

PREPARING FOR THE 2030 CHALLENGE: The Principles of Designing for Carbon Neutrality

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ABSTRACT

Designing buildings for carbon neutrality, in direct response to the mission of the 2030 Challenge, requires that designers go back to the basics of passive design in order to begin to reduce the energy demands of their buildings. This paper begins to define carbon neutral design and outlines the important first steps towards designing for carbon neutrality in the operational energy of the building as well as lowering the carbon costs of the site during construction.

1. INTRODUCTION

The issue of Global Warming, although arising from the arena of sustainable concern about the state of the built environment, is more specifically concerned with greenhouse gas emissions. It is the level of CO₂ that is the direct byproduct of the building industry that requires modification to existing Green Building Protocols to add its consideration.

The 2030 Challenge¹ is a North American based move to reduce the greenhouse gas emissions for all new buildings to zero by the year 2030. The idea was put forth by architect Edward Mazria, one of the early passive and solar pioneers. The fossil fuel reduction targets are aggressive: 60% in 2010; 70% in 2015; 80% in 2020; and 90% in 2025. The inference of carbon neutrality in The 2030 Challenge means using no GHG emitting fossil fuels to operate buildings. The present emphasis for the 2030 Challenge focuses on operating energy and is not presently is not considering the carbon implications of construction, the materials used in the building, the use of the building or associated transportation costs. It is felt that the impact of operational energy is of greater significance as its negative costs to the environment will persist for the life of the building. Although many organizations have adopted the 2030

Challenge, there has yet to be developed a clear method of implementation to achieve its aggressive fossil fuel reduction targets.

2. DEFINING CARBON NEUTRAL

Carbon Neutral Design is a subset of Sustainable Design. Buildings that are currently including issues of sustainable design in their mandate, are likely already addressing some aspects that support carbon reductions. The issue of carbon in buildings is complex. There is carbon involved in the extraction of the resources that we use to create products; in the transportation of these products to the site; in the physical construction of the buildings; in the operation of buildings; and in the lives of people as they carry on business.

Holistic carbon neutral design is looking to reduce the carbon emissions associated with *all aspects of the project*. This would include the operating energy as well as the construction and materials, and additionally the carbon associated with the commercial, institutional or residential use of the building by the occupants. This incorporates the nature of the work or activity that is carried on within a building. Locating the building to reduce transportation costs will factor into this equation, and thereby includes neighborhood and local or regional planning issues.

Zero Energy Design (ZED) differs from Carbon Neutral Design (CND) in that it is more concerned with the reduction of the operating energy requirements for a building, focusing on the eventual use of zero fossil energy. The official ASHRAE definition for a Net Zero Energy building is “buildings which, on an annual basis, use no more energy than is provided by on-site renewable energy sources.” The Office of Energy Efficiency and Renewable Energy provides an array of definitions for Net Zero Energy

Buildings, based on the base premise that, “A net ZEB produces as much energy as it uses over the course of a year. Net ZEBs are very energy-efficient buildings, with the remaining low energy needs typically met through the use of on-site renewable energy.”² The Department of Energy provides supplementary definitions based upon the cases of Net Zero: Site Energy, Source Energy, Energy Costs, Energy Emissions and Energy. Preferred renewable resources would be solar and wind, but renewable resources can include biomass, wood chips and other waste materials, as long as they are from renewable sources. Obviously the burning of any type of fuel, fossil or renewable, results in emissions – creating one of the significant differences of the goals of Zero Net Energy and Carbon Neutral Design.

Both Carbon Neutral and ZED buildings are designed bioclimatically to take advantage of the sun and wind, employ a high degree of passive solar heating, natural ventilation and daylighting, to reduce their energy requirements. They are typically super insulated, and also use higher quality glazing systems. Their interior finishes include thermal mass to store the free heat they capture from the sun. They will generate their own electricity through wind turbines, photovoltaics and micro generation facilities. Their goal is to be able to generate more electricity than they require for operation.

3. CARBON AND ENERGY USE

Energy use is the current focus of arriving at a calculated state of carbon neutrality in building. Long term operating energy is considered to contribute more significantly to greenhouse gas emissions than other aspects of construction. Energy use is the simplest variable to design for, to predict and to verify using post occupancy evaluation. Where on site renewables may be assumed to be carbon free, the use of off-site electricity is more difficult to assess as hydro electricity can be free of carbon emissions, but will not be if coal is used in its production. At present it is difficult to verify the actual source of electricity that arrives at the building.

