

Ultimately, the only way to measure if a building is a NZEB is to look at the energy crossing the boundary. Other definitions, including source, emissions, and cost, are based on this measured information and include weighing factors and algorithms to get to the metric of interest.

Because of the complications involved in making these computations, **site energy measurements** have been chosen through an agreement of understanding between ASHRAE, the American Institute of Architects (AIA), the U.S. Green Building Council (USGBC), and the Illuminating Engineering Society of North America (IESNA).

In this report, a NZEB is a building that produces as much energy as it uses when measured at the site. On an annual basis, it produces or consumes as much energy from renewable sources as it uses while maintaining an acceptable level of service and functionality. NZEBs can exchange energy with the power grid as long as the net energy balance is zero on an annual basis.



Strategies and Actions for Vision 2020

ASHRAE Vision 2020
Producing Net Zero Energy Buildings

ASHRAE defines a NZEB as a building that produces as much energy as it uses when measured at the site.

Based on this definition, ASHRAE will drive NZEB technology by implementing strategies to provide the needed tools to its membership by 2020. ASHRAE will:

1. Develop new tools through research.
2. Facilitate use of new technologies through publishing and education.
3. Use public relations and marketing to energize the ASHRAE membership and to communicate NZEB technology and benefits to the global community of designers, builders, owners, and regulators.
4. Continually revise ASHRAE energy-related resources so that old and new products are complimentary.

Clearly defined actions will implement these strategies.

1. ASHRAE will develop a rating system and branding for buildings, considering design and operations.
2. ASHRAE's rating system and rating will apply to both new and existing buildings.
3. The schedule will be followed that was approved by the ASHRAE Board of Directors in approaching NZEBs.
4. Memorandums of Understanding will be drawn among AIA, IESNA, USGBC, and ASHRAE on NZEBs, with support from EPA and DOE.
5. ASHRAE's Associate Societies Alliance will examine the impact of NZEBs in light of the global sustain ability movement and ASHRAE's global strategies.
6. ASHRAE will identify key players within the larger context of the building environment community— such as computer equipment manufacturers— and will engage them in solutions to reduce standby loss and parasitic power use (plug loads and power transformers).
7. ASHRAE will host a leadership roundtable of owner/manager groups (such as BOMA, IFMA, HEC, ICS, CORENET, Heinz, Intl. Asset Management Council, REIT, and international organizations) to explore integrated design possibilities to reach NZEBs.
8. ASHRAE will swiftly address the highest priority research items working through the Society's Research Advisory Panel and the USGBC Research Committee.
9. The *ASHRAE Handbook* series will be revised and ASHRAE Learning Institute programs will be expanded to include content on how to achieve NZEBs.
10. ASHRAE standards and special publications will be reviewed to identify those with impact on energy.
11. Unregulated loads will be added to Standard 90.1, perhaps establishing a recommended level of W/ft2.
12. Target energy budgets by climate zones and building types in Standard 90.1 will be created.
13. Because the *Advanced Energy Design Guides* (AEDGs) provide the "above code guidance" essential for NZEBs, ASHRAE will develop alternative packages for reaching 30% energy savings in existing AEDGs guides by 2008, and ASHRAE will produce NZEB guides in place of the 70% savings guides planned for 2015.
14. ASHRAE will add emphasis to user-friendly energy modeling tools and interfaces included in *ASHRAE's Research Strategic Plan*.
15. E-Learning modules will be developed to include NZEB content.
16. A Certified Sustainability Design Expert program will be launched, including content on NZEBs.

Implications of NZEB Technology

ASHRAE Vision 2020
Producing Net Zero Energy Buildings

While most of the responsibility of achieving NZEBs will fall on the shoulders of designers, there are considerable and important challenges for all sectors of the building community.

The Industry

If NZEBs are to become reality, manufacturers and designers must be better able to integrate systems into buildings that may be significantly different from most buildings constructed today. Designers will need the tools to design and apply better integrated equipment, manufacturers will need to produce ultra-high efficiency equipment and know how to best apply it to buildings, and both will have to be able to better monitor occupants' needs and provide comfortable conditions, taking advantage of everything that nature has to offer, including human ingenuity.

Integrated Systems
Equipment will have to be fully integrated so that waste energy and other "free" energy sources are used to their maximum possible extent. This is very different from the current practice, where discrete equipment performs independent, discrete tasks. Natural and mechanical ventilation will have to be optimally integrated where appropriate.

Higher Efficiency Equipment and Systems
With integrated systems, there will be a need for ultra-high-efficiency equipment and systems, for variable speed systems that minimize energy use throughout the seasons, and for varying cooling loads imposed by the building's users and the outdoor ambient. Manufacturers will have to make available smaller capacity equipment with better part-load profiles. Better dehumidification and moisture control also will be required to enable cooling to be separated from dehumidification. This could allow the saturated evaporator temperatures to be higher and, thus, have a higher COP. Equipment design rating points and designs may need to change.

Fundamentally, manufacturers will need to understand the potential market for NZEBs so they can design systems to meet that market. Planning decisions need to be made many years in advance of commercialization.

Design Tools
Architects, engineers and manufacturing companies will need refined tools for properly sizing and selecting HVAC equipment in NZEBs. Also needed are tools to better integrate building form and fabric as part of the heating, cooling, and lighting system—as well as balancing the remaining load with the HVAC and electric lighting systems—to satisfy the occupants' needs.

Tools will be needed to improve design of daylighting and hybrid ventilation, integrating low-energy solutions with traditional and next-generation equipment. Also, tools will be needed for comparing applications of different types of equipment and system arrangements to allow engineers and owners to select the most energy-effective approach for a given building.

Clear explanations of the advantages of various types of systems for particular building applications are needed to help designers and owners make educated choices.

Building simulation tools need to be refined for easier and less costly use, permitting low budget projects to take advantage of their capability. In addition, common building types should be "pre-simulated" such that common solutions can be readily accepted by industry.

