Analysis of Sustainable Zero Net Energy Residential Developments:
With a Concentration in Smart Building Technologies

Prepared for:
Brickhaus Partners
May 2015

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I. About the Author

Thomas J. Dacey is from Duxbury, Massachusetts and earned his B.A. in Economics and Environmental Studies from Denison University located in Granville, Ohio. Currently, Mr. Dacey is a candidate for the Master of Sustainable Real Estate Development program in the School of Architecture at Tulane University and is expected to graduate in May 2015. Mr. Dacey will be a third-generation real estate professional from his family and is pursuing a career in real estate construction and development upon completion of the Master of Sustainable Real Estate Development program.

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(See Appendix 2. For author’s Resume)
II. Acknowledgement

First, I would like to say how grateful I am to have the opportunity to attend and graduate from the Master of Sustainable Real Estate Development program in the School of Architecture at Tulane University. I want to thank my family for their unconditional love and support throughout all of my academic endeavors.

In regards to the Directed Research and the people who assisted me throughout this challenging yet rewarding academic processes, I would like to give thanks to the following individuals for their knowledge and support as well as their valuable time and thoughtful consideration. This directed research report could not have been completed without your helpful insight and guidance.

Tulane University
Casius Pealer

Brickhaus Partners
Andrew Brickman
Cassandra Meier
Alexandra Yonkov
Elliot Reusser

Urban Land Institute
Dean Schwanke

Champion Builders, Inc.
Matthew Dacey

No Labels
Caleb Randall-Bodman
III. Executive Summary

1. About the Directed Research Client: Brickhaus Partners

The directed research client, Brickhaus Partners, is a real estate development firm based out of Cleveland, Ohio and has completed multiple residential and commercial projects in northeastern Ohio as well as a hospitality development in Tulum, Mexico.¹ Brickhaus Partners specialize in building residential, commercial, and hospitality developments that are designed to enhance the human experience through creating a place that provides a spectacular living environment.² They achieve their company’s mission by implementing the highest quality development standards, eco-friendly practices, and employing the most cutting-edge building technology.³ Their mission shares common ideologies with the Master of Sustainable Real Estate program at the Tulane University School of Architecture.

Brickhaus Partners agreed to partner with this directed research project because it is in line with their company’s mission and goals. The fundamental directed research concept of incorporating a sustainable development model with advance building technologies and systems, created the opportunity for an mutually beneficial partnership between the student and client. Through this academic-professional alliance, the following directed research report became possible.

³ Ibid.
IV. Introduction

In 2013, the U.S. Energy Information Administration reported that residential and commercial buildings accounted for 40% of total energy consumption. This is an astonishing fact considering how much energy is produced, used and wasted during annual building constructions and operations. In 2012, the U.S. Environmental Protection Agency (EPA) stated that commercial and residential buildings are responsible for 10% of the total U.S. greenhouse gas emissions, which equates to 652.6 million metric tons of CO₂. These statistics represent the importance of energy consumption within the real estate development industry and how it affects global environmental conditions. The trend towards sustainable development is becoming the ideal approach with residential real estate development.

The shift towards green building allows for positive impacts economically, environmentally, and socially within and around a sustainability built environment. The current standard in sustainable residential development is the Zero Net Energy (ZNE) model. The New Buildings Institute (NBI) describes this model as buildings that use no more energy annually than they produce from on-site renewable energy sources. The NBI explains that zero net energy capable buildings achieve energy performance similar

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6 The New Buildings Institute (NBI) is a nonprofit organization working to improve the energy performance of commercial buildings.

to ZNE buildings but do not have enough on-site energy generation to qualify as ZNE.\(^8\)

This directed research report explores the ZNE and ZNE-capable models as they pertain to residential real estate with a concentration on smart building technologies that are utilized within this sustainable development approach. The combination of these two residential model methods and techniques will allow for future developers to create more economically rewarding, environmentally sustainable, and operationally efficient real estate projects.

This report will describe the opportunities for growth of ZNE real estate in the residential development sector. Currently, traditional urban and suburban residential models are becoming outdated and the real estate market is demanding more sustainable and green-featured residences. Andrew J. Nelson, vice president of RREEF Research\(^9\), explains that real estate developers are adopting greener business models in all regions of the world, at all stages of economic development.\(^10\) This change is driven by the favorable financial returns for greener buildings owners and the significant savings afforded by thoughtful green design or renovation.\(^11\) ZNE development is becoming the new market standard among residential renovations and new construction. The client for this directed research report, Brickhaus Partners, is an example of a development company utilizing sustainable methods within their real

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\(^8\) Ibid.

\(^9\) RREEF Research is a division of RREEF Property Trust, which is a continuously offered non-traded, publicly registered real estate investment trust. RREEF Property Trust is a member of the Deutsche Bank Group.


\(^11\) Ibid.
estate projects. Information detailed in this report will help to support Brickhaus’ current design/construction model, while also providing new insight to ZNE building approaches and smart building technologies.

The implementation of smart building technologies with residential development is a relatively new concept that is changing how developers approach the programming of their projects. The three major aspects of smart building technologies address the following: building automation, entertainment, and security systems. With the growing trends in mobile application technologies and the consumer’s desire to have interactive control over their buildings, wireless systems are becoming the response to this need in the 21st century real estate development. The current smart building technologies marketplace offers a wide range of systems that can be utilized effectively in residential development. A concentration on smart building technologies with a critical review of net-zero development methods and techniques will provide a unique platform for real estate professionals interested in advancing any development’s efficiency and market attractiveness.

First, this report will explain the methodology of ZNE projects and the important factors that allow this development model to achieve the goal of net neutrality of energy usage in building operations. This includes important construction and design techniques, specific products, as well as building systems. This breakdown of ZNE techniques will show that there are many approaches to achieving net-zero buildings for many different types of residential real estate projects. It is vital to understand that certain aspects of a development will dictate which approaches in the ZNE model will be
most efficient and effective for said project. Some of these important aspects include the scale of the project, the geographical location and climate zone of the project, and the developer’s capability and experience. Every development will be unique in that different elements will be more or less important in achieving the ZNE standard.

Second, this report will analyze two case studies involving ZNE developments. In doing so, this report will specifically review each project’s successes and shortcomings given their respective ZNE model. The goal of reviewing these case studies is to learn from ZNE developments that have completed construction and are in operational service. Each case study will describe certain aspects the ZNE development process and will be beneficial for any developer who is looking to implement this model within their future development plans. The first case study will look at zHome, a residential development located in the state of Washington. The zHome development site is about 18 miles east of Seattle, Washington, which is the largest metropolitan area in the Pacific Northwest. The International Living Future Institute\textsuperscript{12} explains that zHome is a ten-unit townhome project designed to achieve zero net energy, as well as a number of other environmental benchmarks.\textsuperscript{13} The zHome case study provides insight into ZNE projects as it pertains to smaller-scale residential real estate developments.