Where the energy efficiency of sustainable buildings is only a *portion* of the focus of any of the current protocols such as LEEDTM and Green Globes, it is *the* focus of designing for carbon neutrality within the terms of the 2030 Challenge, as well as the mandatory starting point for more holistic carbon counting assessments. LEEDTM NC V2.0, for instance, only apportions 10/69 credits under the category of Energy and Atmosphere to improving the energy performance of a building – the highest category falling short of a zero energy goal. The use of renewables is maximized at 25% of the site energy. Where the existing protocols offer a smorgasbord of potential credits, or unordered “checklists”, the totality of

the carbon neutral target necessitates an ordering of required steps as the only means to achieve this aggressive goal. Carbon neutral design works against the “checklist” principle and asks for a highly holistic beginning to the examination of the design problem.

The four basic steps that are required to *begin* to design a building to meet a zero carbon target are:

#1 - Reduce loads/demand first (bioclimatic design, orientation, passive solar design, daylighting, shading, orientation, use of natural ventilation, site design and materiality.)

#2 - Meet loads efficiently and effectively (energy efficient/effective lighting, high-efficiency/effective mechanical, electrical and plumbing equipment, controls, etc.)

#3 - Use on-site generation/renewables to meet energy needs (doing the above steps *before* will result in the need for much smaller renewable energy systems, making carbon neutrality achievable.)

#4 - Use purchased Offsets as a *last resort* when all other means have been looked at on site.

Unlike many of the green rating systems or standards, the above criteria can be applied to *any* building or project, including commercial, institutional and any density or height of residential building.

4. BUILDING ON PASSIVE DESIGN PRINCIPLES

Passive principles of heating and cooling a building, in addition to bioclimatic site strategies will therefore need to form the basis upon which to build the design for all carbon neutral buildings. To build carbon neutral requires that a building to be able to source 100% of its operational energy from on site renewable resources. As on site renewables are practically limited requires that the building program and design must adjust its scope and architectural design to attempt to match the amount of renewable power that is available on site. This will mean the implementation of serious reductions in the overall impact and size of projects.

4.1 Reduce loads/demand first

The reduction of loads through the reduction of demand *must* be the starting point for any carbon neutral design. If the building is not carefully designed to lessen its impact (material and energy requirements) from the outset, it will not be possible to provide adequate renewable energy to allow the building to operate. This includes rethinking the scope of the building (size and height). The smaller the building the smaller its carbon footprint and lower the amount of energy to operate. This might not simply infer a

reduction in square footage, but a reinvention of the program. Questions will need to be asked that rank the relative importance of spaces and offer the possibility of doubling up on program needs to make better daily or seasonal use of program functions.



Fig. 1: Aldo Leopold Legacy Center, Wisconsin – Three Season Hall: This space is not used during the winter months as the program of the facility contracts to be able to work within the available on site renewable energy during the winter months. The Center is one of seven buildings categorized as ZEB by DOE.³

Carbon neutral design requires a *back to basics* thinking in passive design terms with deference to the use of natural systems to heat and cool the building. Relating the site to issues of *ORIENTATION* and *MASSING* will begin to impact the way that programmatic requirements may be accommodated in the building. Certain uses may be able to take better advantage of passive heating and cooling if they are located according to site and exterior landscaping characteristics. Daylighting will greatly assist in reducing energy costs as well as provide a higher sense of well being to the occupants. The consideration of local site conditions may help to determine the placement of daylit versus non daylit or service spaces. The *CROSS SECTIONAL CHARACTERISTICS* and *BUILDING HEIGHT* may also need to be modified to feed into lower energy, natural solutions. Synergies may be possible when looking at spaces that have larger mechanical or cooling requirements, where waste heat may be able to be used to provide heat transfer to atria or circulations spaces that can make do with a lower level of constant comfort. Issues such as these are not to be found on any “checklist”, but greatly impact the overall environmental performance and energy requirements of the building.

Site design is critical as it will affect the ability to incorporate renewable energy into the project, as well as impact the potential for natural systems to sequester carbon. Low carbon thinking must inform the site selection as well

as the placement of the building on the site to allow for optimal solar harvesting as well as facilitating maximal carbon sequestration through landscape preservation, restoration and design.