Enhanced Building Automation Systems and Controls
Sensors are needed that are inexpensive and reliable for wide distribution in buildings to achieve better comfort control with less energy use. It is desirable to have these sensors perform multiple functions, such as sensing temperature, humidity and carbon dioxide concentration. Currently, the cost of installing sensors and programming them is a barrier to wide-scale adoption. Advanced sensor technology should be more interoperable, and technologies, such as wireless, may help in reducing the cost.

Better sensors are needed to detect when natural ventilation is the preferable option and when daylighting is available. Accurate occupancy sensors would all benefit energy impacts of buildings. Smart systems are needed that do not condition spaces that are not occupied, can sense/predict when a space will be occupied, and can avoid condensation during unoccupied periods.

Energy can be saved over time by self-commissioning systems that continuously monitor their performance against design intent and auto-tune as needed.

Indoor Air Quality
Tighter building envelopes make ventilation design more critical since a designer can rely less on infiltration. Improved design and installation will allow for better control of indoor air quality. Source control through selection of low-emitting materials and furnishings, along with advanced air filtration and treatment technologies, will reduce requirements for outdoor air ventilation. As a result, energy consumption of heating and cooling ventilation air will also be reduced. Air cleaners – gas, particulate and biological – are further ways of reducing energy use associated with ventilation.

Energy Storage and Performance Standards
Standards for measuring the performance of integrated systems within the building will be needed. For example, metrics and methods need to be developed to better use the energy resources available, both on site and off site. This would involve identifying methods of using energy storage.

Construction
Successful application of design tools, high-efficiency equipment, and integrated systems is dependent upon installation. Construction firms will need to train their employees in new construction techniques and quality control procedures. Trade coordination and cooperation will be required to meet the needs of providing a finished product for the building owner and manager that meet the objectives of NZEB technology.

ASHRAE's Worldwide Membership

The methods to achieve NZEBs will impact building designers and operators in varying degrees based on climatic conditions, demographic factors, and geographic location.

The worldwide view of being sustainable and energy efficient varies tremendously. For example, many European countries have made significant progress along the sustainability path. As another example, China is aggressively developing building energy standards. At the same time, many developing nations are struggling just to raise their basic standards of living.

ASHRAE's vision to achieve NZEBs is initially focused on North America. If, however, we are to make this an "initiative" for use globally, the ASHRAE membership worldwide will need to assist the Society by identifying the regional construction standards, climatic zone variations, economic viability, and other driving forces in their respective countries.

There will be challenges, such as the perception that engineers in one nation are imposing their standards on another. To address this, a "collaborative team effort" will need to be nurtured to achieve the goal of NZEBs worldwide.

Regardless, the intent of this report is to identify the actions by ASHRAE that will provide the tools and guidance to engineers that will lower building energy consumption while reaching achievable sustainability goals.

Outside the ASHRAE Community

The ASHRAE community, including ASHRAE's partners in the development of standards and guides, has a strong influence on energy consumption and consequent environmental impacts. Many other entities play an equally important role. It is important that ASHRAE recognize these entities and engage them in the process of change.

On the energy supply side, private enterprise is becoming increasingly involved with renewable energy. Regulated utilities are major factors in generating electrical power. Various governmental bodies (local/state/federal) have influence on the supply side, whether it is with incentives and/or regulations or rate setting. Also, industry is a major factor in the distribution of energy in the deregulated environment. Each of these entities has a role to play in the vision for NZEBs.

Alternative power generation methods and sources will be a major factor in the political arena and in terms of environmental impact. Nuclear power is a challenging political topic, but it has the potential to strongly reduce CO_2 emissions; therefore, the Nuclear Regulatory Commission will play a role. Coal will have an important influence for a long time to come despite concerns about emissions. Gas and oil will continue to get the public's attention as the cost continues to increase. This means a host of organizations must be included in the 2020 vision.

Partnering Examples for ASHRAE

Groups such as the Institute of Electrical and Electronics Engineers (IEEE) can provide guidance concerning plug loads, such as computing equipment, since they have become a significant factor in the total energy picture.

AIA can be instrumental in providing guidance to minimize the impact on energy consumption by improving the form and fabric of the building.

The USGBC and others use ASHRAE standards as they pursue transforming the marketplace through building rating systems.

Model code organizations, such as the International Code Council (ICC), National Fire Protection Association (NFPA), and others, set the bar for a host of local jurisdictions across the country and are key disseminators of energy standards.

Trade associations, such as the Air-Conditioning, Heating and Refrigeration Institute (AHRI), representing suppliers of products that are the primary consumers of energy in buildings, participate in the regulation of energy consumption.

Building contractors need to implement and follow through with energy-efficient designs, including training trades people on the proper implementation of technologies.

A variety of governmental organizations, with the principal agencies being DOE, EPA and GSA, are active participants in conservation by conducting research, writing standards and implementing energy conservation in government facilities.

National laboratories in the U.S. should implement research plans to address major hurdles facing the building industry as it moves toward NZEBs.