The second case study will review the UC Davis\textsuperscript{14} West Village. The Urban Land Institute (ULI)\textsuperscript{15} describes this development as a mixed-use project that is also the first

\textsuperscript{12} The International Living Future Institute administers the Living Building Challenge\textsuperscript{™}, the built environment’s most rigorous and ambitious performance standard. For more information please visit: \url{http://living-future.org}
\textsuperscript{14} University of California, Davis
planned ZNE community, providing an example of environmental sustainability at the community scale.\textsuperscript{16} The UC Davis West Village was recognized by ULI as a 2013 Global Awards for Excellence Winner for its efforts as a sustainable land and community development project.\textsuperscript{17} This development is located in Davis, California, which is a college-town in the Sacramento Valley of Northern California. The UC Davis West Village case study provides analysis for ZNE projects as when implemented on larger-scale, community development. The details outlined in this case study analysis will allow for a better understanding of ZNE methods and techniques as applied to successful sustainable residential real estate developments.

Third, this report will provide an explanation of smart building technologies including wireless applications for multiple building-control systems. Many of these smart building technologies will go hand-in-hand with ZNE model concepts allowing for developments to attain even higher building performance standards. A review of wireless building automation, entertainment, and security systems will be provided in this section along with an analysis of these systems’ impacts on residential developments. The analysis of the smart building technologies will allow for a discussion of which systems should be recommended or avoided for residential development projects. A major goal of this section is to provide Brickhaus Partners with an in-depth

\textsuperscript{15} ULI is a nonprofit research/education organization that is multidisciplinary real estate forum, facilitating an open exchange of ideas, information, and experience among industry leaders and policy makers dedicated to creating better places. For more information visit: \url{http://uli.org}


\textsuperscript{17} Ibid.
understanding of these products and systems. Brickhaus Partners has requested that this report provide this smart building technologies section because of their interest in utilizing these development systems in their future projects.

Last, this report will provide recommendations and an in-depth cost breakdown of both ZNE and smart building products, systems, and technologies. This list of products will be beneficial for Brickhaus Partners or any real estate professional looking to increase their buildings’ property performance and reduce environmental impacts. The recommended products section will be divided into two subsections. The first subsection will focus on the ZNE model products and the second subsection will provide information about smart building technologies. One or more examples for every product, technology, and system will be described in full detail and will include the most up-to-date purchase price for each of the items. If applicable, the installation costs and any other miscellaneous expenses directly related to each product will be listed with the purchase price. As per the request of Brickhaus Partners, a local Cleveland/Akron regional product supplier will be provided for every product recommended. This will aid Brickhaus Partners in their efforts to gain more efficient access to the recommended products’ sourcing and purchasing for their future smart and sustainable real estate development projects.

In review, this report will be divided into four main sections: ZNE Methodology, Two ZNE Case Study Analyses, Review of Smart Building Technologies, and a Cost Breakdown for both ZNE and Smart Technologies and Systems.

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18 If there are no Cleveland/Akron regional suppliers for a certain product, the report will extend the product search to the entire Great Lakes region.
V. Methodology of the Zero Net Energy Development Model

The ZNE real estate development model is a type of green building that creates environmentally responsible structures. These green buildings positively impact the livelihoods of their inhabitants and the financial gains for the property owners. The National Renewable Energy Laboratory (NREL) describes ZNE development as a building with greatly reduced energy needs, as achieved through efficiency gains such that the balance of the building's energy needs can be supplied by renewable technologies and energy reducing products.\textsuperscript{19} The ZNE methodology is based upon the two critical aspects of energy efficiency and renewable energy. Both aspects are equally important to the ZNE model and are intricately intertwined during the design, construction, and operational processes to promote maximum property performance.

1. Relationship with the Electrical Grid

Before an analysis of energy efficiency and renewable aspects is provided, there must be a review of the relationship a ZNE development has with the national electrical grid. This is due to the symbiotic manner in which a private development’s energy efficiency and renewable energy interacts with the general public’s source of energy. First, there are examples of ZNE properties that exist and operate off the electrical grid and are completely self-sustaining. These properties are often called “passive homes” and are generally categorized as private homes that rely heavily on photovoltaic energy.

generation systems (solar panels) and complex architectural design. These off-the-grid passive houses have very expensive upfront construction costs and are usually created to meet a certain development mission or goal required by the property owner. It should be mentioned that there are a few non-residential passive development examples where the off-the-grid concept is applied to office and educational buildings.

However, this report focuses on ZNE buildings that are connected directly to the national electrical grid. Steven Winter Associates, Inc. (SWA) provides an excellent description of the relationship between a ZNE property and the electrical grid:

Most net-zero energy buildings are still connected to the electric grid, allowing for the electricity produced from traditional energy sources (natural gas, electric, etc.) to be used when renewable energy generation cannot meet the building's energy load. When, conversely, on-site energy generation exceeds the building energy requirements, the surplus energy should be exported back to the utility grid, where allowed by law. The excess energy production offsets later periods of excess demand, resulting in a net energy consumption of zero. Due to current technology and cost limitations associated with energy storage, grid connection is usually necessary to enable the Net Zero Energy balance. Differences in how utilities and jurisdictions address payment for energy that is exported from the building into the grid can impact project economics and should be carefully evaluated.

It is important that developers seeking to implement the ZNE development model understand that the net energy concept is determined by the amount of electrical grid energy used on the property compared against the amount of renewable energy that the property generates. The most effective approach in achieving ZNE building performance

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20 For a passive house example and more information please visit: [http://www.phius.org/home-page](http://www.phius.org/home-page)

21 Steven Winter Association, Inc. is a real estate consulting and advisory firm that operates in the commercial, residential, and multifamily sectors. For more information please visit: [http://www.swinter.com/index.htm](http://www.swinter.com/index.htm)

is to first reduce the total amount of grid energy needed for building operations through increasing energy efficiency, and second, implement the most cost-effective on-site renewable energy systems.