Fig. 2: Beddington Zero Energy Development (BEDZed), Hackbridge, England – the buildings are massed, oriented, glazed and ventilated to maximize their passive potential. Bioclimatic responses to the heating and cooling requirements for buildings will also result in a re-examination of insulation levels and wall construction. In cool to cold climates this infers increasing insulation levels and airtightness in construction. Cold climate buildings that are currently seeking carbon neutrality are working with R values in the floor, walls and ceiling of R30, R40 and R50 respectively. This is a significant increase over current code required levels that require no floor insulation and values of R20 for walls and R30 for ceilings for the same climate severity.⁴

4.2 Reduce the Impact of the Building on the Site

The idea of widespread reduction in the size and scope of projects in their entirety is central to the carbon argument. There have been criticisms levied at “sustainable homes” that reflect excesses in square footage and overall lifestyle. Where upcoming green codes and standards are expected to reflect the need for impact reduction in the area of residential buildings, this is not expected to be part of any requirements for commercial or institutional buildings. Where there are fairly clear minimum space requirements associated with a residential program, the program requirements for non residential buildings are far less fixed, even if measured on a square foot per person basis. A greater level of creativity is necessitated in approaching commercial and institutional design with a mind to the reduction of area and volume, but also to work the form of

the building towards the creation of energy synergies and efficiencies.

Building less also facilitates reductions in operating energy as it would be assumed that the volume to heat and cool would be proportionately smaller. Building less might have a positive impact on the use of the site, leaving more residual space for both landscaping as well as the harvesting of renewable energy. This will work to protect the natural ecosystems on the site as there should be impact reduction through a smaller building. Natural ecosystems can be calculated to generate oxygen – thereby naturally offsetting carbon production on the site.

It is anticipated that carbon reporting for commercial and institutional buildings, rather than assessing carbon per square foot of building area, may move to a carbon value that is based upon occupancy, as relates to the functional use of the building. This would permit a better type to type comparison of relative efficiencies that may more properly reflect appropriate energy use and building size.

4.3 Meet Loads Efficiently and Effectively

Once the building and its program have been designed to reduce their need for heating, cooling and lighting, it is necessary to ensure that whatever mechanical, electrical and plumbing fixtures or systems are chosen are of the highest efficiency so to require the least amount of power/electricity. Systems must be designed and implemented effectively in order to further reduce energy requirements. In order to be able to supply all of the required energy via renewables, the amount required needs to be trimmed down. Sensor systems can assist in eliminating loads for many types of equipment when their use is no longer required. This would include switching systems for lighting that recognizes both the amount of helpful daylight as well as the presence of occupants.

Recently many high profile green buildings have come under fire as they have not been able to perform as well as they had been predicted. In many instances it was not the actual building that failed, but the *use of the building* that contributed to its poor energy ratings. Often the plug loads (computers, electric white boards and other electronic equipment) have been blamed for the bad performance levels. When designing carbon neutral, and relying principally on site generated renewables, a full listing by the client of anticipated plug loads will be essential to the success of the project. Occupant load and duration of work or occupation hours must also be accurate. If a building is essentially disconnected from the grid, the flexibility will not be there to accommodate erratic increases in either occupancy or plug loads, or significant changes in the use of the facility.

Progress has been made in the design of sensors that are capable of shutting off entire rooms or areas when they become unoccupied. This answers the issue of “ghost” or “phantom” loads. Phantom loads happen when electric devices such as computers are turned off, but in fact draw a small amount of power to keep them in a standby mode. These loads become significant when attempting to balance the energy in a building and so the use of “all off” systems can assist in eliminating these loads from the equation. Sensors and monitoring systems do not replace the education of the occupants. Occupant education and involvement will be critical in ensuring that many of the passive systems function optimally, but misuse or unintentional overuse of electrical equipment could easily throw off the entire energy balance.

4.4 Use on-site generation/renewables to meet energy needs

Generally speaking, most of the energy requirements anticipated for carbon neutral buildings may wish to assume electricity for their operation to be able to take advantage of the majority of on-site means for energy generation. Once the building and equipment have been designed for maximum effectiveness and efficiency, it may be possible to generate 100% of the required electrical energy on site – although site characteristics, location, orientation and sheer size may make this more difficult. Carbon neutral buildings may begin the process of design by calculating the renewable energy potential of the site, and designing backwards, to calculate the amount of building and program that can be supported. This may also relate to the building budget. Systems such as photovoltaic arrays are expensive, so it might be necessary to commence with a “set aside” budget for the array.