NZEB Metrics and Recognition

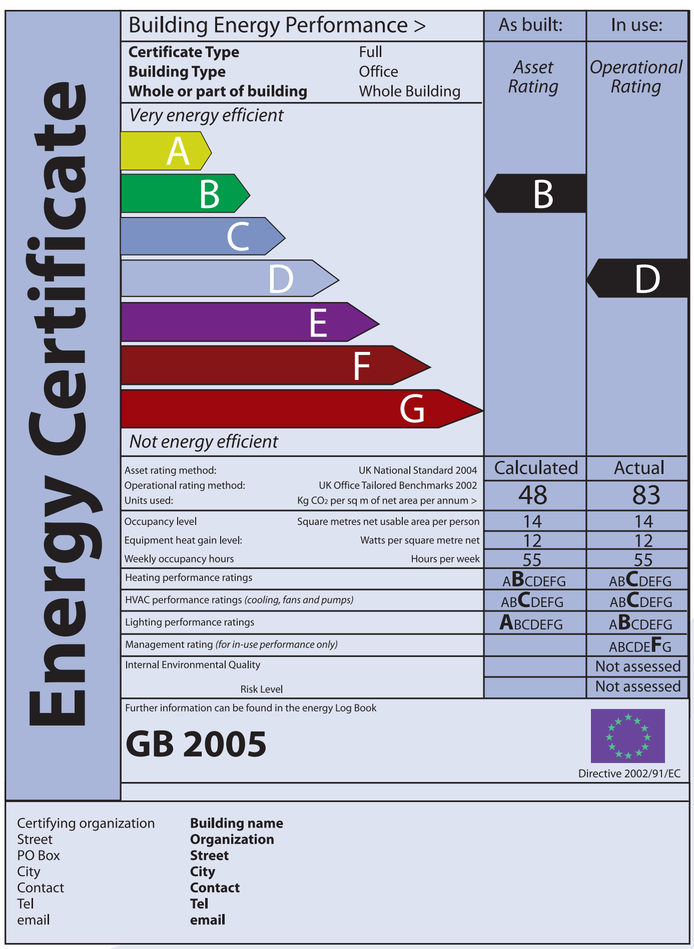
A number of initiatives should be pursued to encourage adoption of NZEB technology and also to support NZEB marketing activities.

The three primary options explored by the committee were building certification, accreditation of professionals, and labels or dashboards that highlight the energy consumption of a given building.

Building Certification

Certifying buildings for net zero energy consumption could serve to motivate building owners and designers. Some of the reasons to certify buildings include market leadership, credibility and visibility. Market leadership can establish a building, along with the owner and design team, as a top performer. And having an ASHRAE-certified building would provide the credibility to make such recognition meaningful in the marketplace.

Building certification could take the form of a plaque, label or certificate that could be displayed prominently in a building. There is a European program in place called *EP Label* (www.eplabel.org) that describes the overall energy efficiency of a building relative to benchmark values.



Building certification raises the issues of adjudication and the infrastructure necessary to support a rating program. If ASHRAE chooses not to pursue a labeling program on its own, the Society could focus on the required tools and collaborate with another organization on the actual labeling program.

Certification of Professionals

ASHRAE may certify individuals in the field of NZEB. This would encourage the practice of NZEB technology; however, ASHRAE must address the issue of adjudication and must provide the necessary infrastructure to support it.

The benefits of ASHRAE's certification programs are clear. They are developed by industry practitioners who understand the knowledge and experience that are expected for superior building design and system operation. The ASHRAE Learning Institute supports the certification effort, thereby providing a complete learning process. ASHRAE enjoys a worldwide reputation as a leader in providing guidance for HVAC&R design, and the Society's certification programs reinforce that reputation.

Measuring Actual Building Performance

While a building label provides a static indication of building performance, a dashboard is meant to describe a more dynamic or real-time indication.

Static dashboards provide a snapshot of building performance and are applicable to building certification, while dynamic or real-time dashboards involve data collection and reporting of the information. The objective is to provide feedback to building owners and occupants on the performance as well as to provide standardized metrics for reporting the building's performance to a larger audience.

Such dashboards have been developed for many other projects. The idea being presented here is to combine various meters and sensors with data logging software and a graphic display to show how the building is performing at a moment in time, over some recent time interval, or over the long term. Such performance can be compared graphically with design values, requirements from codes and standards, expected performance in similar buildings, and past performance of the building in question.

If such a dashboard was centrally administered it would have the advantage of allowing for the collection of energy use and energy production data for the spectrum of participating projects. This could become the framework for a very useful database, both for understanding the current performance of the monitored projects as well as for comparison to Energy Information Agency's Commercial Building Energy Consumption Survey (CBECS) data sets. In this way the dashboard would truly be analogous to the automobile's dashboard in that the information displayed would assist in driving the building industry toward the NZEB destination. Regardless, the objective of data collection is to document improvements in the building stock. One idea for presenting this information is to develop a high performance or green building subset of CBECS which could be referred to as the Green Building Energy Consumption Survey or GBECS.

Given an approach to displaying this information, the next question is what metrics to display. The specific parameters that are displayed on such a dashboard are always going to be building-specific to some degree, and if ASHRAE is going to propose a specific dashboard view, then additional discussion will be needed. The following list presents some of the options:

Energy consumption:
- Real-time, integrated over recent days/weeks/months, annual
- Broken down by use, e.g., fans, chillers, lighting, elevators, etc.
- Reference values: CBECS, design value, etc.
- Local utility demand; prices

System status:
- Airflow rates, including outdoor air intake
- Airstream temperatures

Level of service:
- Thermal comfort: dry-bulb temperature, RH, air speed; multiple locations in the building
- Indoor pollutant levels: e.g., carbon dioxide, fine and coarse particles
- Occupancy

Outdoor conditions:
- Air temperature
- Wind speed and direction
- Ambient pollutant levels: fine and coarse particles, ozone, etc. (this may available from EPA NAAQS monitoring locations)
- Non-energy building performance
- Water usage indoors and outdoors
- Sewage outflow

Energy Conservation in the Built Environment

Energy conservation in the built environment is something that ASHRAE can influence very directly.

It is somewhat problematic that most of our effort is directed at new construction, which constitutes only a small portion of the total energy usage. We have, however, an opportunity to highlight the relative contributions and have an impact on both design and operation. If CO2/Global Warming Potention emissions are the desired end result, perhaps it is not significant to try to segregate. Between energy consumption and emissions, there is the politics of power generation. ASHRAE's influence in this arena may be small, but the impact is huge (for example, consider nuclear power generation).