SWA explains that different regional utility companies have alternative payment methods for determining how a development’s renewable energy is sold or allocated back to the national electrical grid. For example in New Orleans, Louisiana the major utility company distributing electrical power to the general public is the Entergy Corporation\textsuperscript{23}, and they currently offer a net metering program for renewable energy resources. Entergy Corp. states, “net metering is available to residential generation facilities up to 25 kWh and commercial generation facilities up to 300 kWh who do not have any other generator connected to the grid.”\textsuperscript{24} If a property they service meets these generation facilities standards, as well as other specific systems and safety requirements,\textsuperscript{25} then it is eligible to participate in the net metering program for renewable energy resources. It should be mentioned that there are some onetime upfront costs associated with installing this net metering system, but the property owner’s monthly net metering utility bill calculation is very straightforward:

\begin{itemize}
  \item Energy Supplied by Entergy (kWh) - Energy Exported to Entergy’s grid by property (kWh) \\
  Net Energy amount Billed to the Property (kWh)\textsuperscript{26}
\end{itemize}

\textsuperscript{23} Entergy Corporation is an energy company engaged primarily in electric power production and retail distribution operations throughout LA, AK, MS and TX.
\textsuperscript{25} For more information about specific systems and safety requirements visit: \url{http://www.entergy-louisiana.com/your_home/net_metering.aspx}.
\textsuperscript{26} Ibid.
Entergy Corp. explains that in their renewable energy program the property owner will be billed the difference between the kWh’s purchased and the kWh’s supplied to the grid. However, if a property supplies more electricity to the grid than is purchased in a given month, the owner receives the minimum bill\(^\text{27}\) and the excess kWh are credited to the owner’s account. This credit is then applied to the following month’s utility bill.\(^\text{28}\) This kWh credit rollover system is unique to Entergy Corp.’s net metering program. It is generally thought properties that allocate energy back to the grid usually receive a monthly payment in the form of a cashier’s check to the property owner covering the dollar amount for their generated surplus energy. The economical discrepancies of a kWh credit rollover bill payment compared against a monthly cashier’s check deposit payment will have significantly different financial impacts in the operational expenses for a building’s performance. If a developer is interested in utilizing a net metering system for renewable energy on their projects they should research the billing payment options of their local utility company during their development’s due diligence period.

FirstEnergy Corporation provides the next example of a regional utility company having alternative payment methods for determining how a development’s renewable energy is allocated back to the national electrical grid.\(^\text{29}\) FirstEnergy Corp. services Cleveland, Ohio and many other communities in the Great Lakes region. This example provides Brickhaus Partners with the necessary information regarding the impact that

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\(^{27}\) Minimum bill price is a fixed rate set monthly by Entergy Corp.

\(^{28}\) Ibid.

\(^{29}\) FirstEnergy Corp. is diversified energy company that provides electrical power throughout OH, PA, NJ, WV, and MD.
net metering has on developments in their region. Brickhaus Partners will be able to assess, implement and market this green energy system in their developments as well as explain the positive financial benefits of renewable energy to their future customers.

Unlike Entergy Corp., FirstEnergy Corp.’s net metering system does not offer any renewable energy deductions of monthly payments for properties that allocate surplus energy back to the national electrical grid. However, renewable energy systems are still valuable to real estate developments in northern Ohio. FirstEnergy Corp. provides a net metering system to all residential generation facilities with no kWh requirement.  

Similar to Entergy Corp.’s net metering system, FirstEnergy Corp.’s system requires that the property meet the set safety and system requirements and that the property owner must pay an upfront cost for their net metering installation.  The first major benefit of implementing the FirstEnergy Corp. net metering system is that the property owner will be able to significantly reduce, and possibly eliminate, their monthly energy bill by generating their own on-site renewable energy to power their building.  The second benefit of this system is that any excess energy not used on-site will be allocated back to the grid and the neighboring communities will then have access to this renewable energy to power other buildings.  The property owner allocating the renewable energy back to the grid has the option to enroll in FirstEnergy Corp.’s Ohio Residential Renewable Energy Credit (REC) Program.

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31 Ibid.
32 Ibid.
33 Ibid.
The Ohio Residential REC Program allows FirstEnergy Corp. to purchase RECs from residential customers who produce energy from renewable energy resources and are being served by FirstEnergy and their subsidiary energy companies including: Ohio Edison Company, The Toledo Edison Company, or The Cleveland Electric Illuminating Company. According to the REC Purchase Agreement, the type of renewable energy being generated (solar, wind, etc.) and the total amount of energy allocated back to the grid will determine the price at which FirstEnergy Corp. will purchase RECs (see Appendix 1. for copy of REC Purchase Agreement). According to the Ohio Residential REC Program Purchase Agreement, FirstEnergy Corp. will purchase 1 REC for every 1000 kWh of renewable energy generated. The following is a description and example for determining this payment system provided in the REC Purchase Agreement:

Renewable energy delivered from a renewable energy resource project shall be calculated by reading the output of the meter at two different points of the year (i.e. January 1 to December 31). Customer must provide documentation evidencing the initial meter reading. An illustrative calculation of this value is as follows:

Output metering reading on January 1: 1520 kWh
Output metering reading on December 31: 5433 kWh

\[ 5433 - 1520 = 3913 \text{ kWh or 3.9 MWh} \]

\[ 3.9 \text{ MWh} = 3 \text{ REC} \text{ (Note: The remainder 0.9 MWh will carry over into the following year. However, no carryover shall exceed the terms of this Agreement)} \]

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36 Ibid.
The financial benefit for property owners utilizing the FirstEnergy Corp net metering system is a reduction in their monthly energy consumption and billable charges, as well as the option to enroll in the Ohio Residential REC program. More information regarding REC programs will be provided later in this section.

Regardless of financial impacts, if a building achieves maximum energy performance and is able to provide clean renewable energy to the general public, then that property will be of great environmental and communal value in the greater Ohio region. These positive outcomes will occur because of a reduction in fossil fuel conversion into energy and an increase of purchasable clean energy in northern Ohio. While it is difficult to place a monetary value on improving the environment, as well as the lives of people in the affected region, developers can have pride in marketing their company and projects as innovative and forward-thinking sustainable enterprises.

2. Energy Efficiency

Now that the relationship between ZNE development and the electrical grid is better understood, a further explanation of the ZNE model’s two critical components of energy efficiency and renewable energy can be explained. Energy efficiency is a concept that uses efficient building design and sustainable construction products to achieve the minimal energy usage necessary to operate a development. Energy efficiency is a fundamental design criterion and the highest priority for ZNE developments.\(^\text{37}\) Energy efficiency is the most cost-effective strategy with the highest

return on investment. SWA states that maximizing efficiency opportunities before developing renewable energy plans will decrease the cost of the renewable energy ZNE projects require.\textsuperscript{38} When a developer is planning to build a ZNE project their first step in programming their building must be the identification of the best methods to achieve the highest level of building energy efficiency. Attaining a building’s maximum level of energy efficiency will allow the renewable energy generation to have an increased impact on energy cost savings and property performance. The two-step system of achieving energy efficiency is to first implement design strategies and features that reduce the demand-side of building energy loads. These reduced loads should be accompanied with efficient building equipment and systems.\textsuperscript{39}

SWA defines that the energy efficiency design strategies and features that reduce the demand-side of building energy loads as the following:

- High-performance Building Envelopes
- Air Barrier Systems
- Day-lighting
- Sun Control and Shading Devices
- Specific Selection of Windows and Window Glazing
- Passive Solar Heating
- Natural Building Ventilation\textsuperscript{40}

Once a building’s energy loads are reduced, the loads should be met with the following efficient equipment and systems:

- Energy Efficient Lighting (Indoor/Outdoor)
- Electric Lighting Controls
- High-performance HVAC System\textsuperscript{41}

\textsuperscript{38} Ibid.
\textsuperscript{39} Ibid.
\textsuperscript{40} Ibid.
\textsuperscript{41} Ibid.
The integration of building design strategies with energy efficient systems combines to create the highest level of building energy efficiency. It is important to state that not all of the listed design strategies and efficient system are needed to create a ZNE development. There are multiple combinations and approaches of design strategies and efficient systems that can be utilized for ZNE projects and it is up to the developer and their development team to decide what balance is needed to reach their own specific project goals.

