Located 15 miles from the nearest public library, the community saw its children slipping on reading scores because they lacked access to the library district’s summer reading programs. Gradually, families were moving away from Chrisney, their children never to return.

The town realized it needed a library—a new source of pride and a center for community. What it ended up with was a net zero energy library.

Nearly a quarter of Chrisney’s residents attended the first public meeting in 2007 to discuss the prospect of establishing a public library, but the town did not have the funds to pay even a single staff person. The community leveraged its social capital to overcome the fact that it lacked a building, a site, funding, or support from their library district to construct a branch.

Community members supported the building project via donations, phone calls, letter writing campaigns and pursuit of grants. The community honed in on the notion of a library that could produce as much energy as it required to operate. The net zero energy concept was conceived as a way to appease the library district that did not want the operating expenses of a new building.

As momentum built, others stepped up to lend support. The town of Chrisney agreed to donate free water and sewer services for the life of the building.

“We received donations from all across the country and we had volunteers ready to work at the library at a moment’s notice,” recalls Kim Litkenhus, Town Clerk-Treasurer.

“We were so fortunate to have the opportunity for social and economic investment has not been knocking. This community of fewer than 500 has been in a gradual economic decline over the past several decades. Having already lost its high school in the 1970s due to a push for school consolidation, the town took another blow in 2011 when an expansion of U.S. 231 rerouted the four-lane corridor around the town, which was once a thriving rural community in southern Indiana.
The library, which is staffed by volunteers, also serves as a wireless Internet hot spot and as a community gathering space. The library plans to host more community events in the future, including a farmer’s market and musical performances.

### Building Structure

The 2,400 ft² facility met the town’s need for a public branch library that can also function as a community meeting space and classrooms for summer reading programs. The building affords the functions of the library — complete with collection and reading space, a circulation desk, work areas, an office, restrooms and mechanical space. The pavilion is adjacent to the elementary school’s outdoor lab and serves as an open-air classroom and public meeting space.

The library uses a highly efficient building envelope with selective apertures to facilitate daylighting. A modest conditioned volume helps reduce heating and cooling loads. The basic R-25 wall construction consists of wood framing with polyurethane foam insulation. Outboard of the framing is fiber cement lap siding over extruded polystyrene (XPS) rigid foam and oriented strand board (OSB) sheathing. The interior is sheathed with gypsum board. In addition to the insulated slab-on-grade foundation, the R-33 roof assembly consists of 12 in. of cellulose at an 11 ft high gypsum board ceiling.

The design team used daylight studies to analyze the project’s solar access and interior illumination during various conditions and incorporated exactly the amount of glazing needed, and nothing more. The result is a 19.5% glazing percentage with operable windows to allow natural ventilation during mild seasons. High ceilings and T-shaped window openings maximize high daylight sources that reduces glare and maximizes daylight penetration.

### Carbon Reduction Strategies

- **Daylighting** Glazing with a low solar heat gain coefficient; generous exterior windows and high ceilings to increase day lighting; and tubular skylights with remote dimming controls for presentations.
- **Indoor Controls** Occupancy sensors to monitor and control artificial lighting to maximize energy savings.
- **Other Major Sustainable Features**
  - **Building Location** Located in a grove of 100-year-old oak trees, which help reduce summer cooling demand. Carpeting, shingles, and siding manufactured from recycled materials. Natural ventilation. Optimized building envelope.

### Energy at a Glance

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Energy Use Intensity (EUI) (Site)</td>
<td>16.7 kBtu/ft²</td>
</tr>
<tr>
<td>Annual Energy Cost Index (ECI)</td>
<td>$0/ft²</td>
</tr>
<tr>
<td>Annual Net Energy Use Intensity</td>
<td>16.7 kBtu/ft²</td>
</tr>
<tr>
<td>Annual Energy Use (monthly utility service charge of $23 not included)</td>
<td>$1,100</td>
</tr>
<tr>
<td>Annual On-Site Renewable Energy Exported</td>
<td>17.4 kBtu/ft²</td>
</tr>
<tr>
<td>Annual Energy Use Intensity</td>
<td>0.76 kBtu/ft²</td>
</tr>
<tr>
<td>Heating Degree Days (Base 65°F)</td>
<td>5,179</td>
</tr>
<tr>
<td>Cooling Degree Days (Base 65°F)</td>
<td>1,458</td>
</tr>
<tr>
<td>Annual Hours Occupied</td>
<td>1,100</td>
</tr>
</tbody>
</table>

### Water at a Glance

- **Annual Water Use (Data not available since the town of Chrisney provides free water):**

### Key Sustainable Features

- **Water** Bioswales; water-efficient, low-flow fixtures; instantaneous hot water.
- **Materials** LEED specifications were used to create minimum requirements for recycled materials, regional materials, durable materials, low life-cycle cost, low toxicity, and contribution to an integrated strategy for net zero energy.
- **Construction Waste** Separate site dumpsters for recyclables.
- **Daylighting** Glazing with a low solar heat gain coefficient; generous exterior windows and high ceilings to increase day lighting; and tubular skylights with remote dimming controls for presentations.
- **Individual Controls** Occupancy sensors to monitor and control artificial lighting to maximize energy savings.
- **Carbon Reduction Strategies** Daylighting, ground source heat pump system, foam insulation and efficient windows create a tight envelope, PV system generation exceeds building demand.