An initial list of attributes would include the following, each as a function of time:

- Energy consumption per area in new construction (without consideration of plug loads which ASHRAE does not presently influence)
- Energy consumption per area in existing building stock (again without plug loads)
- Energy consumption per area (new construction + existing stock)
- Emissions per unit of energy consumption vs. projected power generation policy
- Emissions per area (new construction + existing stock)

In addition to the attributes above, an assessment of the economics (where to get the "biggest bang for the buck") might be appropriate. Also some proposal to address the existing building stock would seem necessary, although not easy and not cheap. These may suggest additional metrics.

Products & Programs Needed for NZEBs

ASHRAE Vision 2020
Producing Net Zero Energy Buildings

A plan to reach NZEBs requires that good information be made available to motivated practitioners. Development of publications, research topics, and education programs identified below will promote this effort.

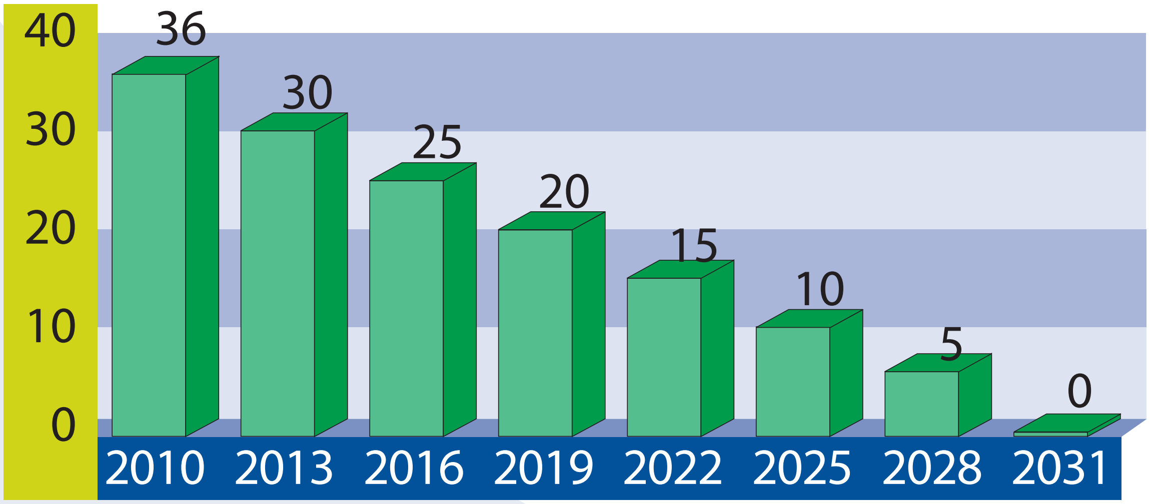
Publications

ASHRAE Handbook
The *ASHRAE Handbook* series and the *ASHRAE Terminology of HVAC&R* should be reviewed to ensure that terms relative to NZEBs are clearly defined. A chapter on "Fundamentals of Sustainability" should be added to the Handbook under the direction of ASHRAE Technical Committee 2.8, Buildings' Environmental Impacts and Sustainability. This chapter should include information on what it takes to create NZEBs, such as day-lighting strategies.

Standards and Guidelines
While it is acknowledged that NZEB technology is still developing, there are components of that body of knowledge whose aspects should be included in ASHRAE standards and guidelines. These include methods of testing for NZEBs. Additionally, the scopes of Standards 90.1 and 189P should be expanded to include plug loads, cooking equipment, and refrigeration loads.

ASHRAE's Board of Directors has approved Energy Use targets for its code-intended standards.

Energy Use Targets
For Code-Intended Standards



Targets in kbtu/square foot/year

Advanced Energy Design Guides

Advanced Energy Design Guides (AEDGs) are currently planned to be a series of guides that provide 30% energy reduction guidance, 50% energy reduction guidance, and 70% energy guidance. The committee recommends that the 70% energy reduction guides scheduled for completion by 2015 be modified to become net zero energy design guides. These guides would offer strategies that provide design guidance for 70% energy savings and strategies for on-site renewable energy concepts that result in NZEBs.

Education

Continuing education for building designers, contractors, operators, owners, and occupants is necessary for NZEBs to become a reality. To that end, ASHRAE must expand its educational offerings to ensure that its members and others have the necessary tools to be the source for knowledge on NZEBs. In order for this to happen, ASHRAE's Technical Committees must continue to develop state-of-the-art content for its suite of educational tools. In order to ensure maximum coverage, NZEB offerings should be developed in the eLearning modules, short courses, and the professional development seminar series, and those new technologies for information dissemination, such as podcasts, should also be developed.

Certification

Certification will become an important aspect for ASHRAE members to market themselves as NZEB-certified designers. The certification for the High-Performance Building Design Professional program should be expanded to include certification for NZEB design professionals as the body of knowledge is formed and design guidance becomes available.

Research Needed for NZEBs

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Producing Net Zero Energy Buildings

Research must be completed in support of NZEBs in order to provide design guidance by 2020. Topics span all aspects of the building industry, including the building envelope, mechanical equipment, lighting, service water heating, and all related controls. In addition to these building-related aspects, the design process must be carefully examined to ensure NZEB. ASHRAE must partner with other organizations, such as the USGBC Research Committee, to ensure the timely completion of these tasks. Additionally, within ASHRAE, this information will be important for the Research Advisory Panel as they prepare the next version of the Research Strategic Plan. Specific research topics are prioritized and listed in the appendix of this report. Following are examples of some of the highest priority research topics necessary to provide design guidance for NZEB.

Building Envelope

The building envelope should be designed to minimize buildings' HVAC and lighting loads. For example, on a residential scale, the U.S. Department of Energy Research toward Zero Energy Homes demonstrates methods to get to 70% efficiency and recommends roof areas with a given efficiency of solar domestic hot water (SDHW) and photovoltaics (PV) to meet the remaining loads. This methodology can be applied to commercial typologies as well. For buildings with high lighting requirements, daylighting needs to be a primary façade element; similarly, cooling or ventilation loads should influence envelope design.