3. **Renewable Energy**

The second critical component of the ZNE model is the implementation of renewable energy. Renewable energy can be defined as resources that rely on fuel sources that restore themselves over short periods of time and do not diminish such as the sun, wind, moving water, organic plant and waste material (eligible biomass), and the earth’s heat (geothermal).\(^{42}\) Renewable energy is separated into two different categories, on-site and off-site renewable energy generation. SWA provides an insightful summary of the relationship between a ZNE building and off-site renewable energy generation:

Depending on the ZNE guidelines used, buildings may be permitted to use energy generated off-site to offset energy used in a building. Most often, credit for off-site renewable generation is gained by purchasing renewable energy credits (RECs). RECs are available from many renewable energy technologies. Large, utility-scale wind farms, solar plants, geothermal plants, and hydropower facilities generate electricity without using fossil fuels or primary energy. The costs of constructing and operating these generation facilities are often paid for by selling

the "credit" for generating energy renewably as well as selling the energy itself. The structure and market for RECs is evolving and it varies regionally.43

This explanation of off-site renewable energy generation and REC relates directly to the previously mentioned Ohio Residential REC Program. It can be understood that FirstEnergy Corp. will purchase RECs from residential properties generating renewable energy then sell those same RECs to third party consumers for tax-reduction purposes and/or to supply their energy needs using a more sustainable approach. While the concept and structure of off-site renewable energy generation is a fascinating and related subject, the remainder of this section focuses on the importance of on-site renewable energy generation.

Once the major energy efficiency measures have been incorporated into a ZNE building, the remaining energy needs can be achieved by applying on-site renewable energy technologies. Some commonly implemented on-site electrical generation systems include the following:

- Photovoltaic (PV) Systems
- Geothermal Heat Pumps
- Solar Water Heating
- Biomass/Biofuels
- Wind Turbines44

SWA states that for ZNE developments, priority should be given to renewable approaches that are readily available, replicable, and most cost-effective.45 Economic evaluation for on-site renewable energy systems is critical for the overall success of a

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44 Ibid.
45 Ibid.
ZNE project. Similar to the energy efficiency concept, it is important that the developer and their development team assess which renewable energy technologies will have the most impact in creating a ZNE building that is systematically sound and financially rewarding.

That being stated, this report concludes that high priced renewable energy systems, such as photovoltaic (PV) systems and geothermal heat pumps, might not be the most cost-effective products for Brickhaus Partners due to these products’ extensive payback periods. Brickhaus Partners explained that in their past developments the utilization of solar panels and geothermal heat pumps resulted in minimal financial gains.\textsuperscript{46} These minimal financial gains were a result of the high purchase and installation cost of these products, as well as insufficient rental rates in the northern Ohio marketplace.\textsuperscript{47} If either FirstEnergy Corp or the state of Ohio improves the incentives for developers to implement complex renewable systems, then Brickhaus Partners should revisit these concepts for consideration. Per the request of Brickhaus Partners, this report will focus on ZNE systems and technologies that are the most cost-effective for their company’s residential developments goals.

As previously mentioned, there are many different construction and design approaches in achieving a ZNE development. This review will explain methodologies that are more beneficial for residential properties located in continental climate\textsuperscript{48} regions. This report focuses on the continental climate region to provide Brickhaus

\textsuperscript{46} Andrew Brickman, telephone conversation with the author, April 10, 2015

\textsuperscript{47} Ibid.

\textsuperscript{48} Continental climate is categorized as having hot/hot and humid summers and cold/severely cold winters with four distinct seasons.
Partners with a more accurate analysis of ZNE technologies and products that will be useful for their developments in the Great Lakes region. The *Home Energy* magazine provides and in-depth review of energy efficiency and renewable energy systems in an article describing energy efficient and high performance buildings in Ohio. This article reiterates many of the same ZNE methodology described by SWA.

In order to satisfy Brickhaus Partners’ request for the most cost-effective product recommendations, the following subjects will become the primary focus of ZNE methodology systems for the remainder of the report:

- Airtightness and Insulation
- Specific Selection of Windows
- Energy Efficient Lighting (Indoor)
- Electric Lighting Controls
- High Performance HVAC Systems

After the case study analysis, this report will offer thorough product reviews, cost breakdowns, and will provide a list of regional product suppliers to Brickhaus Partners for these exact systems and technologies. It should be mentioned that Brickhaus Partners currently implements ZNE methodology systems such as passive-solar architectural designs, sustainable development landscaping, and energy efficient appliances in their developments. This report will supply further information to assist this real estate company in achieving more energy efficient developments with the goal of creating ZNE residential buildings. Brickhaus Partners requested that the reviewed products be practical and highly cost-effective so that the recommendations can be implemented in their developments as soon as possible. Also, the recommended ZNE

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methodology systems are directly applicable with smart building technologies and will help Brickhaus Partners’ developments attain maximum property energy performance, higher revenues with development sales and rental rents.

VI. Case Study Analysis: Two Zero Net Energy Developments

1. Case Study: zHome

![Figure 1. Photograph of zHome development entrance](image)

*Development Information*

**Development Name:** zHome  
**Location:** Issaquah, WA  
**Project Description:** Residential Townhouse – 10 Units  
**Project Area Size:** 1596 m² (0.39 acres)  
**Typology:** Neighborhood
Period of Construction: **22 Months**

![Figure 2. Photograph of a zHome townhouse unit](image)

**Development Team**

Developer/General Contractor: **Ichijo USA**

Architect: **David Vandervort Architects**

Structural: **Harriott Valentine Engineers**

Landscape: **Darwin Webb Landscape Architects**

Civil: **Core Design**

zHome is a 10-unit townhouse residential development that uses smart design and cutting-edge technologies to significantly reduce its environmental impacts. zHome is touted as the first multifamily, production, zero-energy, and carbon-neutral community in the United States. zHome provides a great opportunity to evaluate a smaller-scale ZNE development. The development scale and design aspects of zHome are very similar to some of Brickhaus Partners’ past projects. The zHome development team set five distinct benchmarks to guide their development process:

- **Zero Net Energy**
- **60% Less Water**
- **Healthy, Low Toxins**
- **Deep Green Materials**