### Note:

- 2013 data.
the rating system’s indoor environmental quality credit guidelines for materials specifications, including low-VOC finishes. Operable windows with screens allow for natural ventilation. No combustion was involved in the HVAC system, which eliminated the potential for associated by-products.

**Renewable Energy**

The Chrisney Branch Library uses bifacial photovoltaic panels to provide electric power for the facility. The 0.9 kW PV (grid-tied, no battery storage) array is sized for 101% of the anticipated annual energy load. Inverters direct excess captured solar energy to the public utility’s electric grid.

By constructing a separate PV array (mounted atop the Learning Power Pavilion) in the sun and keeping the building in the shade, much less summer cooling is required. The array creates a community meeting space and serves

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### BUILDING ENVELOPE

**Roof**

- Type: 12 in. of cellulose atop 3/4 in. gypsum board ceiling in vented attic; wood truss frame, sheathing, asphalt shingles
- Overall R-value: R-32.86
- Reflectivity: 0.12 (medium brown asphalt shingles)

**Walls**

- Type: 0.6 in. gypsum board; 2 × 6 wood (southern pine) stud with 5.5 in. polycylyene foam insulation; 0.5 in. oriented strand board (OSB) sheathing; 1 in. extruded polystyrene (XPS) rigid insulation; 0.3 in. fiber cement siding lap siding: 6.25 in. width
- Overall R-value: R-25.23 (weighted against framing percentage)
- Glazing Percentage: 19.5%

**Basement/Foundation**

- Slab Edge Insulation R-value: R-7.5
- Under-Slab Insulation R-value: R-7.5
- Effective U-factor for Assembly:
  - 0.28 fixed frame; 0.27 casement
  - Solar Heat Gain Coefficient (SHGC):
    - 0.28 fixed frame; 0.26 casement
  - Visual Transmittance:
    - 53% fixed frame; 48% casement

**Location**

- Latitude: 38.0136° N
- Orientation: Building orientation is rotated 30° west of magnetic north; adjacent pavilion with solar panel canopy is oriented toward solar south

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### BUILDING TEAM

**Building Owner/Representative**

Lincoln Heritage Public Library

**Architects**

- Energy Modeler: Landscape Architect
- Browning Day Mullins Dierdorf Architects, Indianapolis
- General Contractor: Craftsmen Construction, Inc., Huntingburg, Ind.
- Structural Engineer: Wilke Structural Engineering, Evansville, Ind.

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LEED credits regarding materials and indoor environmental quality served as a guide for the design and specification of the library’s interior spaces.

**MEP Systems**

Energy modeling of the building envelope determined the most cost-effective, energy-efficient building systems. A ground source heat pump (GSHP) using two 400 ft vertical closed-loop wells provides a simple, energy-efficient solution for mechanical heating, cooling and ventilation.

High efficiency fluorescent light fixtures provide nighttime illumination and supplement the daylighting strategy during overcast days. Occupancy sensors monitor and control electric lighting to maximize energy savings.

Low-flow plumbing fixtures and an instantaneous electric heater for domestic hot water reduce the library’s relatively small and infrequent need for potable water.

While the project did not pursue LEED certification, good indoor air quality was achieved by adhering to LEED credits regarding materials and indoor environmental quality served as a guide for the design and specification of the library’s interior spaces.

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In 2013, the on-site photovoltaic solar panel installation produced 12,341 kWh of electricity, while the property consumed 11,805 kWh, an energy surplus of approximately 4.3%. In 2012, the property produced 12.6% more energy than it consumed. Per the simple payback calculation method referenced by the EPA ENERGY STAR Small Business Guide, a conventionally built library in this climate region would have an annual energy bill of nearly $2,400, including the charge from the public utility to install their service. Considering the Chrisney Branch Library was funded by grants and donations, the simple payback for the net zero construction cost premium was about three years.

The library celebrated the five-year anniversary of its opening in April 2014. The library has not experienced any problems with maintenance or operation of the solar pavilion, according to the district director.

Performance
Data published in July 2010 demonstrated that over the first 12 months of typical operation, the Chrisney Branch Library was operating at net zero site energy, producing approximately 17% more energy than it consumed. Since then, the facility has continued to perform at an energy surplus.