Design Tools

There is a need for more accurate geometry for architectural models imported to energy simulation programs. The industry should actively pursue standardizing interoperability between software tools and developing software tools that can accurately model NZEBs. More specific recommendations are included in the appendix.

Small Power/Plug Loads/Miscellaneous Loads

Since these loads are not regulated in Standard 90.1 and also not under the control of the designer, they tend to be neglected. It is important that an evaluation of plug, process, cooking, and refrigeration loads is factored into the NZEB calculation. More specific recommendations are included in the appendix.

Operating Issues

There is a need to reduce constraints imposed by the structure of the current building industry. Maintainability, simplicity, ease of operation, and controllability are important considerations to ensure optimal operation of a NZEB.

Incentives & Restructuring Relationships

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Producing Net Zero Energy Buildings

The following three sections discuss crucial items that are not building-specific but will impact the success of ASHRAE Vision 2020. They address restructuring professional relationships and incentives in the building industry to encourage energy efficiency, researching the relationship between building energy and source energy to effectively reduce overall environmental impact, and coordinating building systems with the operation of larger regional systems.

Alleviate Constraints Imposed by Current Industry Structure and Incentives

The numerous parties involved (architects, engineers, specifiers, purchasers, contractors, lenders, owners, and tenants) in building construction and operation have different and conflicting financial motivations that discourage investment in innovative energy-efficient building designs. This structure can favor the purchase and installation of oversized HVAC systems even after energy-efficient measures have been made in the design of the envelope and insulation. Identifying and understanding these opposing incentives are a high priority because they determine the ability of building professionals to champion energy-efficient changes.

How to change and motivate engineers, developers, design professionals, and clients to excel:

A. Establish a fee structure based on performance rather than equipment cost.

Bids may be structured in several parts: one component may cover the costs for designing a "baseline" efficiency system; other components can reward designers and engineers for incremental reductions in energy costs throughout the life of the system or in total life-cycle costs. Fees can be contingent on performance as projected by design specifications, and distributed after corroboration by commissioning documents or energy bills. Means may need to be developed to have accountability for the separate parts of the design, maintenance, and operation of the building.

Utilities often reward customers with rebates for installing efficient equipment. Consider a "built-in" design royalty that passes along a percentage of these "hardware" rebates to the engineer or architect as compensation for their "soft" design contributions.

B. Educate current students about emerging standards and issues.

Educate the next generation of practitioners to make high-performance standard practice.

Sponsor outreach and educational programs that promote the integration of building science and energy systems into the curricula of architecture and engineering schools. Support curricula that include energy-efficiency courses in the core requirements, and allow students the flexibility to take additional electives in energy efficiency.

C. Educate developers and financiers.

Developers and financiers have incentive to minimize capital costs and maximize resale potential. They are typically less motivated to invest in energy-efficient systems because they currently do not benefit from the future energy savings. Reform accounting methods so that discounted rates can accurately portray the capital costs of superior systems. Show lawyers, commercial lenders, investment advisors, appraisers, and developers seminal issues such as:

i. Avoided operational energy costs can enhance retail market value.

ii. Capital costs reduced by proper HVAC sizing may be able to create cost neutral or capital cost savings through optimizing entire building systems. Building elements optimized in isolation tend to increase costs and have the opposite effect, whereas optimizing whole systems helps realize increased efficiencies while reducing cost.

iii. Any extra capital investments in superior HVAC systems can be paid back in savings from improved occupant productivity because the present value of capital costs for mechanical systems are dwarfed by the present value of employee salaries.

D. Educate maintenance staff on the intent of technically advanced systems and on managing and caring for systems accordingly.

Time, budget, training, and ease of operation (including simplicity of computerized interfaces) are considerations that should be factored into system cost calculations.

E. Promote interdisciplinary design, i.e., mechanical, electrical, and architectural.

Mechanical, electrical, and architectural expertise are typically provided by different sources, and HVAC systems are often designed as an afterthought to existing architectural plans. This disconnect is reinforced by lack of experience in integrated design, fear of taking on new financial risks by changing design processes that "work," and conflicting ideas and metrics for what makes a "high-performance" building.

One strategy to promote interdisciplinary design is to use total present-valued life-cycle occupancy cost as a financial objective. This can help to align design goals, make the case for early integration of mechanical and electrical input, and encourage communication between disciplines that currently emphasize exclusive "specialization" over transparency and information sharing.

F. Educate the client regarding net zero, thereby encouraging the demand.

i. Discourage oversizing of HVAC systems for the sake of accommodating possible future tenants who may (or may not) have higher load requirements. Provide for tenant flexibility and save money by specifying pads and stub-outs for future add-ons, thereby avoiding the initial capital and operating energy costs associated with unnecessarily oversized components.

ii. Raise awareness of different fee structures that can reward efficient designs.

G. Establish contracts that include a complete set of specifications, and provide for full commissioning, operations and maintenance training, and documentation.

Specifications should avoid ambiguous statements like "high-efficiency motor" or "low-emmissivity glass." Consultant fees and design schedules should be increased to accommodate the additional specification detail and editing required.

H. Encourage the adoption of Standard 90.1-based codes.

I. Design a "cost-neutral" high-performance building.

This may include a systems approach to LCA and bundling efficiency packages to optimize both cost and energy performance. It also implies active integrated engagement of the engineering team in the early schematic building design to coordinate building mechanical costs and building design optimization (i.e., investments in more efficient glazing can enable downsizing and reduced costs in the HVAC system).

J. Structure leases so energy-saving retrofits can benefit both tenant and owner.

Promote cost-effective sub-metering. Favor requirements to provide performance-based ASHRAE comfort conditions as opposed to support for outdated lighting and heating loads.

Establish the Boundaries of the Building

The following items may be addressed in collaboration with the USGBC.

A. Source energy should be included if the primary motivation is to reduce the impact of building energy consumption on global warming.