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Outside

While the developer, Ichijo USA, is a global residential developer and contracting firm, they explain that achieving a ZNE development was the most difficult environmental benchmark to attain for zHome. Ichijo USA was able to successfully build a ZNE residential development by implementing energy efficient systems and generating on-site renewable energy. zHome achieved this benchmark by first starting with energy conservation, utilizing a number of advanced energy efficient construction techniques to reduce overall townhouses energy usage. This reached two-thirds of the net energy requirements to attain their ZNE benchmarking goal. In order to fully achieve their ZNE goal, zHome implemented solar panels to generate and offset the remaining one-third of the needed net energy usage. These steps towards a ZNE development used by zHome reflect the same processes stated in the ZNE methodology section of this report. The graphic below displays the energy saved in a zHome townhouse unit:

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54 Ibid.
55 Ibid.
56 Ibid.
Also, zHome highlights the following four similar recommend ZNE products for Brickhaus Partners described in the previous methodology section of the report:

- Super Insulated Walls
- Double-paned Windows
- Extremely Tight Exterior Walls
- High efficiency Lighting (CFLs and LEDs)

It is important to mention that these four energy efficient products and techniques are a small part of a highly complex building system working together to attain zero net neutrality for zHome. As a developer, it takes a thorough understanding of all the

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57 Ibid.
minuscule but necessary elements to build a ZNE development. Some of the lessons learned through the evaluation of the zHome development are the following:

**zHome: Lessons Learned**

- Some potential buyers, such as retirees, were attracted to zHome’s zero or low utility bills, but were not as excited about multi-floor living that required the usage of stairs. In the future, using more universal design techniques in projects to account for requests and needs of the retiring, baby-boomer generation of costumers would behoove the developer.  

- Net metering programs and systems in the state of Washington have different incentives for builders and owners. The instate made PV panels allow owners to sell power to the utility company for two to three times the rate compared to out-of-state made PV panels. Buying local panels early in projects located in WA, will maximize development benefits and allow for better financial projections. Developers should maximize financial gains by using available state and federal subsidies and cost-reduction programs.

- Projects such as zHome are complex, long term and take unanticipated turns. A long city council review process (nine committee meetings) of the initial contracts ultimately paid off in ongoing community project support through difficult periods.

- Compared to the technical and economic challenges zHome confronted, managing the partner team was more difficult. zHome’s organic and opportunistic evolution at times exacerbated the partners’ differing views of roles, priorities and process. While a partner agreement was created partway through the project, a more deliberate understanding from the project’s outset, and continued communication throughout the project’s completion, would have been beneficial. However, the benefits of the partnership hugely outweighed these difficulties.

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59 Ibid.


61 Ibid.
2. Case Study: UC Davis West Village

![UC Davis West Village Rendering](image)

**Figure 4. Rendering of UC Davis West Village**

*Development Information*

Development Name: **UC Davis West Village – Phase I**

Location: **Davis, CA**

Project Description: **Mixed-Use Development**

Project Area Size: **130 acres**

Typology: **Campus Community**

Period of Construction: **26 Months**

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Mixed-Use development consisted of student housing, commercial space, educational buildings and recreational amenities.
Development Team

Developer(s): **Carmel Partners & Urban Villages**
Civil: **Cunningham Engineering**
Landscape: **SWA Group**
Architecture Single-Family Home: **Lim Chang Rohling & Associates**
Architecture Student Apartments: **MVE Institutional**
Architecture Mixed-Use Buildings: **Studio E Architects**

UC Davis West Village is a mixed-use neighborhood development that is also the first planned ZNE community, displaying planning for environmental sustainability at the community scale. This development is an urban campus community and consists of single-family housing units, student apartments, and mixed-use buildings. More than just housing units, UC Davis West Village is a thriving community that contains

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commercial space, educational facilities, and recreational amenities.\textsuperscript{65} According to ULI, the UC Davis West Village development was formed on the following three basic principles: community, environmental responsiveness, and place making.\textsuperscript{66} However, for the purpose of this case study analysis this report will focus on the environmental responsiveness principle and their approach to creating a ZNE community development.

The West Village development team achieved a ZNE project through reducing the demand of energy loads and increasing supply of renewable energy with on-site generation. ULI explains that on the demand side, the West Village buildings are designed to use 50 percent less energy than California building code standards.\textsuperscript{67} On the supply side, the buildings operate on a four-megawatt PV system that is designed to meet the annual energy usage for the apartments.\textsuperscript{68} These practices are reflected in the previous case study as well as the ZNE methodology. It is important to note that the same steps of achieving a ZNE development are necessary and do not change due to the overall scale or typology of the project. The best cutting-edge technology and systems are identified below to make UC Davis West Village as sustainable as possible:

- Benchmarking goal to exceed existing California building energy standards by 50 percent.\textsuperscript{69}
- Developed a strategic plan for exterior lighting, with an emphasis on energy efficient fixtures and controls. The fixtures will light pathways, building walls, facades, parking areas and streets. They will operate at a lower level when not needed, reducing light pollution and energy use. The lighting throughout UC

\textsuperscript{65} Ibid.
\textsuperscript{66} Ibid.
\textsuperscript{67} Ibid.
\textsuperscript{68} Ibid.
Davis West Village will use approximately 60 percent less energy than standard lighting.\textsuperscript{70}

- Used energy conserving building components such as heat-reflecting roof materials; heat-blocking roof sheathing, roof overhangs and exterior window sunshades; added insulation in exterior walls; and high-efficiency light fixtures, air conditioning systems and appliances.\textsuperscript{71}

Many of the goals set forth by UC Davis implement the same or similar products mentioned in the zHome case study as well as the product types listed as recommendations for Brickhaus Partners. The most effective approach in creating sustainable dwelling units is the implementation of the most cost effective energy efficient system within developments. An example of this can been seen in the listed goals and technologies used by the UC Davis West Village Development team.

\section*{VII. Review of Smart Building Technologies}

Smart building technologies and systems are applied to residential real estate developments to improve consumers dwelling experiences and to maximize buildings automation efficiency. These smart building technologies link home appliances, security, entertainment, and automation systems through a wireless connection to computers and mobile devices where consumers can control these operational systems from a central application. As new devices become connected to wireless technologies the more

\textsuperscript{70} Ibid.  
\textsuperscript{71} Ibid.
features smart building technologies will include. Currently, some of the most common centrally controlled smart building technologies include the following:

- Automated door locks and security systems
- Temperature and ventilation controls
- Energy consumption monitoring devices
- Entertainment systems
- Smart lighting systems
- Smart appliances
- Vehicle detection systems; and
- Plant and pet monitoring systems

If applied correctly through efficient building design and cost-effective purchasing, these smart systems can increase the overall productivity of the ZNE residential model. Along with a more sustainable residential unit, smart buildings have a wide array of benefits.