The common methods assumed for power generation are: BIPV or non integrated photovoltaics, wind (large or micro turbines), combined heat and power (CHP), and geexchange. The design of Building Integrated Photovoltaics needs to be incorporated into early design discussions involving the massing and orientation of the building. Surfaces need to be maximized for the architectural incorporation of PV units. Geoexchange and CHP systems will work on both urban and less dense sites. Wind generation is likely to be the most contentious to incorporate as it is the least architecturally integrated of the systems and due to its appearance and acoustic issues, most likely to generate neighbor issues. For independent projects these should be provided on site. Micro turbines can provide wind power for smaller developments that is more suited to the scale of these types of projects.

As the electrical output of renewables tends to be variable, it is advised to incorporate multiple systems into the project to allow for lulls in generation. This would be particularly

advised when using solar and wind systems. If connected to the grid, net metering is likely preferable to battery storage for over production as there are environmental issues with the chemicals and materials that comprise the batteries themselves as well as their limited longevity and subsequent disposal. If net-metering, then the cleanliness of the grid should be factored into the carbon assessment. If the local system is working from coal fired generation, then any shortfall of the project will be compromised by the local power source.

It has been suggested that in order to achieve a state where renewable energy is able to be counted on for 100% of the energy required, that the design begin by determining the amount that can be produced, and work the design through in reverse to determine how much building area, volume or program can be supported. Dense urban sites are likely to pose the most difficulty in this regard as they may have compromised solar potential for either site or building installed systems such as BIPV. Urban sites will also tend to have less open space to allow for the installation of site generated power. There are likely to be existing regulations that may prevent the installation of some systems.



Fig. 3: The budget and resultant square footage of PV was determined at the early stages of design for the Aldo Leopold Legacy Center, and the building was sized to suit.

For larger developments, such as in the proposed carbon neutral “Eco Towns” in the United Kingdom, plans include the creation of district power as it is deemed more effective in providing power for a residential development than attempting to provide power on a per house basis. Combined Heat and Power plants make use of waste materials (often wood chips salvaged from regional industrial processes). Such waste products are normally bio-fuels and therefore able to be classed as renewables. They do result in emissions, and begin to differentiate Carbon Neutral and Zero Energy buildings and developments.

Solar hot water heating systems are typically used to provide the hot water needs of the project. To reduce heating losses in the lines, a higher than normal level of insulating pipe wrap should be installed from the water source to the equipment. Efficient appliances with low flow and sensors will reduce the need for solar hot water heating, and therefore reduce the size of collectors required – leaving more area available for PV installations.

Geothermal energy is also frequently used in low to zero carbon projects. The heating or cooling can be simply circulated through slabs and radiant panels using electric powered pumps. The ability to pre heat or pre cool the heating or cooling medium vastly reduces the amount of heating or cooling that must be supplemented. The ability to drill deep systems makes these suitable as well for constricted urban sites. The use of radiant slabs works well with passive thermal mass storage direct gain solar approaches to heating design.



Fig. 4: Jubilee Wharf, Penryn, England – this zero energy development uses 4 micro turbines to provide power. Evacuated tubes provide solar hot water. Roof area for PV has been designed, but no PV is presently installed. Directional wind cowls assist with natural ventilation to the point that no A/C is provided. A 75kW wood pellet boiler provides under floor radiant heating. The building is super insulated with 300mm of insulation netting a U value of $0.1\text{W}/\text{m}^2/\text{°k}$. Designed by ZEDFactory.⁵

Carbon neutral design also rethinks the selection and use of renewable building materials. Holistic *sustainable* motivation would offer that renewable materials are simply better because earth’s resources are in finite supply. The carbon argument examines the value of different materials based upon their carbon costs, both in fabrication, transportation and site assembly. Any carbon costs associated with the materials themselves must be offset by the ability of the site to absorb the same carbon. The restoration of native ecosystems on site is looked at as a means of providing for increased capacity of the site to

sequester or process CO₂ into oxygen. The use of local materials is of obvious benefit as it has the potential of drastically reducing the carbon associated with transportation. It is the complexity of the building materials issue that has led the current initiatives towards carbon neutral design to set this aspect of the building aside and concentrate on operating energy. The latter is far easier to define and therefore calculate. However, once carbon neutrality is achieved in operating energy, the carbon associated with embodied energy becomes more significant in terms of the overall carbon of a building project.