B. ASHRAE can develop a standard for quantifying regional greenhouse gas (GHG) emissions that enable individuals to:

i. Arrive at a figure for the amount of nonrenewable energy used by a building.

ii. Identify regional greenhouse gas intensity coefficients to determine a building's net carbon emissions as well as source energy impact. This coefficient should address distance/transmission loss issues as well as source energy type. It should also address time of day dependence on energy conservation rates. Use of this coefficient will allow conversion between energy use, source, and emissions.

C. ASHRAE to co-publish EIA energy generation fuel type data.

D. Renewable Energy Credits (RECs)

ASHRAE should promote demand-side reduction and the use of on-site renewable sources by stipulating that a minimum of 50% of building energy be brought to net zero through efficient building techniques and on-site generation. RECs should not be permitted to offset building nonrenewable energy use or carbon emissions for more than 50% of the building's net energy consumption.

i. ASHRAE should be clear about the motivations for purchasing RECs or offsets (i.e., promoting the use of renewable energy, offsetting carbon emissions, or both) and provide a defined method for converting units of energy used to the corresponding RECs or offset units.

Net nonrenewable energy use (calculated in kilowatt-hours) can be offset with RECs that are certified for "additionality" by acceptable authorities.

GHG emissions (calculated in tons of CO2 equivalent) can be brought to net zero by carbon offsets certified for additionality by acceptable authorities.

ii. Specify standards for offsets and RECs based on: demonstrated additionality, credible determination of offset project's baseline emissions, credible quantification of offset project's GHG emissions reductions, permanence of offsets, clear ownership of project reductions, and verification and registration of offsets (to reduce the possibility of multiple ownership and sales). Provide a list of acceptable certification programs (i.e., atmosphere, Carbon Neutral Co., Climate Care, Climate Trust, co2balance, etc.).

E. Potable water, wastewater, and utility connectivity: Water use for a building must be included in the building energy utilization index (EUI).

This is done by quantifying the water used or produced by the building and converting that amount to its energy equivalent. Buildings that generate potable water (or clean sewage) in excess of their use should be credited through net metering.

Currently, projects that include on-site wastewater treatment are essentially penalized (e.g., Oberlin's Lewis Center). Others use potable water and sewage systems and impose loads that are not ac counted for in a typical energy analysis.

F. Embodied Energy

Effort should be made to account for and reduce the energy embodied through construction. Standardized databases should be expanded with applications created to assist designers in making decisions about embodied energy.

Integration of Building with Larger Systems

A. ASHRAE should target reduced base loads as well as peak utility loads.

i. Create real-time load shedding information systems capable of integrating demand and loads in a two-way condition. This includes the broader definition and generation of the "smart grid."
ii. Broadly adopt net metering systems that encourage distributed generation in a manner that is profitable for all parties.
iii. Development of building based electrical (or energy) storage systems that provide dispatchable energy (including the "plug-in hybrid" systems).
iv. Generation and adoption of policy at the utility level that encourages the above, including smart residential and commercial utility interface kit sets.

Marketing Communications Plan

ASHRAE Vision 2020
Producing Net Zero Energy Buildings

ASHRAE and its activities are well known within the HVAC&R industry. As the circle of groups involved in the financing, development, design, construction, and operation of buildings expands, eventually including building occupants and government regulators, awareness of ASHRAE diminishes.

The strategy to promote NZEB technology, and ultimately the construction of NZEBs, will have four prongs:

- Raise awareness within the building community of the feasibility for and the benefits of constructing NZEBs.
- Establish demand for building certification and professional accreditation within the building community.
- Promote the sale of NZEB-related publications and educational products.
- Build general public awareness that the technologies of building heating and cooling and industrial processes can be compatible with sustainable buildings.

Raising Awareness in the Building Community

Audiences for this marketing strategy will be communities consisting of architects, code officials, building developers, design-build professionals, and manufacturers.

The two major vehicles used to reach these audiences will be news and articles in trade publications and a Green Team Resource Group that will serve as a speakers' bureau for conferences and association meetings in the industry. This response team will also be prepared to share messaging when opportunities arise in the media.

A major initiative that will be explored is the creation of an NZEB Technology Conference. This conference will present invited speakers rather than assembling a program through a call for papers. The purpose of the conference will be to educate practitioners, government officials, and developers on the benefits of NZEBs. Both the technical side of NZEBs as well as financing and construction will be explored.

Establishing Demand for Certification

The most important and challenging aspect of the marketing communications effort will be to create demand for building certification and accreditation of professional NZEB services. This needs to be accomplished by building value in these programs and effectively communicating this value. Successful completion of this effort will support execution of the three other prongs of the strategy.

The steps to be followed for execution are:

a. Identification of market segments that make purchasing decisions related to NZEB construction and services.
b. Placement of "success" stories in communication vehicles that serve those audiences.
c. Targeted advertising campaigns in communication vehicles that serve those audiences.
d. Development of tools that can be used by owners of NZEB-certified buildings and by accredited professionals that will allow them to bring attention to the respective programs.
e. Promotion by ASHRAE that will result in business opportunities for persons earning certification, and promotion by ASHRAE to the general public that will draw attention to building owners and developers who support NZEB technology.

Promote Publications and Educational Products

A full suite of publications and educational products will be developed in support on NZEB technology. Promotion plans will be developed for these products, grouping them for efficient use of the marketing budget.

A key objective of the marketing communication strategy is to make the effort revenue neutral to ASHRAE through increased sales.

The primary market will be the ASHRAE membership. But professionals in all related disciplines will also be targeted with special emphasis on:

- Lighting designers
- Architects
- Contractors
- Owner's operating staffs

A concerted effort will be made to engage in cooperative marketing efforts with the associations serving these non-ASHRAE audiences.

Within ASHRAE, a program track promoting use of and engaging in discussion about NEZB products will be held at ASHRAE meeting. Other association partners will be encouraged to organize similar tracks at their meetings.