Net Zero on a Budget
Not only has the net zero project resulted in reducing monthly operation costs (the utility charges a monthly service fee), it was constructed in a cost-effective manner while meeting federally funded building requirements. The building, mechanical and electrical systems, including the geothermal and photovoltaic panels and their associated components, were constructed for $155/ft². These savings were achieved by using a simple rectangular layout, conventional residential framing techniques familiar to local builders, and cost-effective interior and exterior finishes. The project cost was below that expected cost for a public library. A national

![Image](https://example.com/image1.jpg)

Above: The desire to maximize solar access while minimizing tree removal led to siting the solar panels on a free-standing wood structure in a clearing, while nesting the building within the shade of nearby oak canopies.

Below right: The Learning Power Pavilion is adjacent to the elementary school’s outdoor lab and serves as an open-air classroom and public meeting space.

![Figure 1: ENERGY PRODUCTION VS. CONSUMPTION, 2013](https://example.com/image2.jpg)

**FIGURE 1**

**ENERGY PRODUCTION VS. CONSUMPTION, 2013**

<table>
<thead>
<tr>
<th>Month</th>
<th>Total PV Yield</th>
<th>Total Energy Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>1,800 kWh</td>
<td>1,400 kWh</td>
</tr>
<tr>
<td>Feb</td>
<td>1,600 kWh</td>
<td>1,500 kWh</td>
</tr>
<tr>
<td>Mar</td>
<td>1,400 kWh</td>
<td>1,600 kWh</td>
</tr>
<tr>
<td>Apr</td>
<td>1,200 kWh</td>
<td>1,300 kWh</td>
</tr>
<tr>
<td>May</td>
<td>1,000 kWh</td>
<td>1,100 kWh</td>
</tr>
<tr>
<td>Jun</td>
<td>800 kWh</td>
<td>900 kWh</td>
</tr>
<tr>
<td>Jul</td>
<td>600 kWh</td>
<td>700 kWh</td>
</tr>
<tr>
<td>Aug</td>
<td>400 kWh</td>
<td>500 kWh</td>
</tr>
<tr>
<td>Sep</td>
<td>200 kWh</td>
<td>300 kWh</td>
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<tr>
<td>Oct</td>
<td>0 kWh</td>
<td>100 kWh</td>
</tr>
<tr>
<td>Nov</td>
<td>0 kWh</td>
<td>200 kWh</td>
</tr>
<tr>
<td>Dec</td>
<td>0 kWh</td>
<td>300 kWh</td>
</tr>
</tbody>
</table>

**Advertisement formerly in this space.**
LESSONS LEARNED

Budgeting Net Zero Energy. The limited budget of the project required the design team to be judicious with design features, building systems and overall project complexity. Knowing this project would be built by local residential builders, it was designed as a simple rectangular slab-on-grade wood-framed home, but also designed to meet the state and federal code requirements for a commercial building. By setting the net zero energy goal at the outset of the project, the team was better able to balance the construction costs against that of the on-site photovoltaic system.

Design Performance Modeling Makes a Difference. With a gross floor area of approximately 2,400 ft² and a meager construction budget, the project team did not have the financial resources to hire a specialized energy modeling firm to run a comprehensive energy analysis on the library’s design. However, the team was experienced enough to realize a strategy of taking advantage of every opportunity to optimize all building systems in an integrated manner. Simple design rules-of-thumb would not suffice. The design team decided to take advantage of an emerging field of commercial and noncommercial software platforms that have been designed to make detailed performance analyses more accessible to design professionals. By using such software platforms, the design team was able to integrate design performance modeling into the project’s workflow, which allowed iterative analyses that led to refined siting, daylighting, thermal performance, and on-site energy strategies.

User Group Plays Critical Role. Over the course of the project, the design team and owner became aware of the virtues of understanding how the building’s systems work. If mismanaged, design features such as operable windows and plug loads can become major hindrances to the project’s energy performance goals. Staff was educated regarding best use of operable windows, and ENERGY STAR laptops with relatively low power consumption were selected for library patrons. The community embraced the high performance goals of the library and ensured that key personnel were knowledgeable about the various building systems and could train future staff.

Conclusion

Despite the seemingly impossible set of design and budgetary constraints, the Chrisney Branch Library was eventually willed into existence, becoming the first net zero energy public library in the U.S. Three separate 12-month samples have verified that the building produces more energy than it consumes. While the project is a demonstrative case study for an integrative design team and early-stage design performance modeling, the Chrisney Branch Library is first and foremost a story of community perseverance.

ABOUT THE AUTHORS

Daniel Overbey, AIA, LEED AP BD+C, is the director of sustainable design practices at Browning Day Mullins Dierdorf Architects in Indianapolis. A registered architect, he also teaches environmental systems at Ball State University and the Boston Architectural College’s Sustainable Design Institute. William Brown, AIA, LEED AP BD+C, is the director of sustainability at Indiana University Bloomington. A registered architect, he is also an adjunct professor in the IU School of Public and Environmental Affairs, teaching graduate level classes in sustainability, leadership and sustainable communities.