The intent of the Energy Petal is to signal a new age of design, wherein the built environment relies solely on renewable forms of energy and operates year round in a safe, pollution-free manner.

-International Living Future Institute
http://living-future.org/
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This is an interactive document! All hyperlinks to resources are highlighted in blue and will take you to the appropriate website upon clicking.
Designing a Net Positive Energy building is not a linear process. There is a basic work flow which we have identified through five key steps, but in practice teams do not always follow these steps in order to reach the end goal.

For example, after finishing step 3 sometimes you need to go back to step 1 - which may be accomplished by looking ahead to the larger picture goals outlined in step 5.

After researching successful project work-flows, we advise that when designing for Net Positive Energy you look at your work as a continual process that takes all 5 steps into consideration throughout each phase of design.
1.1 Why Choose LBC?

The Living Building Challenge (LBC), started by the International Living Future Institute (ILFI), is one of the most ambitious third party building certifications in the marketplace today. Successful projects are well regarded within their communities, bringing project teams positive exposure and recognition. Net Positive Energy is an integral and often misunderstood aspect of the Living Building Challenge. The benefits of a Net Positive Energy Building include a self-sustaining structure, high environmental performance, low or no energy costs, and an infinite return on investment. However, the potential challenges are equally prevalent. This Implementation Guide will identify these challenges in order to equip the project team with knowledge, resources and next steps to successfully seek LBC certification. By reading this guide and utilizing these resources throughout your project, you have the chance to lead environmental stewardship and pave the way for future Net Positive Energy building types. Your contribution to this cause not only has specific benefits to your project’s return on investment, but also regional and national benefits. Putting your project on the LBC map yields recognition for achieving sustainable goals that surpass any other sustainability certification process in the world.

If you are reading this guideline, you are most likely aware of the seven ‘petals’ that contribute to the LBC certification process. This guideline is specific to the Energy Petal.

1.2 Heads Up, Client Team!

Pursuing a Living Building Challenge Certified project is an important decision for any building owner. It is a decision that carries many impacts – specifically for the Energy Petal certification. The Energy Petal cannot be achieved by the owner alone. It requires input and collaboration from all parties involved – the owner, design team, construction team, daily occupants, and the building maintenance staff. To achieve the goal of a LBC Certified project, the owner must task the building occupants with the same responsibility in daily operations that is required from the design team.

Embracing these responsibilities offers building owners and tenants significant opportunities to achieve a return on their investment. By greatly reducing operating costs, the life-cycle cost of the building yields quicker payback periods. Furthermore, by producing 105% of the building’s energy consumption on site, the self-sufficient building has reduced its reliability on the grid. Additionally, many building owners find enhanced branding & marketing opportunities by achieving such a goal.

To realize these benefits, building owners must first evaluate the technical feasibility of a LBC certification for their project. One of the most important technical aspects of the project is becoming a net-positive energy building; this is one of the requirements of the Energy Petal. Thus, initial inquiries should include:

- What does the organization/company hope to gain from certification?
- Does the organization embody the deep devotion to sustainability that will be required to make this a successful project?
- Is the team prepared to make an initial investment that will pay dividends in the long term?
- Is a net-positive energy target feasible for the scale and location of the project?
- Which renewable strategies are applicable to the building type and are they compatible with the Living Building Challenge?
- Are there any local incentives or rebate programs that make a certain renewable energy or high-performance building strategy attractive?
- Does the local utility allow Netmetering?

The questions above will help the client team assess the opportunities and challenges associated with the LBC Energy Petal and determine the feasibility of achieving a net-positive energy building. Refer to Chapter 2: The Process, for a comprehensive look at the steps in the process.
For the Design team, the goal of an LBC certified project is equally as ambitious as it is for the client. The design team is tasked with not only steering and encouraging the client and the contractor, but also pushing fellow design consultants to think differently. This requires an integrated design process, often called an Integrated Project Delivery (IPD), where a diverse team is engaged with the project from the beginning, when it matters the most.

Net Positive Energy can only be achieved by analyzing and optimizing each and every energy consumer within the building. From the largest energy consumers down to the smallest; no detail is too small to ignore! This is precisely why an Integrated Project Delivery is crucial to achieving the end goal. In bringing a wide range of knowledge and skill sets to the table, the team can challenge each other to think rigorously for creative solutions.

The design team must also keep the end users in mind throughout the design process. The daily operations of the building staff and users are just as important as the initial planning and design of the building. Prior to occupying the building, it is critical to teach the occupants how to best use and operate the building. This education should continue throughout the life of the building, parallel with continuous building monitoring and commissioning.

Lastly, it’s important for the design team to keep a positive and encouraging attitude throughout the process. Satisfying the requirements of the Living Building Challenge requires considerable teamwork and coordination across disciplines. The client will often question why particular decisions have been made. The design team must encourage the client to consider long-term benefits of the building, weighing the benefits of life-cycle costs. Continuously remind the entire team of the end goal – it’s not a sprint, it’s a marathon!

The next chapter contains more detailed guidelines regarding the integrated sustainable design process.

Sustainable design is beautiful, and fun to create! For designers on the architectural team it is important to recognize the aesthetic effects of sustainable strategies and implement them at the beginning of the design process: sell this to the client! The way the building is massed and oriented is molded by sustainable best practices. Sustainable materials and methods used during construction require elevated care. The use of high performance façade systems and material specifications require careful integrated design strategies with the mechanical, plumbing and electrical team. In addition, the coordination of red list materials on a project and avoiding high embodied energy should be a task that is coordinated early and often throughout the design processes.

All of these points serve as an education tool to the client. The design team should encourage the client to consider the long-term benefits of the building, the life-cycle costs of the design materials and pay-back periods when the budget conversations initiate.
2.0 Introduction

Chapter 2 describes the various steps required to complete a Net Positive Energy Building. These five steps split the design process into goal-based categories in relation to achieving the over-arching target of a Net Positive Energy Building.

- **Step 1 - Research:** Includes early information gathering which will facilitate the ease of quick decision making once the design process is underway.
- **Step 2 - Design:** The kick-off of the design process, including a full team design eco-charrette.
- **Step 3 - Optimize:** Takes the rough ideas from the Design Step and further develops the project into a refined and optimized building.
- **Step 4 - Generate:** Establishes the energy consumption from the optimized design and determines the required amount of energy production to achieve a Net Positive Energy Building.
- **Step 5 - Certify:** Ensures that the building is able to meet the Living Building Challenge, including post-occupancy monitoring and commissioning.

It is important to note the difference between the typical stages of the design process, i.e. Concept Design through Construction Documents, and the five Steps outlined in this process. The typical stages of the design process are linear phases, meaning that Conceptual Design must take place before Schematic Design, Schematic Design before Design Development, etc. The five Steps for building toward Net Positive Energy is not a linear process; rather, each Step must be considered throughout each phase of the typical design process. An example to further explain these non-linear steps is with renewable energy. Renewable energy strategies must be considered in the Research Step to best understand what renewable strategies are sensible for the project site and climate. It should be considered within the Design Step for best integrating renewable energy strategies into the design, and considered within the Generate Step to size the renewable systems to ensure Net Positive Energy is achieved. Lastly, it should be equally considered in the Certify Step for the commissioning of the systems.
2.1 Step 1: Research

2.1.1 Why researching the archetype is important

Research and pre-design of the archetype is the first and most impactful step in optimizing the building form itself and lies in the hands of the architect. Care must be taken in deciding the optimum building orientation, massing, glazing, and shading selections to ensure that the building works with the climate instead of against it. In pre-design phase, the designer must keep in mind what building materials have the appropriate thermal resistance to prevent heat loss to the outdoors during colder months while taking advantage of solar heat gain during summer months. In a heating dominated climate zone 5A this is particularly important as the heat resource provided by the sun can be a valuable ‘free’ source of heat when appropriate - an effective strategy may be to size horizontal shading depths to shade the solar oriented windows during cooling seasons, while allowing the solar heat gain into the building when the sun is lower during heating seasons. Vertical shading or blinds on the east and west facades can provide control of the large variation of solar heat gains on these orientations.