The use of a Life Cycle Assessment analysis can facilitate and examination of the carbon costs of the building materials. Durability offers something similar in that the longevity of the building and its components can reduce the long term carbon cost of a building. Replacement of materials and systems with a short life span increases the carbon cost of a building over its lifetime. The intention is that a carbon neutral building be durable as not to incur a carbon debt over time. Design for disassembly increases the complexity of the design of a project but does offer the potential of short circuiting the cradle to grave cycle of a building, thereby saving future carbon.

Embodied energy gains complexity when assessing materials that may be high in carbon, but are indispensable in passive design. Concrete is highly effective as a thermal mass. More detailed synergistic assessments are required before discounting certain materials that may in fact provide the best means of energy effectiveness, and able to offset their material carbon costs.

4.5 Offsetting

Site conditions for many projects can place constraints on the viability of using your own renewables. Limited site area, incorrect exposure for solar and PV, overshadowing, etcetera will restrict the output of site located systems. Offsetting is the ability to purchase carbon credits to balance any carbon shortfalls in your own project (or action). Credits are purchased from others who are able to prove that they are able to absorb your excess carbon by some means. If it is simply not possible to balance the energy required to operate the building with renewable energy generated on site, purchased offsets can be used as a *last resort* when all other means have been looked at on site. Offsetting and carbon trading are becoming an increasingly popular way to look at compensating for the carbon expense of a project. The quantity of carbon offsets that can be supplied on a global scale will be finite.

Offsetting is also likely to be developed in relationship to the size and scope of a project. As few truly carbon neutral buildings have been constructed to date, a pattern has not

yet emerged. But it is not too difficult to predict that the need for offsetting will be higher where the proportion of building size to site exceeds the capability of the project to generate its own renewable power. Smaller buildings with less electrical load will be more capable of achieving carbon neutrality without offsetting.

5. CARBON, CONSTRUCTION PRACTICES AND THE SITE

When moving outside of the definition of carbon neutral design as it refers to the energy consumption and patterns of the building itself, the site must be more closely considered as a means to mitigate carbon on the site. Beyond the capacity of the site to provide a place to harvest renewable energy, the treatment of the site itself can either be used to sequester or release carbon into the atmosphere. Construction practices need to be refined to consider carbon. As carbon can be sequestered or stored in the ground as a means of removing it from the atmosphere (including geosequestration), it needs to be appreciated that it is also released during excavation and any such processes where land is disturbed. The potential and preservation of the landscape and existing ecosystems on the site needs to be included in design and construction planning.

5.1 Site and Location Matter

Whether you are building on a Brownfield or conserved ecosystem, and whether the site is urban, suburban or rural, will greatly affect the ability to restore or regenerate the ecosystems on the site. The ecosystems of the site will determine the *potential* for carbon sequestration on site. Where the current green building assessment systems give preference to Brownfield sites, unless these undergo intensive replanting and natural restoration, they may prove to be more difficult when it comes to the ability to sequester carbon on site through its natural systems. This is not to say that Greenfield development is better, only that more consideration to the regeneration of Brownfields from the perspective of new planting and new ecosystems will be required to assist in the containment of carbon.

5.2 Disturbance is Impact

Carbon is released into the atmosphere when earth is disturbed. Existing green building protocols require that contractors limit their use of the site for staging to protect the natural ecosystems, the protection of the existing soil and vegetation in this instance is intended to limit the release of carbon through disturbance. Designing the foundations to minimize impact might mean the use of micro-piles or drilled foundations in lieu of an open excavation so that less soil is overturned. Minimizing the

moving of soil around the site for earth works will also limit unnecessary carbon release. Disturbance changes existing ecosystems, natural habitats and changes water flow and absorption, which may have other negative effects on the site condition as well. Disturbance can kill trees, lowering the site potential for carbon reduction. The release of carbon through disturbance is difficult to accurately calculate so is not presently included in most calculation methods for Zero Carbon Buildings.

5.3 Natural Ecosystems Sequester Carbon

Carbon is naturally stored below ground and is released when soil is disturbed. There are significant scientific efforts underway to look at using the ability for the earth to sequester carbon in massive quantities through injection (geosequestration). Proper treatment of the landscape can keep this carbon in place (*sequestration*). This is in part related to reducing disturbance of the earth itself, and also related to the type of plantings that are chosen for the landscaping on the project. Proper treatment of the landscape and selection of plant materials can be designed to store/accumulate/sequester more carbon over time. Biodiversity can assist in creating a healthy landscape that is capable of processing CO₂. Avoidance of annuals and the selection of perennials and low care ground covers can virtually eliminate the need for tilling and maintenance that disturbs the soil. The addition of larger tree species can increase the capacity of the project to sequester more carbon as sequestration increases with the growth of trees. It is necessary to verify the landscape design type with your *eco-region*. The use of indigenous plant material requires less maintenance/water. Additionally healthy plants absorb more CO₂. It is therefore possible to use the natural ecosystems on your site to assist in lowering the carbon footprint of your project.