1. **Benefits of Smart Buildings**

   As the world becomes smaller with the growth of technology and the readily available unlimited access to information, people are always looking for ways to improve their quality of life. Smart building technologies allow for consumers to implement systems that save them time in controlling and maintaining their property. Smart technologies bring together multiple building systems into one application for total control. Along with increased consumer convenience, “smart homes also have the potential to be greener and cheaper: water and energy-monitoring tools, and programs to optimize energy consumption, could impel us to lower our water and energy usage,

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73 Ibid.
which could, in turn, lower our bills and reduce our carbon footprint. Essentially, smart building systems are improving three critical areas of the built environment: increasing the consumer’s daily convenience, lowering the cost of building operations, and increasing green living practices.

2. A Growing Market

As technology improves and becomes more available and affordable, smart building systems are increasing in popularity with the new millennial generation of residential purchasers and renters. In the past, two distinct categories of people invested in smart building technologies, technology mavens and home automation enthusiasts. The technology mavens bought smart building systems because they wanted to be first with cool and cutting-edge technology. The automation enthusiasts have been experimenting for years and the new products are just their next generation of improvements in their own smart home. However, as the newer generation of homebuyers and renters emerge in the marketplace, what once was thought as cool or cutting-edge is now becoming the norm. According to Allied Market Research, the global smart homes and buildings market is expected to grow at a significant compound annual growth rate (CAGR) of 29.5% between 2013 and 2020. The market study

74 Ibid.
76 Ibid.
states that this increase in growth is directly attributed to rising energy costs and government initiatives. Clearly, growth and further developments of smart building technologies is to be expected within the upcoming years. Allied Market Research provides an insightful illustration of what is come within the smart building technology marketplace:

Figure 6. Market study overview of the growth of the smart building technology industry

The growth of smart building technologies proves that these advance systems are becoming the market standard and that consumers’ desire a more modern residential lifestyle. However, with the rapid growth of smart building technologies some practical issues are present with these products.

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78 Ibid.
3. Current Challenges of Smart Homes

The first major challenge of adopting smart building technologies has to do with the compatibility of smart homes systems with available smart devices. Due to the market fragmentation and growing consumer adoption, there is little mainstream data and awareness of what is currently available for residential smart building technologies and systems.\(^{79}\) There are two main approaches when deciding which smart home system is appropriate for residential developments. These two systems are either fully intergraded custom smart home systems or application-based smart home systems.\(^{80}\) The fully intergraded systems are designed and implemented through consulting and working with certain architectural or design-construction firms.\(^{81}\) These custom systems are very expensive and are generally used for specific developments that request these types of specialized systems.

As per request of Brickhaus Partners, this report will focus on the more cost-effective and flexible application-based smart home systems. Other than the expensive custom smart home systems previously mentioned, multiple software, electronic, and telecommunication companies provide the majority of application-based smart home systems currently available on the marketplace.\(^{82}\) The most challenging aspect of implementing an application-based smart home systems is evaluating and deciding which system a developer or consumer should install within their unit(s) or project(s).


\(^{80}\) Ibid.

\(^{81}\) Ibid.

\(^{82}\) Ibid.
The following companies produce some of the more popular and widely used app-based smart home technologies systems:

- Nest
- Honeywell
- Sonos
- SmartThings
- AT&T Digital Life

More information regarding specific smart building technologies will be provided in the Product Recommendations: Smart Building System & Technologies section of this report.

**VIII. Conclusion**

The focus of this report is to show that while the ZNE development model and smart building technologies many differ in their individual concepts, when brought together in a strategic approach they can help to create a cost-effective, sustainable, and desirable residential development. In support of this directed research, the two graphs (see Fig. 7 & Fig. 8) display the increase in projected revenues for both the green and sustainable building construction industry and U.S. smart home market. Along with these statistical figures, current market data also supports the financial benefits of utilizing both the ZNE development model and smart building technologies.

However, it is important to mention that some of these increases in sales revenue and rental rates for sustainable homes have to do with certain green property verification processes. The green property verification processes can be understood as a third party company/institution that endorses a real estate developments under their

__83 Ibid._
unique designation(s) of greenness or sustainability; if the development meets the specified criteria then it is awarded a specific certification. The most recognized green verification process is the U.S. Green Building Council’s (USGBC) Leadership in Energy and Environmental Design (LEED) certification.\textsuperscript{84} According to the Earth Advantage Institute, properties in the Portland, Oregon metropolitan area that received a third party sustainable certificate award are sold at a premium price of 3%-5% greater than their noncertified competitors.\textsuperscript{85} Also, this same study stated that the sustainability certified homes stayed on the market for 18 days less when compared against noncertified residential units.\textsuperscript{86} This study shows that developers who invest in sustainable residential projects with third-party certification will receive greater financial gains due to increase in the market demand for green homes. While these green certifications can be beneficial for real estate projects, they are not necessary for creating a successful and sustainable residential development.

The following statements provide facts supporting the growth of sustainable developments in the residential real estate industry:

- Recent studies confirm that that, as of January 2015, the market for houses with green certifications is 10 to 14 percent more than for comparable homes without them.\textsuperscript{87}

\begin{flushleft}
\textsuperscript{84} For more information visit: \url{http://www.usgbc.org/leed}
\textsuperscript{86} Ibid.
\end{flushleft}
62% of those building new single-family homes report that they are doing more than 15% of their projects green. By 2018, that percentage increases to 84%.  

73% of single-family builders and 68% of multifamily builders say consumers will pay more for green homes.  

Harris Interactive poll of over 2,000 Americans found that nearly half (49%) consider eco-friendly features more important than luxury items in a home (31%).  

It is estimated that by 2016 the green single-family housing market will represent 26-33% of the market. This represents an opportunity ranging from $80 billion to $101 billion based on current forecasts.  

In a recent survey, 54% of those building new multifamily projects report that they are doing more than 15% of their projects green. This number is expected to surge exponentially with that percentage rising to 79% by 2018. Firms that do not begin making preparations for a significant uptick in the green residential market risk being locked into an increasingly uncompetitive segment of the residential market.  

Multifamily green residential projects were one of the earliest sectors to recover after the 2009 downturn, with 23% growth in 2010. A high level of growth has been sustained since, with the market rising steadily from $18 billion in 2009 to $48 billion in 2013. This represents high market resiliency even in the face of severe economic challenges, underscoring the high degree of consumer demand for green residential spaces.  

With a strong support of data showing that sustainable residential real estate is a growing trend and the future of the industry, this report concludes that Brickhaus

89 Ibid.  
92 Ibid.  
93 Ibid.
Partners should implement the best practices of sustainable design, construction, and development. The ZNE development model provides the necessary steps and approaches for achieving the highest levels of residential sustainability, maximum building performance, and financial benefits for property sales, rental rate, expenses during building operations.