Heat is also commonly lost through air infiltration and thermal bridging. When making a building airtight, it is important to make sure that the envelope will still be able to dry out, instead of trapping water vapor inside the envelope which can cause mold or rot. Make sure to place a vapor retarder close to the source of the moisture. For example, in a cold climate it would be placed on the on the interior (warm side) of the building due to the vapor drive going from inside to outside. Care should also be taken when detailing any external connections such as wall to wall, wall to window, wall to roof, wall to slab, and wall to floor to prevent thermal bridging through the envelope. Once the thermal resistance of the envelope is maximized to the point of diminishing returns, these factors play a large role in the envelope heat loss and must be minimized.

For more on optimizing the archetype consult the [Passive House US Standard](https://www.passivehouse.org/).

1 For the purposes of this guideline, the team chose to localize research and data within climate zone 5A.

2.1.2 Climate Analysis

To deliver a Net Positive Energy building, the design team must have an in-depth knowledge of the local climate. The following is a cursory list of climate characteristics and inherent design opportunities in climate zone 5A.

**Characteristics**
- Climate - winter is potentially most dominant - the design must minimize heating energy
- Solar radiation on south/east/west walls is significant.
- Solar radiation on roofs is significant.
- Summer is hot/warm.
- Summer also has a moderate diurnal range.
- Winter is cold.
- Winter prevailing winds typically from the north.
- Summer prevailing winds typically from the south.

**Design Priorities**
- Address hot summer day comfort.
- Address hot summer night comfort.
- Minimize solar gains in summer.
- Maximize heat gain in winter.
- Minimize radiant heat risk (via solar conduction).
- Minimize summer day heating rate.
- Maximize summer evening/night cooling rate.
- Address cold winter day comfort.
- Address cold winter night comfort.
- Minimize heat loss.
- Minimize air infiltration.
- Maximize effective natural cross ventilation - day and night.
- Utilize good diurnal range potential.
- Use solar energy potential (renewables).
- Prevent rain penetration (during summer vent).
- Prevent insect access when permitting ventilation.

1 For the purposes of this guideline, the team chose to localize research and data within climate zone 5A.
2.1.3 Code Considerations: Chicago

Introduction to Illinois Energy Code

Currently, the Energy Conservation Code adopted by the State of Illinois, based on the International Energy Conservation Code (IECC) of 2015, is in effect in Chicago. The City of Chicago, however, has additional Energy Conservation Code requirements in the Municipal Code that apply as well.

To learn more about specific codes required by county, check out the following link on the Illinois Capital Development Board website. This website also has an invaluable code directory that has local contact information for each code.

Achieving a high performance building requires investment into innovative design strategies. Couple this with the fact that high performance buildings are a minority, local building code does not always align with design strategies. Despite both code and high efficient design looking to minimize risk to the occupant, local code research needs to be a priority. Consider early contact with a local code official or permit official. For example, Chicago Municipal Code requires a mandated 8% net glazing area minimum of the floor area served. Some projects may be designed to use less while also ensuring adequate light.

An example on the materials side is in the Illinois plumbing code, standards are provided for PVC and CPVC, but does not have a standard for alternative materials not listed on the materials red list. This puts the burden of proof of material compliance on the designer. If you find yourself in a situation where alternate compliance is necessary for material requirements that are not listed in the city of Chicago municipal building code, a few steps are included below to help guide you through the process.

1. Start early!
2. Gather information about the jurisdiction and applicable codes.
3. Gather information about the specific alternatives.
4. If needed, find and enlist the help of allies and sources of expertise.
5. Maintain a positive attitude and take the high road.
6. Meet and share information with the building officials.
7. Get specific feedback from the building officials – listen carefully, get it in writing.
8. This is a process of building trust – pay attention to the relationships.
9. Address concerns and objections as directly and reasonably as you can.
10. Demonstrate patience and persistence.
11. Carefully consider all your options – appeals, special agreements, political pressure.
12. Acknowledge and thank those who helped and share your lessons learned.

A focus on minimum energy compliance in the code today fast tracks projects through prescriptive design. Prescriptive design impacts the price point in two ways: it reduces design time and increases the number of companies that feel confident to bid on the project since they can follow prescriptive guidelines for building minimal compliance buildings. Since high performance buildings are not covered explicitly in building code, the time and effort on code compliance is increased. The differences between a prescriptive emphasis on minimum compliance buildings and an open ended alternative compliance path that requires review approval for each deviation from the code is inevitably related to the client as a cost premium. Look out for red list materials, local ventilation code requirements and daylighting requirements. Research the code early, be conscious of possible road blocks, and start studying early when designing your next energy efficient building in Chicago!

Additional References

A report that discusses barriers to building codes was created in 2008. Despite being outdated, many of the code barriers are still active in current codes. It can be found in the following two links:


Interested professionals are encouraged to become familiar with the Chicago Energy Conservation Code, specifically Chapter 18-13: Energy Conservation. Another resource for Chicago codes online can be found at http://www.amlegal.com/codes/client/chicago_il/.
2.2 Step 2: Design

2.2.1 Efficient Technology & Passive/Green Strategies

Once the heating and cooling load of the building has been minimized, the next step is to minimize the amount of energy needed to illuminate and condition building spaces. This step has been largely driven by energy code, which sets efficiency standards for the selection of MEP equipment. While more efficient systems are initially more expensive, simple life cycle assessment can show that the increased efficiency will save the owner money, resulting in a payback. However, the feasible payback time will be influenced by the ownership structure of the building. For example, a school or detention facility will be designed with the intention of longevity; hence a longer payback period may be more acceptable. Conversely, in a core and shell office tower where energy costs are paid by the tenants, the owner may not be as concerned with resiliency or decoupling operational costs from the large fluctuations in the energy markets.

Once the building has been optimized through energy conservation measures, passive strategies can be considered. Solar and wind resources can provide free light, heating and cooling to the building when external conditions are favorable. Effective glazing design and natural ventilation are the most common passive strategies used in modern building techniques as described in the AIA 50 to 50 Flashcards and in the book Sun, Wind and Light. It is important to note that passive strategies are not new – these are the time tested strategies used in buildings to maintain comfort in buildings before the modern day mechanical, electrical & plumbing systems existed. To utilize these strategies effectively, the designer must have an in-depth knowledge of the surrounding climate (see previous section) and use the ASHRAE 55 adaptive comfort standard instead of the traditional comfort model used for mechanically cooled buildings.

Design tip: the Energy Petal has a no combustion rule that eliminates biomass as a source for heating/energy, not just fossil fuels. However some projects qualify for a scale-jumping opportunity, which would mean that the project could scale from the Living Building Challenge program to the Living Community Challenge program, which are designed to work together.