Build Public Awareness

It may be questioned whether any investment to reach the general public is an efficient use of resources. The ultimate beneficiary of NZEBs, however, is the public, and the public—as building occupants and through government—should be recognized as a force for the implementation of NZEBs.

Because the effort to reach the public will be so large, it is essential that ASHRAE not undertake this effort alone. An effort should be made to obtain funding from a foundation interested in advancing technology for environmental benefit. This also should be done in partnership with the other associations contributing to the effort, such as USGBC, AIA, BOMA, and IESNA.

Activities that will be pursued include:

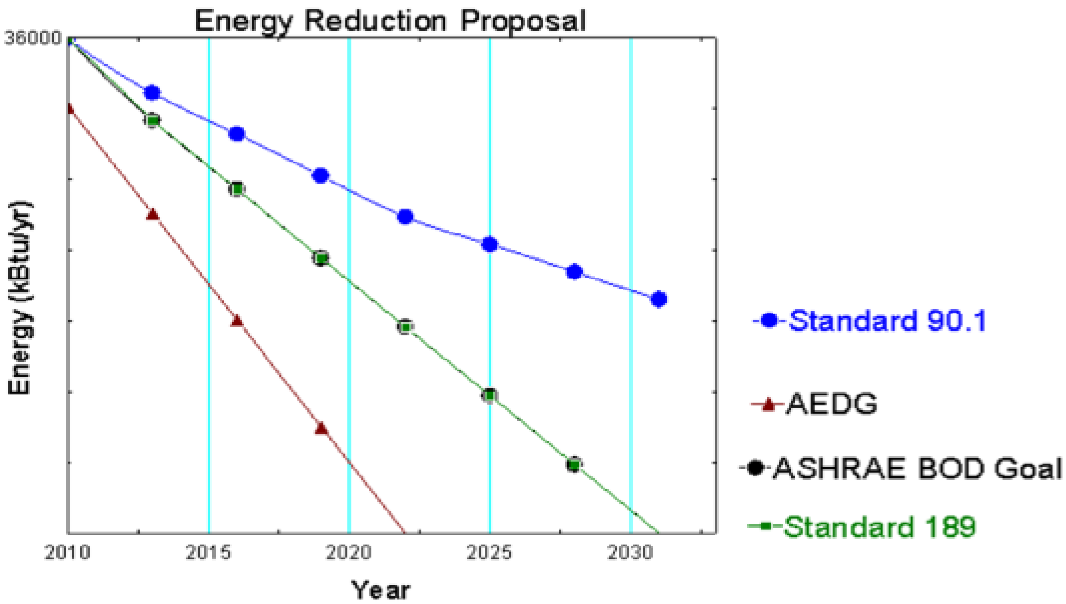
- PBS or NPR underwriting;
- Development of educational programming for secondary schools, perhaps based on adaptation of the ASHRAE eLearning module for NZEBs;
- Placement of articles in media dealing with office environments, such as the publications for chief financial officers, human resource managers, office administrators, etc.

The Plan for Existing Products

The code arena has many different versions (issue dates) of codes being used in different jurisdictions. Similarly, ASHRAE will likely need to have various versions available for an indefinite period of time of its publications related to NZEBs.

The following are fundamental points regarding ASHRAE NZEB documents:

- The ASHRAE documents should be referenced to a fixed baseline, ANSI/ASHRAE/IESNA Standard 90.1-1999.
- The document name should be tied to our ASHRAE baseline. AEDGs should give a percentage reduction from the baseline and the year of issue. For example, the title of an AEDG will not change once it is published, so a 30% AEDG remains a 30% guide. The next version would be more stringent—say, 40% or 50%. Each guide would be referenced to Standard 90.1-1999 as representing the "turn of the millennium." Thus, as new versions of Standard 90.1 (and Standard 189) are published, there will be a conversion given that identifies the percentage relative to the new version of the standard. For example, the 30% small retail guide savings relative to Standard 90.1-2004 are seven percentage points less than when compared to Standard 90.1-1999. Older versions will be made available in digital format with the recommendation that the user update to current versions.
- When the new versions of Standards 90.1 and 189 are issued, the AEDGs and other energy-related documents need to be updated. The older versions would still be available even if printed by demand (downloadable from the Web and in print)—this is how you buy ISO standards today. This also saves on mailing cost.
- The Standard 90.1 and 189 Energy Target Direction approved by the ASHRAE Board of Directors in March 2007 as shown below should be followed.
- Technology Council should take the lead in making sure that NZEB design documents are technical-content coordinated and coherent. This will require a review of *ASHRAE Handbook*, special publications, standards, and guidelines.
- Products should be made available in the market as an integrated suite of products—for example, the Commercial Energy-Efficiency Suite (Standard 90.1, 90.1 Users Manual, and five 50% AEDGs and e-Learning modules).



Volunteer Coordination

Strategic Direction 1 of the ASHRAE Strategic Plan states that ASHRAE will lead the advancement in sustainable building design and operation. Further, strategy 1.2 states that ASHRAE will lead the drive toward the design, construction, and operation of NZEBs through research, publications, and education.

To accomplish this, coordination strategies will need to cut across all councils. Technology Council and its committees have the research point in the strategy stating that ASHRAE will lead the drive toward the design, construction, and operation of NZEBs through research, publications, and education. The Publication and Education Council (PEC) has the responsibility for the publishing of the technical information related to net zero energy and for producing education programs for training of building professionals.

In order to stay ahead of developments, Technology Council and Publishing and Education Council should communicate regularly regarding strategy 1.2 actions plans, schedules, and results. To ensure this communication, both councils should consider appointing a champion for this strategy that reports progress to their respective councils. These champions would work together and establish routine communication so that both councils are aware of work being done by both councils and their respective standing technical and project committees.

Members Council and the Chapter Technology Transfer Committee (CTTC) will also play a vital role in the move to net zero energy use in facilities. CTTC should be on point for outreach to ASHRAE chapter members regarding progress being made in NZEB design, construction, and operation. The first need will be to convince ASHRAE members and other stakeholders of the importance of this work. Working with the Publications Committee, this outreach, including progress, should be done through publication of articles in *ASHRAE Journal* and other periodicals and through chapter meeting materials designed to get the message across.