5.4 Sequestering Carbon with the Building

Buildings and material choices can help to sequester carbon. The materials that you choose can help to reduce your carbon footprint and the construction methods associated with materials and systems can also impact carbon production. In a holistic consideration of the carbon issues surrounding the built environment, the energy used to construct the building should also be considered. What types of tools and equipment are used in construction? Electrically powered tools can make use of available Green Power if the renewable sources are not yet in place on the site. The use of heavy equipment adds carbon use to the project as these typically run on diesel fuel.

Wood from certified renewable sources, wood harvested from your property, or wood salvaged from demolition and saved from the landfill can often be considered net carbon

sinks. Certified wood is addressed in existing green building protocols as is construction waste management. Harvesting wood in a sustainable fashion from the site property or by arrangement from a local forest is new to the carbon problem. This has been successfully accomplished on the Aldo Leopold Center, one of seven carbon neutral projects in the United States as of November 2008.⁶



Fig. 5: The Aldo Leopold Center started with the sustainable harvest of the Leopold forest. The wood was assessed and sized to maximize the number of structural columns and beams. The remaining wood whose diameter was insufficient was cut into smaller members as well as exterior and interior cladding. The structural system of the building was designed based on the materials list. This runs contrary to normal practices where the building is first designed and the materials ordered (even if limited to a close radius to reduce emissions impacts).

Incorporating *green roofs* and *living walls* into the building design can assist in carbon sequestration and become part of the building itself. These systems have long been incorporated into the LEED™ Credit system, but carbon neutral design is looking for their benefit in a more particular way.

6. CONCLUSION

Carbon Neutral Design can be seen to be a specific detailed subset of the more general objective of sustainable building design. Its approach to energy design is directed at arriving at a goal of Net Zero Energy through significant reductions in the loads generated by the building, its use and equipment, in order to be able to generate a 100% of its power requirements with on site renewable energy sources. As can be seen, the primary starting point for this type of design must begin with the reduction of loads and impact. This calls into play aggressive passive design protocols for heating, cooling and daylighting the building.

Although Carbon Neutral Design requires highly technical design, evaluation, simulation and post occupancy assessment to verify that its processes are indeed operating to a state of Net Zero Carbon, it is both possible as well as necessary to use holistic passive/bioclimatic design as the *architectural* starting point upon which to build the more technically driven solution.

Although the precise definition of carbon neutral is being debated, the premise of beginning to design for carbon neutrality based on operating energy, as targeted by the 2030 Challenge, seems to have met with widespread agreement. Regardless of the holistic degree of the aim of carbon neutral for the particular project or jurisdiction, the four point premise that has been outlined herein, “reduce loads/demand first, meet loads efficiently and effectively, use on-site generation/renewables to meet energy needs and top up with purchased offsets”, provides a good working method based upon sound principles that can be applied to all projects, regardless of their size, program or location.

7. THE CARBON NEUTRAL DESIGN PROJECT

The Carbon Neutral Design (CND) Project is a joint effort by the American Institute of Architects, members of AIA Committee on the Environment (COTE), and the Society of Building Science Educators to produce educational and resource materials for carbon neutral design. SBSE, a non-profit educational organization with members from the academy, governmental agencies and publishers, has for over twenty years served as an incubator for new approaches to teaching environmentally responsive architectural design. This partnership with the academy has capitalized on the expertise of building science educators and practitioners to produce a peer reviewed, web-ready content on carbon neutral design.

The initial phase of the Carbon Neutral Design Project focuses on reducing the carbon emissions for the operating energy of the building. Operating energy has been selected over embodied energy as it represents the major contribution to the carbon emissions of a building, and is the focus of the 2030 Challenge. Practices, protocols and tools to reduce the carbon associated with embodied energy will form the focus of subsequent research associated with this project.

The project may be accessed at:
www.architecture.uwaterloo.ca/faculty_projects/terri/carbon-sbse/

It is the intention of the CND Project to assist practitioners and educators in making the *leap to zero carbon*.

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