2.2.2 Design Workflow

An integrated approach for the design workflow should be implemented from the earliest stages of the design and should encompass a sustainable vision, performance goals, a multidisciplinary project team, and clear first steps. These early stages are most effectively achieved through an eco-charrette: a workshop in which various project stakeholders and experts meet to consider design issues, brainstorm solutions and facilitate a discussion among the project team members, building users, and project management staff. This affords the team the ability to meet both the building users’ requests and the sustainability vision for the building design. At the conclusion of the charrette, the participants should have identified performance goals that meet the program needs. The following section outlines the eco-charrette process and how to best utilize this as part of the design.

2.2.3 Eco-Charrette Guidelines

The eco-charrette can be used to start creating the important sustainability and quality-of-life goals defined in the project visioning session, while also taking into consideration project specific challenges and resources. The process should help the team identify problems, develop solutions, understand technical and budgetary constraints, and establish the next steps forward towards a successful Net Positive Energy building. The following steps provide a framework for conducting a focus-eco-charrette and developing potential strategies.

The Basics

The following issues should be addressed prior to the eco-charrette:

- **Determine Attendance** - The most diverse team can result in successful brainstorming session.
  - Architects
  - Engineers
  - Owner
  - Operations & Maintenance
  - Energy Modeler
  - Sustainability Consultant
  - Contractor

- **Determine facilitator** - the facilitator runs the charrette and ensures that the overall event schedule and task progress as planned.

- **Set duration** - while an eco-charrette can vary in length depending upon the project, setting a time limit helps maintain creative bursts of energy and reduce fatigue. A duration time of 4 hours is a good starting point.

- **Address logistics** - ensure the workshop location has sufficient AV equipment, meeting supplies, conference space, and presentation space. Identify someone to create meeting minutes and have a photographer and/or equipment operators as necessary.

- **Assemble project information** - goals pertaining to operations, maintenance, process, education, and outreach should always be provided. Further relevant information depends on the scale of the project. For example, for a single building project, extensive detail should be provided about the potential sites and programmatic requirements. For a large-scale development project, less detail is needed for each individual building and more detail should be provided about the overall master plan, infrastructure, and facilities.

- **Develop an agenda** - informing participants of clearly stated goals and charrette activities will ensure the team is on the same page from the start.

The Phases

The eco-charrette outlines various phases that are recommendations in order to produce a successful Net Positive Energy design. The recommended phases outlined in the next section could be held in one larger session, or each phase could be individual sessions themselves.
• **Phase 1 – Opening Session**

  The opening session allows the team a chance to get to know one another, establish objectives, demonstrate the owner’s interest in constructing a Net Positive Energy building, and foster enthusiasm among participants. The opening session should be led by the facilitator and involve the following activities:

  • Keynote address
  • Speech given by facilitator & owner
  • Why Net Positive Energy & why LBC Energy Petal?
  • Owner’s commitment to sustainable design & occupant health and comfort
  • Team Introductions
  • Networking (an important outcome of the eco-charrette)
  • Icebreakers
  • Share individual desired outcomes

• **Phase 2 – Set Goals**

  The goal setting session communicates the various goals determined as a result of the focus group eco-charrette and provides the design team with guidelines, desired parameters, levels of importance, and information on project specific resources and obstacles. The following are examples of targets to be established while considering the focus group’s guidance during this phase:

  • Building Program Outlining
  • Orientation
  • Massing
  • Envelope Performance
  • R-Values
  • U-Values/SHGC
  • Visible Light Transmittance
  • Glazing Percentage
  • Infiltration
  • Thermal Bridging
  • Indoor Environmental Quality Goals
  • Thermal comfort

• **Phase 3 - Brainstorming**

  During the brainstorming session, the participants creatively identify solutions to problems and strategies to address specific goals. The challenges and resources associated with each task should be identified, along with the pros, cons, and budgetary impact of each idea developed to address it.

  • Define the framework for brainstorming session
  • Develop a list of action items to address required goals
  • Brainstorm strategies to address each action item (the table below is a useful tool for organizing strategies):

<table>
<thead>
<tr>
<th>CHALLENGES</th>
<th>RESOURCES TO ADDRESS SPECIFIC CHALLENGE</th>
<th>STRATEGIES</th>
<th>PROS</th>
<th>CONS</th>
<th>BUDGET</th>
</tr>
</thead>
</table>

*For a full page charrette guide, see the end of this section.

• **Phase 4 – Select Champions**

  The most effective design processes feature “champions” responsible for moving specific tasks forward as planned. Once the goals are associated with action items and planned strategies, identify champions to ensure that the first critical steps are taken and that progress is continued. The champion should be passionately involved in the project, be able to influence project decisions, and have experience with and time for the specific area of development.

• **Phase 5 – Follow Up**

  The follow-up phase is an important element of the eco-charrette. In this part of the process, confirmation is established on the project’s goals and momentum is generated for moving the project to completion. Follow-up measures can include:

  • Issue evaluation forms to participants to comment on the charrette
  • Develop executive summary including a review of the evaluations
  • Schedule follow-up meetings as needed
NET POSITIVE ENERGY DESIGN CHARRETTE WORKSHEET

<table>
<thead>
<tr>
<th>CHALLENGES</th>
<th>RESOURCES</th>
<th>STRATEGIES</th>
<th>PROS</th>
<th>CONS</th>
<th>BUDGET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individually list project and site-specific challenges</td>
<td>Individually list project and site-specific resources available to address each challenge in first column</td>
<td>Develop strategies to exploit resources to address challenges listed in prior columns</td>
<td>Evaluate the strengths of each strategy listed in third column</td>
<td>Evaluate the weaknesses of each strategy listed in third column</td>
<td>Estimate the budget impact of each strategy listed in third column; a relative estimation (e.g. $$$, $$$, $$) is sufficient at this time</td>
</tr>
</tbody>
</table>
2.3 Step 3: Optimize

2.3.1 High Performance Systems

This section applies to the actual performance of the building once built. Complex control strategies of the MEP design can ensure that the high efficiency MEP and Passive strategies engage only when needed, minimizing waste.

All the efficiency in the world will not be able to correct inadequate operation of the building once it is built. It is important that the building systems are installed as intended to ensure the building will perform as intended. MEP and Envelope commissioning can help this process. Systems are becoming more complex, especially in Net Positive Energy buildings, and typically require more complex controls strategies. Effective education and training of the building operators and occupants will help the building perform as intended.

An Energy Petal Certified building will have to provide 1 year of utility bills to prove that it is performing to the net positive requirement. To that end, accurate forecasting of energy performance is key to the success of building design. This section details a typical energy modeling workflow that can be conducted for a Net Positive Energy building.

Phase 1 - Perform a Climate Analysis

An in depth knowledge of the surrounding climate is imperative to the success of a building design. The energy modeler can provide informative climatic indicators to the design team, at the pre-design phase, so that they can create a building that works with the climate rather than against it. It is important to evaluate design challenges caused by the climatic characteristics early so that they can be considered at all phases of the design.

Phase 2 - Establish a Baseline & Identify the Largest Contributors to Energy

Once the design goals have been established, such as building type and area, the energy modeler can establish a baseline building performance (a building that could be designed to meet these goals while still meeting local code requirements). This can inform the design team on the largest sources of energy consumption, which can then be prioritized and minimized.

Phase 3 - Establish a Renewable Energy Potential & Energy Reduction Goal

Using climate specific data, the design team should forecast how much renewable energy they believe they can generate on site. This will give the design team an indication of how much the baseline energy consumption must be reduced to achieve net positive performance.