All three councils will need to work together to develop the materials required to deliver this message. To that end, both Technology Council and Publishing and Education Council should appoint liaisons to CTTC and Members Council whose responsibility is to keep CTTC informed of the progress being made toward net zero energy usage in facilities.

ASHRAE Vision 2020
Producing Net Zero Energy Buildings

Following is a more detailed listing of possible research topics needs to provide net zero energy design guidance:

ASHRAE Research Topics—Priority 1

Topics listed as Priority 1 fall within ASHRAE's core competency.

Building Envelope

The building envelope should be designed to match buildings loads and resources. For example, on a residential scale the U.S. Department of Energy Research Toward Zero Energy Homes demonstrates methods to get to 70% efficiency and recommends roof areas with a given efficiency of solar domestic hot water (SDHW) and photovoltaics (PV) to meet the remaining loads. This methodology can be applied to commercial typologies as well. For buildings with high lighting requirements, daylighting needs to be a primary façade element; similarly, cooling or ventilation loads should influence envelope design. Some areas to develop include:

a. Dynamic "advanced" facades
b. Glazing
c. Frames
d. Daylight devices
e. Envelope airtightness

Design Tools

There is a need for more accurate geometry for architectural models imported into energy simulation programs. Actively pursue standardizing interoperability between software tools and developing software tools that can accurately model net zero energy buildings (NZEBs).

Small Power/Plug Loads/Miscellaneous Loads

Since these loads are not regulated in Standard 90.1 and also not under the control of the designer, they tend to be neglected. It is important that an evaluation of process, cooking, and refrigeration loads are factored in to the NZEB calculation.

Operating Issues

There is a need to reduce constraints imposed by the structure of the current building industry. Maintainability, simplicity, ease of operation, and controllability are important considerations to ensure optimal operation of a NZEB.

ASHRAE Research Topics—Priority 2

Some Priority 2 research topics do not fall under ASHRAE's core expertise. They should be addressed by working with the indicated organizations.

Design Tools
The following may be pursued with assistance from IESNA.

a. Daylighting simulation and evaluation tools
b. Ability to size HVAC systems accounting for daylighting technologies including thermal storage
c. Renewable energy integration tools

Electrical Power
ASHRAE should work with IEEE and others to address these issues.

a. Demand control and load shedding
b. Electrical equipment efficiency
c. Integrating renewable generation (DC current) in building electrical systems
d. Small scale cogeneration integration
e. Electrical storage
f. Net metering standards

Service Water Heating
These items are not addressed by the Research Strategic Plan (RSP) but will impact NZEBs.

a. Research projects/new standards
b. Domestic Hot Water (DHW) conserving fixtures
c. Instantaneous DHW systems

ASHRAE Research Topics—Priority 3

Some Priority 3 research topics do not fall under ASHRAE's core expertise. They should be addressed by working with the indicated organizations.

Climate Typology
Co-publish solar and wind data with NREL solar databases. There is a need for a better index of clear/cloudy skies and to understand the implications for design.

Topics Addressed Outside of ASHRAE Research

The following topics are important to the ASHRAE Vision 2020 initiative and are being pursued, or should be pursued, by other committees within ASHRAE, such as the Research Advisory Panel impaneled to development the next-generation Research Strategic Plan and the Advanced Energy Design Guide Steering Committee. Continued attention should be given to these topics to enhance net zero energy design guidance.

Climate Typology

a. Develop basic recommendations for each of the ASHRAE climate zones to simplify "packages" of recommendations for designers (currently being addressed by the AEDG committee).
b. "Advanced Energy Design Guide" approach for larger facilities to hit efficiency improvements of 70% relative to baseline (currently being addressed by the AEDG committee).
c. Better envelope standards guidance per location and orientation (currently being addressed by Standing Standard Project Committee 90.1).
d. Consider the extension of the comfort zone (should be addressed by Standing Standard Project Committee 55).

Design Tools

a. Provide building balance point tools for use in the schematic design stage to match building envelope to climate conditions (currently addressed in the ASHRAE Research Strategic Plan).
b. Energy simulation for Standard 90.1 evaluation.

HVAC

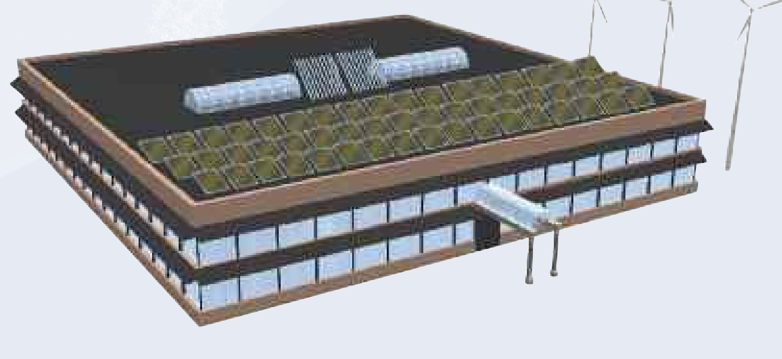
HVAC is currently addressed in the ASHRAE Research Strategic Plan.

a. Natural ventilation design standards and guidance
b. Alternative HVAC distribution
c. Boiler efficiency
d. Chiller efficiency
e. Increase the delivered efficiency of heating, cooling, and ventilation, perhaps with a shift from air to water as the medium for energy
f. Consider total combined energy efficiency: fan energy, electrical distribution, and gas distribution

Lighting

Lighting is currently addressed by IESNA.

a. Lighting system design with emphasis on lighting quality, task lighting, and sample packages of lighting system designs that reduce the required lighting power density
b. Lighting controls
c. Lamp technology
d. New lamp materials (photonic crystals)



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