As previously mentioned in the Review of Smart Building Technologies section of this report, smart homes are in growing demand in the residential real estate market. According to a survey conducted by Coldwell Banker Real Estate LLC, 64% of their sale associates surveyed agreed that consumers today are more interested in homes with smart building technologies and systems then they were 2-5 years ago. This survey also states that 62% of their sale associates agreed that homebuyers are more interested in controlling their smart home technologies and systems through wireless and mobile devices. These survey responses from a national realtor company helps to support that smart building technologies are becoming the norm among current and future homebuyers. The majority of consumers are requesting affordable wireless application-based smart home systems, which is the model recommended for Brickhaus Partners. From and industry standpoint, the sales of smart home devices will exceed 20

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95 Ibid.
million units by 2015 and increase to 36 million units by 2017.\textsuperscript{96} It is clear from the data presented in the previous section, as well as in this conclusion, that the market is demanding more implementation of smart building technologies and systems for residential developments.

With the rapid progression of the residential building industry, developers must continuously educate themselves on the best available building models, products, technologies, and systems in order to produce high quality living spaces. The ability to continually construct desirable developments will allow Brickhaus Partners, or any other developer, to always produce a competitive product within the residential marketplace. The information provided regarding the ZNE development model and smart building technologies, shows that each concept can be successfully implemented individually into a residential development to create a comfortable living experience. However, if both concepts are intergraded together for the purpose of building smart and sustainable residential developments, this combined model will further advance the concept of modern living in the 21\textsuperscript{st} century.

1. Statistics: Project Revenues of Green & Sustainable Construction

Figure 7. Projected revenue of green and sustainable building construction industry from 2012-2017 (in billion USD)
2. Statistics: Project Revenues of the Smart Homes Market

Figure 8. Projected revenue: Americas smart home market 2013-2020 (in billion USD)
IX. Product Recommendations: ZNE Methodology Systems & Technologies

1. Indoor Lighting and Controls

Company: LIFX
Product Line: White 800
Retail Price: $39.99 (per bulb)\(^97\)
Company Website: http://www.lifx.com
Supplier(s): BestBuy, Home Depot, Lowes, online

The LIFX White 800 is a LED light bulb that is energy efficient and compatible with smart building systems. This light bulb allows for control over the degree of light in a room and is connected directly to wireless systems. These light bulbs can be controlled with mobile application devices and/or personal computers and are compatible with the Nest and Honeywell smart technology systems. These light bulbs and control systems incorporate both sustainable and cost-saving systems.

2. Windows

Company: Anderson Windows and Doors
Product Line: 400 Series
Price per Window\(^98\): $310\(^99\)

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\(^98\) This price is for a single wood double-hung window, price for a complete development subject to change due to bulk purchasing of all windows and contracting with a window company/provider:

Company website: [http://www.andersenwindow.com](http://www.andersenwindow.com)

Local Supplier(s): **The Home Depot; 2100 Libby Rd. Maple Heights, OH**

**Lyndhurst Lumber Company; 1511 Lyndhurst, OH**

The Anderson Window and Doors 400 Series offer flexible and reliable residential windows and doors that are energy efficient and come in a wide range of shapes and styles to be tailored to specific building designs:

- Six exterior colors
- Natural pine or white interiors
- Energy efficient
- Durable Perma-Shield® exteriors never need painting
- Extensive range of styles, sizes, and shapes

### 3. Airtightness and Insulations

**Company: Icynene Inc.**

**Product Line:** Spray Foam Insulation


Local Supplier(s): **SonRise Spray Foam & Insulation**

Supplier Website: [http://www.sonrisefoam.com/index.html](http://www.sonrisefoam.com/index.html)

Icyenne Inc. spray foam insulations are an advanced energy efficient construction applications that are a one-step installation performance materials, which both insulate and air seal a building for the lifetime of the structure. The spray foam insulation is

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guaranteed to perform as stated for the lifespan of the building. The following are some of the benefits associated with this product:

- Savings with building heating and cooling cost
- Fill undetected cracks and gaps that cause air leakage
- Increase building comfort
- Keeps out air pollutants and allergens
- Reduces noise levels

4. High Performance HVAC Systems

Company: **Green Home Solutions**

Company Website: [http://ghsohio.com](http://ghsohio.com)

Company Location: **4900 Brookpark Rd. Cleveland, OH 44134**

Recommended HVAC products:

- Carrier Air Conditions
- Carrier Heat Pumps
- Carrier Gas Furnaces
- Carrier Duct-Free Systems
- Infinity® Series Air Purifier
- Performance™ Series Energy Recovery Ventilators
- Performance™ Series Germicidal UV Lamps
- Water Heater & Tankless Water Heater

Due to the complexity of evaluating, selecting, pricing and installing home HVAC systems, this report recommends selecting a sustainable and cost-effective home equipment provider. GHS offers custom design and install state of the art, energy

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102 Ibid.
103 Ibid.
efficient, air conditioning and heating systems and suggest environmentally safe products from Carrier, the world leader in air conditioning and heating systems.\textsuperscript{105}
X. Product Recommendations: Smart Building System & Technologies

1. Nest

Product Line: **Nest Learning Thermostat**
Price per Unit: $249<sup>106</sup>
Product Website: [https://nest.com](https://nest.com)
Supplier(s): Amazon.com, Apple Store, Home Depot, Lowes, BestBuy, Google Store, Nest.com

The Nest is an all-in-one application based smart home control systems that operates through the Nest Learning Thermostat and connects to the consumer’s computer and/or mobile device(s). Not only this product a thermostat that can improve the heating/cooling energy usage for homes, this device can also be synced with other smart devices such as home locks, smoke/alarms, lighting, appliances, phones, cars, fans, security systems, entertainment systems, and lifestyle products such as fitness applications, etc. The wide selection of compatible smart devices allows the property-owners to customize their smart home experience to their personal product preferences and budget. The current Nest system is the second generation of the device, and is a far more advanced smart home system compared to its predecessor. Also, Nest has a program in which home developers can sign-up to create smart and energy efficient homes.<sup>107</sup> The Nest Learning Thermostat is a cutting-edge and is the best smart building technology system on the market.

<sup>107</sup> Nest developer information visit: [https://developer.nest.com](https://developer.nest.com)
2. Honeywell

Product Line: **The Lyric Thermostat**
Price Per Unit: $279\textsuperscript{108}
Product Website: [http://lyric.honeywell.com](http://lyric.honeywell.com)
Supplier(s): Honeywell Pro Contractor, BestBuy, Home Depot, Lowes, Ace Hardware, True Value Hardware, Verizon Wireless

The Honeywell Lyric Thermostat is a smart device that controls home heating/cooling as well as lighting, security, and provides outside weather updates very similar to the Nest. Unlike the Nest, the Honeywell systems can be implemented with one installation service. However, the Honeywell system offers less compatible smart home devices when compared to the Nest. Honeywell is a trusted company in home automation, and their Lyric Thermostat is a good smart home option.