For example: If the baseline energy use intensity was forecasted to be 55 kBtu/SF and the renewable energy potential of that site was 13 kBtu/SF, then the final design must have a maximum energy use intensity of 12 kBtu/sf, resulting in an energy reduction goal of 43 kBtu/sf.

Phase 4 - Inform the Optimization of the Building Archetype

With each iteration of the geometry of the building, the energy modeler should provide feedback on how these design changes affect the energy reduction goal. The goal is to find the best orientation, window to wall ratio, shape and program for reduced heating and cooling load that the HVAC must satisfy. This is an iterative process where the architects and energy modeler must work closely to achieve optimum results.
Chapter 2

Phase 5 - Identify & Simulate Passive Strategies

Once the geometry is optimized the modeler should identify opportunities to open the building to the external environment through passive strategies when conditions are favorable. The energy modeler has the unique opportunity to determine how the geometry of the building will react to the climatic conditions and identify ways to take advantage of the natural resources outside the building. If innovative solutions are adopted here, the modeler may also need to conduct a CFD (Computational Fluid Dynamics) analysis to prove that the design concept will be successful.

For example, free cooling may be available at certain times of the year due to favorable external dry bulb temperatures in addition to humidity. The energy modeler can forecast the proportion of the year that this will be possible (approximately 20-30% of occupied hours depending on the application in 5A) by using an annual weather file to forecast how much energy a natural ventilation strategy using this free cooling would save.

Phase 6 - Inform Efficient Mechanical, Electrical & Plumbing Design

Once the archetype and passive strategies are optimized, the energy modeler should help the MEP Engineers evaluate different design options to achieve optimum performance. This will typically include the simulation of numerous HVAC options to determine which ones meet the building load with the least energy. Payback information on reduced lighting power densities can also be generated. In addition to the impact of daylight harvesting, water heaters can be compared to the analysis of different fixtures. This should result in an optimized mechanical system.

Phase 7 - Summarize Inputs & Results

At this point in the modeling process, the design should be relatively finalized and optimized due to modeling feedback. The final design should be simulated to determine the energy needed from renewables and confirm that the building is forecasted to perform to the net positive requirements. All inputs should be reconfirmed with the design team. It will be important to share all inputs and assumptions with the commissioning agent so that this informs the operational manual of the building. If the building is not operated as designed there is a larger risk of under performing.

Phase 8 - Comfort Analysis

Occupant comfort should be analyzed throughout the entire modeling process. The final design in particular should be evaluated to ensure that occupant comfort is forecasted to be satisfied. If the building has incorporated passive strategies, the Adaptive Comfort Standard should be referenced instead of the traditional PMV Standard. Please see ASHRAE Standard 55 for more information.

2.4 Step 4: Generate

2.4.1 Green Power

Deceptively seen as one of the first steps, renewable energy is the final piece of the Net Positive Energy puzzle. At this stage, minimizing the amount of energy needed to maintain comfort in the building has been the focus. As a result, less renewable power will be needed to make the building Net Positive.

Photovoltaics generate electricity on site and solar thermal systems heat water. These technologies can be incorporated into the design of the roof, external sun shades, parking canopies or elsewhere on site. Optimum orientation of the panels is an important consideration depending on the project-specific characteristics. Wind energy can also be harnessed on site. Note that vertical axis wind turbines often perform better than horizontal axis wind turbines in urban settings due to wind turbulence caused by the built environment.

The Energy Petal has a no combustion rule that eliminates biomass as a source for heating/energy, not just fossil fuels. As noted in Section 2.2, some projects qualify for a scale-jumping opportunity, which would mean that the project could scale from the Living Building Challenge program to the Living Community Challenge program, which are designed to work together.

2.4.2 Renewable Energy

Once you have an estimate of usage, the next step is to size the capacity of any renewable systems. In order to achieve positive energy, the building must produce more energy than is used for an entire year. Depending on the source of renewable energy, the building may have a deficit of electricity during some parts of the year and a surplus during others in order to satisfy the requirements. Projects must demonstrate Net Positive Energy over a 12 month period.

To be considered for certification through the Living Building Challenge all sources of electricity must be renewable. Electricity generated with equipment like cogeneration turbines and biomass boilers are efficient options, but any method that uses combustion will not be eligible for certification.

The following rules of thumb and other great resources for renewable energy and sustainable design come from The Green Studio Handbook and the Whole Building Design Guide by the National Institute of Building Sciences.
Storage

In addition to generating power, projects must demonstrate that sufficient backup battery power be installed for emergency lighting (at least 10 percent of lighting load) and refrigeration use for up to one week for greater resiliency.

Calculate the total lighting and refrigeration loads for one week and then use that number to determine your storage capacity. Convert Wh to Ampere hours by dividing by your systems voltage. Once you have the total amperage hours, calculate how many units you need by dividing by their individual capacity.

Solar

Things to consider:

- Area available
- Angle of panels
- Orientation of panels
- Solar access (shading by nearby buildings, trees, etc.)
- Efficiency of solar panels

For an accurate estimate for the output of your array a good resource can be found here: [http://pvwatts.nrel.gov/](http://pvwatts.nrel.gov/)

For a quick rough estimate of the area required for a PV array, that can be used for Schematic Design, use the following equation:

\[
A = \frac{C}{3.3}
\]

- \(A\) = required area of PV module in SF
- \(C\) = desired PV system output in W

This equation assumes a PV efficiency of 4%

Divide the result by 2 for 8%, 3 for 12%, or 16 for 16%

An example of a case study that utilized this resource to reach net positive is the Bullit Center. See Chapter 3 for more information.

Wind

Things to consider:

- Average annual wind speed for the site should be at least 9 mph
- Site should be at least 1 acre
- Wind speeds increase with higher altitude
- Aesthetics of wind turbines on your site
- Level of wind turbulence

Turbines range in size and output. After determining that space and wind resource requirements are sufficient, design teams can select the appropriate unit for the project.

An example of a case study which integrated wind turbines successfully is the Oklahoma Medical Research Foundation.

2.4.3 Alternative Sources

The alternative sources discussed below have yet to be used in a project to secure Energy Petal Certification. However, small scale hydro and geothermal are allowed as long as they do not disrupt an ecosystem and involve no combustion.

Hydropower

Hydropower has been used for centuries to power buildings and processes. It is frequently associated with large scale hydroelectric dams, but there are also micro-hydro turbines that can be used to power individual buildings.

Most hydro turbines will require a head distance (the measure of the vertical distance between the intake and turbine exhaust) of at least 3 feet. Small scale hydro turbines will produce up to 100 kW. Medium scale turbines may go as high as 15 mW.

Geothermal

This type of resource can be utilized on a case by case basis. Typically, for electrical generation the source needs to be hot enough to produce steam, around 107–181 degrees Celsius. However, for uses other than electrical generation, energy stored in the earth can be used in a variety of ways to help reduce overall building energy expenditures without reaching the 107 degree threshold.
2.5 Step 5: Certify

2.5.1 Certification Process

At the point of registration, a team provides known project details, including the project’s typology and transect. In addition, project team members join the Living Building Challenge Community and gain access to online support resources. Ideally, project registration should take place prior to the onset of the design process, but this is not required.

Once registered, a project team can begin organizing and submitting documentation. A project team can elect to receive additional support at the beginning of, or during its design process by choosing from a menu of technical assistance services offered by the Institute. As questions arise, project teams can submit requests for technical clarifications to the Institute via the Dialogue, or refer to the Institute’s array of resources.

A project team continues the documentation process through the project’s construction phase and its operational phase: twelve consecutive months of operation, during which project performance data is recorded. Once the operational phase is complete, a project team may submit data for audit. Prior to the audit, certification fees are submitted and are based on project type and size.

Project teams pursuing full certification (or “Living” status) may opt to undergo a separate preliminary audit to receive a conditional assessment of imperatives whose requirements are less likely to be impacted by the operational phase. You can learn more about the two-part certification process here.

Once the Institute verifies that all documentation has been submitted, an independent auditor performs a content review of the documentation followed by a project site visit. Following the site visit, the auditor compiles a final report. The Institute then reviews the auditor report, notifies the team of the audit results and certifies the project accordingly. Pricing information for the verification and auditing can be found here.
2.5.2 Energy Petal Required Documentation

**General Requirements**
- General Project Information Summary
- General Project Documentation

**Case Study Questionnaire**
Project Teams must complete the [20-1 Case Study Questionnaire](#) for each Imperative submitted for audit. Documentation that is likely to be used as supplemental case study content is noted in that questionnaire.

**Basic Documentation**
A detailed brochure for basic documentation can be found [here](#) (refer to page 12 for the Energy Petal required documentation. All projects require the basic documentation outlined, unless noted otherwise:
- Energy Narrative
- Energy System Schematic
- Photographs
- Energy Bills
- Energy Production and Demand Table
- Resilient Energy Storage Documentation

**Exception Documentation**
Projects that use exceptions to compliance paths that are not standard for all projects require additional documentation.

**Net-Zero Energy Building Certification**
For Net-Zero Energy Building Certification, follow this [link](#).
Chapter Three

Considerations for your Building Type

3.0 Introduction

The process we outlined in chapter two of this guide will not go exactly the same for every project. No two buildings are exactly the same and the differences become even greater when comparing different building types, such as K-12 education and hospitality. For this reason we have tried to provide additional information on several of the major types. Each one has its own challenges and opportunities based on factors such as their occupancy patterns and typical massing. The intent of this section is not to design a prototype for each building type, but to bring to your attention some of the key considerations when approaching each from the perspective of energy performance. As you read this section refer to the case studies per building type to see specific examples of some of the principles that we have outlined.

CBECs Data

Each building type is paired with CBECs data (2012). The graphic outlines the typical building loads specific to each building type, based on operating schedule and the percentage of electrical demand by end use. This allows the design team to consider the trends in building loads per building type when designing for optimum energy performance. Each sub-category: heating, cooling, lighting, plug loads, hot water, ventilation, and cooking and prep is compared to each other based on the electrical demand by end use as well as the natural gas demand by end use. This distinction between how much energy is used through electric loads versus gas loads is an important design consideration when designing for energy conservation and production.

3.1 K-12

K-12 school buildings are typically owned and operated by the same entity, therefore any predicted energy use will have a direct impact on the owner. While financial budgets are typically low for these types of facilities, the value proposition for a Net Positive Energy Building has much merit. With fuel prices rising and future cost uncertainty growing, a Net Positive Energy building is decoupled from fluctuations in energy prices by generating power on site. On-site power generation also offers resiliency against future power outages, offering teachers and students an operational facility even during grid failure. A Net Positive Energy building can also be used as a teaching tool, to educate students on environment and the innovative methods to protect it.

Note: this data represents the typology average energy consumption, to be used to inform research and strategies - remember that no combustion is allowed in order to be considered for petal certification.
Considerations for Designers

ARCHITECTS

Fostering student achievement is the main goal of a K-12 facility. Architects should optimize daylighting through effective glazing strategies. Careful consideration should also be given to prevent over-glazing and glare control. Refer to the study by Terrapin Bright Green that details the dollar value of optimizing interior environments.

MECHANICAL ENGINEERS

High occupancy density (>25 people per room) and summertime closures are characteristics of a K-12 building. These spaces have an inherent high ventilation load, which can be a challenge in a location with a low amount of economizer hours, however reduced summertime utilization facilitate a reduced need for cooling.

ELECTRICAL ENGINEERS

K-12 facilities often have numerous spaces that are used sporadically. Occupancy control strategies will prevent unnecessary use of electricity. For daylighting control, optimize dimmable ballasts and occupancy sensors with required design lighting levels. Typically featuring flat, open roof construction, K-12 facilities can offer excellent solar opportunities as well.

LBC Examples (case studies on the following pages)

- Bertschi Living Building Science Wing - Seattle, WA
- Hawaii Preparatory Academy Energy Lab - Kamuela, Hawaii
- Sacred Heart Lower and Middle School Stevens Library - Atherton, CA

K-12 case study

BERTSCHI LIVING BUILDING SCIENCE WING

LOCATION: Seattle, Washington

SUMMARY: Bertschi School Living Science Building, located in Seattle’s Capitol Hill Neighborhood, was one of the first projects in the world to pursue the Living Building Challenge v2.0 criteria and the first to achieve it. This non profit elementary school science wing was collaboratively designed with the students’ input and pro-bono by the entire design team. A 20 kilowatt PV system produces all of the electricity for the building and allows students to participate in real time monitoring of the building’s energy use and solar power production. All the water needed for the building is collected and treated on site. This is done through a variety of methods including cisterns for storage, an interior green wall of tropical plants which treats grey water and a composting toilet to treat black water. The most important aspect of the project is that all sustainable features are visible and functional to students to learn ecological concepts that can become intrinsic values for future generations.

ENERGY PETAL KEY FEATURES:

CONSERVATION:
- Natural ventilation
- Cellulose wall insulation
- Daylighting
- Radiant floor heating
- Energy recovery ventilation
- Real time energy monitoring

PRODUCTION:
- 20.1 kW rooftop mounted PV system with 225 W Sanyo panels
- Enphase micro-inverters

SOURCES:
- http://living-future.org/case-study/bertschiscience#energy

CERTIFICATION:

- Certified Living, Living Building Challenge
HAWAII PREPARATORY ACADEMY ENERGY LAB

LOCATION: Kamuela, Hawaii

SUMMARY: The new Energy Lab at Hawaii Preparatory Academy functions as a zero-net-energy, fully sustainable building. The project’s fundamental goal is that of educating the next generation of students in the understanding of environmentally conscious, sustainable living systems. The project targeted, and subsequently achieved, LEED Platinum and Living Building Challenge certification. Completed in January 2010, the Energy Lab today strives as a living laboratory, furthering its educational goals as a functioning example of sustainability. Students are surrounded by the systems that they study, and constantly reminded of their methods. Hawaii Prep’s Energy Lab offers a continuous sustainable ‘teaching moment’.

ENERGY PETAL KEY FEATURES:

CONSERVATION:
- Radiant cooling
- Chilled water
- Natural ventilation with automated louvers
- Automated building controls
- Daylight harvesting
- Real time energy monitoring

PRODUCTION:
- 10.8 kW PV with built-in inverters at the north array
- 12.6 kW PV with SMA inverters at the central array
- 2.73 kW PV panels with SMA inverter

CERTIFICATION:
- Certified Living, Living Building Challenge

SOURCES:

SACRED HEART LOWER AND MIDDLE SCHOOL STEVENS LIBRARY

LOCATION: Atherton, California

SUMMARY: This project includes 4 buildings totalling 11,935 SF as part of the lower and middle school. The primary mission of this high-visibility campus hub is to teach the students about being stewards of our planet. In support of that mission, a key goal was to display the ways in which its construction and daily operations contribute to the school’s ethos of conservation and stewardship.

ENERGY PETAL KEY FEATURES:

CONSERVATION:
- Indirect and direct evaporative cooling
- Heat pump as a renewable energy source
- Displacement ventilation
- Low-flow water fixtures
- High-performance envelope
- Shading systems & solar tubes
- Low power density lighting systems
- Daylight monitoring systems
- Lighting occupancy sensors
- Energy monitoring systems

PRODUCTION:
- 53,188 kWh from a 42.5 kW PV solar array

CERTIFICATION:
- Certified Living, Living Building Challenge

SOURCES:
3.2 Higher Education

Considerations for Clients

University buildings are typically owner occupied, which puts the client in a beneficial position to gain long-term benefits from achieving the LBC Energy Petal. Clients can track and control energy and occupant behavior, including long-term maintenance, life-cycle processes and post-occupancy studies. Campuses can particularly benefit from district-wide green energy strategies, such as central utility plants, wind turbine farms, PV solar array grids, geothermal and rainwater harvesting networks. The client may consider looking at the campus as a regional net-positive and carbon neutral network to maximize value to the University. Middlebury College in Vermont, Oberlin College in Ohio and the Cornell Tech Campus in NY have all successfully pursued similar strategies.

Considerations for Designers

ARCHITECTS

Higher education building types have a wide array of programs, including living/learning communities, dining halls, and academic facilities – the design should be unique to each type and respond to whether the program type is internally or externally loaded.

MECHANICAL ENGINEERS

Current trends in LBC case studies in higher education include high performance systems, airtightness in facades, and a focus on occupant behavior. This includes a need for detailed energy modeling and building commissioning to ensure maximum value. The mechanical engineering team may consider the use of chilled beam systems, displacement ventilation, heat recovery chillers, variable-refrigerant-volume air source heat pumps, and heat-recovery ventilation – all of which can be designed to provide year round building conditioning with minimal energy consumption.

ELECTRICAL ENGINEERS

Current trends indicate the use of PV arrays, solar canopies and high efficiency lighting to achieve Energy Petal Certification. Keys to success among current case studies include close monitoring of energy usage and proper faculty, owner and occupant training. The electrical team may consider detailed monitoring of the total electrical consumption and photovoltaic electrical production over one-year periods in order to track energy usage, including utility statements and building monitoring data loggers.

LBC Examples (case studies on the following pages)

- Deep Green Student Residence - Berea, KY
- Living Learning Center - Eureka, MO
- UIUC, Electrical & Computer Engineering Building - Champaign, IL

Note: this data represents the typology average energy consumption, to be used to inform research and strategies – remember that no combustion is allowed in order to be considered for petal certification.
### BEREAL COLLEGE - DEEP GREEN STUDENT RESIDENCE

**LOCATION:** Berea, KY

**SUMMARY:**
The Deep Green Student Residence on Berea College’s campus is approximately 40,000 GSF and includes an academic space for 120 students within the student residence. It has been certified ‘Petal’ and included many on-campus workshops and charrettes in order to achieve the administration and certification goals. Hastings & Chivetta Architects and Hellmuth & Bicknese Architects partnered to collaborate on the planning and design process, consisting of many working groups, surveys, and the use of social media.

**CONSERVATION:**
- Closed loop geothermal system
- Increased insulation
- Heat-reflective roof
- High-efficiency windows
- Daylighting
- Energy efficient appliances
- High-efficiency lighting
- Rain gardens

**PRODUCTION:**
- 50 kW solar panel array producing 14% of the building’s annual energy usage

**CERTIFICATION:**
- Certified Petal, Living Building Challenge
- LEED Platinum

**SOURCES:**

### LIVING LEARNING CENTER AT TYSON RESEARCH CENTER

**LOCATION:** Washington University, Eureka, MO

**SUMMARY:**
This 3,000 SF building is a certified “Living” building through the use of net-zero energy by PV panels, potable water by rainwater harvesting, greywater treated in infiltration gardens, and composting toilets. The proper faculty and owner training throughout the design process was very important to the certification process. The operational efficiency combined with the electrical production from photovoltaic solar panels were the key energy features.

**CONSERVATION:**
- Variable-refrigerant volume air source heat pump
- Heat-recovery ventilation
- Detailed energy models
- Utility logging

**PRODUCTION:**
- PV panels

**CERTIFICATION:**
- Certified Living, Living Building Challenge

**SOURCES:**
Higher Education case study

UIUC ELECTRICAL & COMPUTER ENGINEERING BUILDING

LOCATION: Champaign, IL

SUMMARY: This 230,000 GSF academic building on University of Illinois at Urbana-Champaign’s campus features a 400 seat auditorium, faculty offices, large community gathering spaces, 280 graduate student workstations and 45 instructional and research labs. It recently opened in time for the 2015 school year, and achieved LEED Platinum in addition to aspiring to a Net Zero Energy rating. SmithGroup JJR are the architects of record, and strived for energy efficiency not only as a priority but as a design driver. The building will use 50% less energy than the standards established in ASHRAE 90.1-2007, quite an achievement considering the nature of a laboratory building is very energy-intensive. The 3-story solar canopy supports the remaining energy consumption.

ENERGY PETAL KEY FEATURES:

CONSERVATION:
- High Performance Rainscreen System
- Chilled Beam System
- Displacement Ventilation
- Heat Recovery Chillers

PRODUCTION:
- 3-Story Solar Canopy

CERTIFICATION:
- Registered Net-Zero
- LEED Platinum

SOURCES:

3.3 Commercial/Retail

Considerations for Clients

The development of net-zero commercial and retail buildings is in its nascent stages, with few existing examples - but many in the works. Responsible for the highest energy costs of the 5,000,000+ commercial buildings in the United States, retail stores offer a strong candidate for implementing net-positive standards that will have a significant global impact. These buildings frequently feature energy-intensive lighting and refrigeration usage, and require careful planning and a holistic approach to achieve Living Building certification.
Considerations for Designers

ARCHITECTS

Providing customers with a comfortable and compelling shopping experience while capturing the interest of potential shoppers is a major goal for retail business owners in a climate of growing online shopping. Architects should optimize massing and orientation and consider operable glazing, dynamic shading, and canopy roofs to maximize natural light and ventilation to provide an inviting, comfortable yet sustainable environment. High performance facades ensure air-tightness and are a crucial step to sustainable retail building design.

MECHANICAL ENGINEERS

Recent approaches to achieving net positive energy certification for retail buildings entail high performance systems with airtight facades, and a focus on detailed energy modeling and enhanced commissioning. The mechanical design may utilize equipment such as radiant panels, chilled beams, heat recovery chillers, variable-volume refrigerant units, and geothermal systems. Refrigeration is also of particular significance in retail applications; strategies including CO2 refrigerant and geo-exchange systems can dramatically reduce energy without relying on harmful HCFCs.

ELECTRICAL ENGINEERS

Common approaches combine efficient LED lighting with daylight harvesting and control, and renewables including photovoltaic arrays and wind turbines with grid-based storage to achieve Net-Positive Energy certification.

LBC Examples (case studies on the following pages)

- Bertschi Living Building Science Wing, Seattle, WA
- Hawaii Preparatory Academy Energy Lab, Kamuela, Hawaii
- Sacred Heart Lower and Middle School Stevens Library, Atherton, CA

NET-ZERO WALGREENS

LOCATION: Evanston, IL

SUMMARY: Sporting two wind turbines, nearly 850 solar panels and a geothermal system burrowed 550 feet into the ground, the Walgreens Net Zero store is the nation’s first net zero energy retail store, anticipated to produce energy equal to or greater than it consumes. The use of innovative refrigerant management systems and extensive use of daylighting design demonstrates the feasibility of zero net energy design even with unavoidable energy-intensive end uses.

ENERGY PETAL KEY FEATURES:

CONSERVATION:
- LED lighting
- Dimming controls
- Daylighting controls

PRODUCTION:
- 550’ Geothermal wells
- 800+ Solar panels designed for 220,000 kWh/yr
- Wind turbines

CERTIFICATION:
- Net-zero

SOURCES:
Designed by Farr Associates and dbHMS, Harmony House for Cats’ brand new shelter is Chicago’s first commercial building designed for zero net energy (though not certified) that has achieved LEED-NC Platinum certification. Adorned with a striking bright orange and white exterior, the 7,085 square foot single-story building on the city’s north-west side provides state-of-the-art facilities for its feline residents, featuring intelligent daylighting design and an array of geothermal wells, solar thermal panels, and photovoltaic cells.

**CONSERVATION:**
- Daylighting design
- Solar thermal panels

**PRODUCTION:**
- PV Cells
- Geothermal wells

**SOURCES:**

**CERTIFICATION:**
- Certified LEED NC-Platinum

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### 3.4 Workplace

**Average Energy Consumption in MMBtu**

- **Electric**
- **GAS**

**PETAL KEY FEATURES:**

- **CONSERVATION:**
- **PRODUCTION:**

**Considerations for Clients**

Net Positive Energy in the commercial office sector is gaining steam; more and more corporations are realizing the benefit of sustainability in the marketplace. High performance office environments not only reduce costs, but also improve productivity, increase the chance for daily attendance and improve the well-being of occupants. Enhanced lighting & air quality can be achieved while also improving energy efficiency; don’t forget, instilling an energy saving culture in an office environment can be the greatest energy saving measure!
Considerations for Designers

ARCHITECTS

For office design, the design team must strike a balance between the quality of indoor environment and the building envelope. Most recent research has defined a direct relationship between the internal environmental quality of office environments and employee satisfaction. This research suggests optimizing internal environments will lead to increased employee productivity and retention. Careful planning for daylighting without glare can reduce lighting loads. Optimization of the aspect ratio of the floor plates can also drive lighting load reduction. Consider the R-value, glazing percentages, and glazing properties independently for each facade orientation.

MECHANICAL ENGINEERS

In offices, designers must remember that a more efficient piece of equipment might not have the most impact in reducing site energy use. In new construction, an engineer might have the ability to discuss with the architect different glazing, shading, and orientation of a building. If the office is a retrofit, the client may have limited control over the base systems. Make sure to have a full understanding of what is in place and how this will affect your energy conservation goals. Options for efficient HVAC systems include VFD, inverter compressors and water side economizers, etc. Regardless of the system selected, using demand controlled ventilation can optimize the amount of outdoor air required to be conditioned. Incorporating CO2 sensors that monitor indoor air quality can also impact energy usage.

ELECTRICAL ENGINEERS

Other areas to consider are plug loads from printers, computers & appliances. Investment in occupancy sensors, lighting controls, photo sensors and automatic timer devices will reduce operational energy, as well as potentially reduce the required capacity of the heating & cooling system.

LBC Examples (case studies on the following pages)

- NRDC Midwest Offices - Chicago, IL
- Bullitt Center - Seattle, WA
- DPR Construction Office - Phoenix, AZ
**Bullitt Center**

**Location:** Seattle, WA

**Summary:**

The Bullitt Center is a six-story commercial office building in the Central Area of Seattle, WA. The Center is home to a number of commercial office tenants who are successfully operating their businesses, while working in a net-positive energy environment. The Bullitt Center aims to advance the awareness and adoption of high-performance building through ongoing educational efforts, and by demonstrating that performance-based design works in a market-rate commercial project.

**Energy Petal Key Features:**

- Rainwater collection
- On-site infiltration of grey water
- No red list materials
- Daylighting
- Heavy timber structure
- Ground source heat exchange system

**Production:**

- PV rooftop solar array, 575 PV panels total
- Surplus of 90,793 kWh of electricity (60%)
- Operated with actual EUI of 10

**Certification:**

- Certified Living, Living Building Challenge

**Sources:**


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**DPR Construction’s Phoenix Regional Office**

**Location:** Phoenix, AZ

**Summary:**

DPR Construction’s new office is a unique example of urban revitalization and sustainability. DPR incorporated passive/active cooling solutions including 87 operable windows, four shower towers, an 87 foot long, zinc-clad solar chimney, and a 79 kW-dc rated photovoltaic solar panel covered parking lot to control the indoor environment naturally and produce energy on site. A Lucid Building Dashboard system is utilized to allow DPR to monitor and share building water and gas usage, lighting and power consumption, and photovoltaic energy production in real time.

**Energy Petal Key Features:**

- Climate controlled operable windows
- Dashboard system to monitor and share building water, power and gas usage
- Site meets the Limits to Growth Imperative
- Vampire switch to control nighttime plug loads
- Daylighting

**Production:**

- Solar thermal hot water system
- PV array over parking structure functions dually as a shading structure and maximize the amount of Solar tube skylights on roof
- Net excess generation of 6,980 kWh

**Certification:**

- Net Zero Energy Building

**Sources:**

- [http://living-future.org/node/137/#Limits to Growth](http://living-future.org/node/137/#Limits to Growth)
CHAPTER 3
IMPLEMENTATION GUIDE

3.5 Hospitality

The hospitality sector has been slow to adopt any measures that would lead towards Living Building certification. There are several perceptions in the industry linked to this type of investment:

- Perception that green costs more.
- Difficulty of implementing procedural changes if the developer, owner, and manager are distinct entities. Each entity has different financial drivers.
- Location, climate, size, and brand are variables that limit and restrict successful high performance hotel design, construction, and operations.

However, these perceived barriers should not prevent hotel projects from achieving the Living Building Challenge. The market is always changing and consumers now see added value from sustainable practices.

ARCHITECTS

Controlling occupant behavior to improve energy efficiency in hotels while maintaining high standards of comfort that the occupants expect from a hotel is important. Specific strategies to reduce energy use in hotels center on automatic controls that utilize sensors or other means to control systems. Occupancy sensors for lights and thermostats, ventilation that is controlled by CO2 sensors, and key cards that are directly linked to the room power have all been proven as effective ways to reduce energy use.

MECHANICAL ENGINEERS

Hotels pose significant challenges to provide individualized control of heating and cooling for each room and maintain high levels of efficiency. In the past, this has been accomplished with through wall units for each room, but hotels that have been more successful at conserving energy have transitioned to centralized systems that are zoned appropriately. Hot water usage is also high in hotels. Solar hot water systems work well to reduce much of the energy usage.

ELECTRICAL ENGINEERS

Hotels are a twenty-four hour occupancy building and rely heavily on electric lighting. Always use high efficiency lighting systems and coordinate occupancy sensor strategies wherever possible.

LBC Examples (case studies on the following pages)

- Hotel Skyler – Syracuse, NY
- Proximity Hotel – Greensboro, NC
- Explorer Hotel - Oberstdorf, Germany
**Hotel Skyler**

**Location:** Syracuse, New York

**Summary:** Hotel Skyler is a LEED platinum hotel that is also an adaptive reuse project. The energy conservation measures in the hotel reduced usage compared to a typical building by 60%. Hotel Skyler consists of 58 keys, using a key card energy management system to conserve energy.

**Energy Features:**

- Conservation:
  - 63 ton closed loop geothermal heat pump system
  - Key card energy management system

- Production:
  - N/A

**Certification:** Certified LEED Platinum

**Sources:** [http://www.hotelskyler.com/](http://www.hotelskyler.com/)

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**Proximity Hotel**

**Location:** Greensboro, North Carolina

**Summary:** Proximity Hotel was the first LEED Platinum hotel, an honor that has only been granted to a few other hotels since its accomplishment. It falls short of being a net positive building, but it is a great project to learn from. The hotel uses 39% less energy than a typical hotel. Proximity Hotel consists of 147 keys and uses a key card management system to conserve resources.

**Energy Features:**

- Conservation:
  - 39% reduction in energy use by using efficient materials
  - Regenerative drive elevators
  - Variable speed hoods in restaurant
  - Energy recovery units used for guest room ventilation
  - Natural lighting in 97% of spaces

- Production:
  - 100 solar panels covering the 4,000 SF rooftop in order to produce hot water

**Certification:** Certified LEED Platinum

**Sources:** [http://www.proximityhotel.com/LEED_platinum.htm](http://www.proximityhotel.com/LEED_platinum.htm)
EXPLORER HOTEL

LOCATION: Obersdorf, Germany

SUMMARY: The Explorer Hotel Oberstdorf is the first certified passive Hotel worldwide. It is a climate-neutral or zero emissions building that uses renewable energy, biogas and electricity from its own photovoltaic and river hydropower. In contrast to comparable hotels it uses 70% less total energy including 85% less heating energy.

ENERGY PETAL KEY FEATURES:

<table>
<thead>
<tr>
<th>CONSERVATION:</th>
<th>PRODUCTION:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 3 large ventilation units with a rotary heat exchanger</td>
<td>• PV system producing 68,000 kWh</td>
</tr>
<tr>
<td>• Efficient building envelope</td>
<td>• River hydropower</td>
</tr>
</tbody>
</table>

CERTIFICATION:

- Certified Passive House

SOURCES:

3.6 Residential

Across the country there are residential buildings achieving net-zero energy standards and Living Building Challenge certification, proving that it is possible to achieve these stringent energy levels.

The owner of the residential unit is in a unique position to influence the decisions made for the design of the residence(s). Thus, energy conscious owners can follow suit with the corresponding design considerations to reach a Net Positive Energy building. If these residences have utilities connected to the grid, excess energy may be stored in the utility power grid. This option is available if the PV system produces more energy than the home uses and thus is able to sell energy back to the grid.
MISSION ZERO HOUSE

LOCATION: Ann Arbor, Michigan

SUMMARY: The Gorcoff family occupies this historic 1901 single family home. The 1,500 sq. ft. home is designed to weather the four distinct seasons of Ann Arbor, Michigan while preserving the heritage of the building without expanding the footprint. The intent of the Gorcoff’s is to prove that a home is more than four walls, but a space to cultivate and sustain community.

ENERGY PETAL KEY FEATURES:

CONSERVATION:
- Optimal solar orientation
- Wall/Floor insulation
- Windows/Sealing system
- Efficient systems, appliances, and controls

PRODUCTION:
- 8.1 kW PV panel system
- 8,939 kWh
- Net Energy Generated = 295 kWh/yr

CERTIFICATION:
- Certified Net Zero Energy

SOURCES:

ARCHITECTS

For every decision, there should be great consideration for the occupants of this building type. The occupant behavior in the residences is vital to the overall energy use of the building. The residences should be designed for high levels of comfort, health, and durability. This creates a peaceful indoor environment while placing less stress on the outdoor environment. Be conscious of the materials that are selected for construction by taking into consideration the life cycle analysis.

MECHANICAL ENGINEERS

Appropriate sizing of the mechanical equipment is vital for reducing the building’s demand for energy. Automated thermostats can aid in tightening the occupant control on a space. Evaluate mechanical systems through life cycle analysis. For example, DX (Direct Expansion) units are typically less costly but also less efficient than their VRF (Variable Refrigerant Flow) counterparts.

ELECTRICAL ENGINEERS

A key characteristic for this building type to consider is that residential units are typically operated 24/7, year-round. Incorporating an energy management system where there is real-time tracking of the energy use can help with occupant behavior. Occupancy or vacancy controls on lighting systems can reduce the impact of occupant behavior. Most buildings in the residential sector, after reducing the demand-side energy, bring their energy use to Net Positive through photovoltaics.

LBC Examples (case studies on the following pages)

- Mission Zero House – Ann Arbor, MI
- 2home – Issaquah, WA
- Healthy Efficient Homes – Spirit Lake, IA

Considerations for Designers

For every decision, there should be great consideration for the occupants of this building type. The occupant behavior in the residences is vital to the overall energy use of the building. The residences should be designed for high levels of comfort, health, and durability. This creates a peaceful indoor environment while placing less stress on the outdoor environment. Be conscious of the materials that are selected for construction by taking into consideration the life cycle analysis.

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**zHOME**

**LOCATION:** Issaquah, Washington

**SUMMARY:** zHome is a ten-unit townhouse project designed to achieve net-zero energy standards. One of the units is being used as a long-term education center and will become an affordable housing unit by 2016. This project is out to prove that "homes that use zero net energy and 60% less water, emit net zero carbon emissions, have clean indoor air and use only low-toxicity materials are possible and scalable to mainstream home production."

**ENERGY PETAL KEY FEATURES:**
- Efficient building envelope
- Common ground loop heat exchanger
- Water furnace heat pump
- In-floor hydronic tubing under slab
- Bamboo flooring
- Heat recovery ventilation
- Natural cooling ventilation
- Energy feedback monitors
- Phantom load switched outlets

**PRODUCTION:**
- Solar Electric Production per unit
- 240 W panels with micro-inverters

**SOURCES:**

**CERTIFICATION:**
- Certified Energy Petal, Living Building Challenge

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**HEALTHY EFFICIENT HOMES**

**LOCATION:** Spirit Lakes, Iowa

**SUMMARY:** The first U.S. Department of Energy (DOE) Zero Energy Ready certified home built by custom home builder Jim Johnson with Healthy Efficient Homes LLC. This four-bedroom, three-bath, 3,048 sq. ft. one-story home may not be certified as net-zero but carries key features that make a great case to achieve the net-zero energy standard in the future. Johnson, a builder of his own past 10 homes, said that his experience with his first DOE Zero Energy Ready Certified Home was a good one and plans to build more while encouraging others to do so as well.

**ENERGY PETAL KEY FEATURES:**
- Efficient building envelope
- 2 solar thermal collectors for 90% average usage of water
- SEER 17 mini-split heat pump
- Radiant floor heat with modulating 92% efficient gas boiler
- Electric fan with HEPA filter
- 95% LED lighting

**PRODUCTION:**
- 4 kW PV system, wired for internet connection
- 32 SF solar hot water panels
- Annual Energy Savings = 16.4 Mbtus
- Projected Annual Energy Cost Savings = $5,280

**SOURCES:**

**CERTIFICATION:**
- Certified DOE Net Zero Energy ready home
The Living Building Challenge Collaborative: Chicago is a group of industry members from across the city who share the same goal of advancing the Living Building Challenge. We meet quarterly to discuss best ways to further this mission. Find us through our Facebook page!

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