XI. Illustrations

1. Figures


XII. Bibliography


https://store.nest.com/product/thermostat/.


https://www.firstenergycorp.com/content/fecorp/upp/oh/rec_pros/OhioResidentialRECProgram.html.

http://westvillage.ucdavis.edu/partnership/.


http://epa.gov/climatechange/ghgemissions/sources/commercialresidential.html

Steven Winter Association, Inc. is a real estate consulting and advisory firm that operates in the commercial, residential, and multifamily sectors. For more information please visit: http://www.swinter.com/index.htm


XIII. Appendix

1. FirstEnergy Corp. Ohio Residential REC Program Purchase Agreement

Second Amended Residential Renewable Energy Credit Purchase Program Agreement

THIS SECOND AMENDED RESIDENTIAL RENEWABLE ENERGY CREDIT PURCHASE PROGRAM AGREEMENT ("Agreement") is made and entered into as of the ___ day of __________, 20__, by and between __________________________, hereinafter called the "Company," and __________________________, hereinafter called the "Customer," (collectively the "Parties" or individually the "Party"), and is effective as of __________, 20__. (the "Effective Date").

WITNESSETH

WHEREAS, the Company is an electric distribution utility and electric light company, as defined in R.C. § 4928.01(A); and

WHEREAS, Customer is a residential customer, currently taking electric service at its residence under the Company's Residential Service Rate in the Company's Schedule of Rates for Electric Service Tariff; and

WHEREAS, R.C. § 4928.64 requires the Company to meet certain alternative energy resource benchmarks and such compliance may include the use of Renewable Energy Credits ("RECs"); and

NOW THEREFORE, in consideration of the mutual promises set forth herein, and for other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the parties, intending to be legally bound, do hereby agree as follows:

1. Residential Customer: Customer represents and warrants that Customer is a residential customer of Company, and that Customer owns or leases a customer-sited renewable energy project in the State of Ohio that has been certified and approved by the Public Utilities Commission of Ohio (the "Project"). Customer further represents and warrants that Customer has signed and completed the Company's Interconnection documents and currently participates or will participate upon execution of this document in the Company's Net Energy Metering Rider.

2. Fully Aggregated REC(s): Customer expects its Project will generate one or more REC(s), on an annual basis, and understands that fully aggregated environmental attributes associated with one megawatt hour of electricity derived from Customer's Project is equivalent to one (1) REC. Customer shall be responsible for tracking and recording renewable energy that amounts to less than one (1) megawatt hour. Such renewable energy shall not be counted as one (1) REC, until such time it amounts to one (1) megawatt hour of electricity derived from Customer's Project.

3. Project Criteria: Customer acknowledges and agrees that:

The Project shall meet the following criteria:
i. Project must have a placed-in-service date of January 1, 1998, or after, and meet the definition of "Renewable Energy Resource" as defined in R.C. § 4928.01(A); and

ii. Project must be able to generate at least one (1) megawatt hour annually on the Company's energy delivery system.

iii. Project must have a meter that meets the standard set forth in Ohio Administrative Code 4901:1-10 provided by the customer, at its own cost and expense, on the output of the inverter if applicable, where kilowatt hours consistent solely from the Project's generation can be measured and verified. This requirement is waived if the existing utility meter has the incremental functionality described above to measure and verify the kilowatt hour output of the Customer Project.

iv. Project must be attached as a permanent fixture at the Customer's property (service address) during the term of the contract.

v. Renewable energy delivered from a renewable energy resource project shall be calculated by reading the output of the meter at two different points of the year (i.e. January 1 to December 31). Customer must provide documentation evidencing the initial meter reading. An illustrative calculation of this value is as follows:

Output metering reading on January 1, 2009 is 1520 kwhs
Output metering reading on December 31, 2009 is 5433 kwhs

5433 - 1520 = 3913 kwhs or 3.9 MWhs

3.9 MWhs = 3 RECs  (Note: The remainder 0.9 MWhs will carry over into the following year. However, no carryover shall exceed the term of this Agreement)

4. Quantity: Unless this Agreement is otherwise terminated, Company shall pay for the actual whole REC(s) generated by Customer’s Project during the Initial Payable Period, and as applicable, each Subsequent Payable Period. The “Initial Payable Period” means the period from July 31, 2008 through December 31, 2009. The “Subsequent Payable Period” means each such calendar period from January 1st through December 31st. All reasonable costs associated with the administration of this Agreement and the purchase of REC(s) shall be recovered through the Companies’ Rider AER.

5. Purchase Price: Company hereby agrees to purchase RECs on or before December 31st of each year at an amount (“Payment Amount”) to be determined on the last day of the applicable Initial Payable Period (“Initial Payment Date”) or Subsequent Payable Period (“Subsequent Payment Date”). The Payment Amount for residential Ohio solar RECs will be based on the weighted average price (based on the REC price bid for the applicable calendar year) the Companies paid for the product Ohio solar RECs through the Renewable Request for Proposal (“RFP”) which produced a bid(s) for Ohio solar and was held most recent to the applicable Initial Payment Date or Subsequent Payment Date. The Payment Amount for residential Ohio non-solar RECs will be based on the weighted average price (based on the REC
price bid for the applicable calendar year) the Companies paid for the product Ohio non-solar RECs through the RFP which produced a bid(s) for Ohio non-solar RECs and was held most recent to the applicable Initial Payment Date or Subsequent Payment Date. In the event that the Companies have not purchased a single REC for the product Ohio solar and/or the product Ohio non-solar RECs through a RFP, the Payment Amount shall be the Alternative Payment set forth for the applicable year in Attachment B. Notwithstanding, the Companies will issue an RFP in each of 2009 (4th quarter), 2010, and 2011 to the extent that the Companies need additional RECs to meet their statutory benchmarks for the period of the Companies’ Stipulation.

6. Term: This Agreement shall be for a fifteen (15) year term commencing on the effective date of this Agreement. Notwithstanding the foregoing, the residential renewable energy credit program shall not be offered to new customers after May 31, 2011, nor shall an Agreement bear an Effective Date after May 31, 2011.

7. Credit: Customer understands and agrees that Customer must remain in good financial standing with the Company and not become delinquent on any accounts with the Company. Delinquent is defined as having service terminated for nonpayment.

8. Creation of REC(s): Company will rely upon and, shall use information supplied by Customer to create solar and wind REC(s) in PJM Environmental Information Services, Inc.’s Generation Attribute Tracking System (“PJM’s GATS”). Company shall require and shall only accept any and all other renewable energy resource (i.e. other than solar and wind) REC(s) that Customer has created in either PJM’s GATS or MISO Midwest Renewable Energy Tracking System (“M-RETS”). Customer shall also complete the certification documents on file with the Public Utilities Commission of Ohio and the Affidavit of Performance, attached hereto as Exhibit A.

9. Inspection and Audit: Company has the right, upon seventy-two (72) hours prior notice, to inspect and audit performance of the Project. Company will provide Customer written documentation as a result of the inspection and audit. Notwithstanding the foregoing, it shall be the sole responsibility of Customer to operate, maintain, repair, and inspect the Project to ensure its proper working order.

10. Payment (Solar/Wind): Customer hereby agrees to submit an Affidavit of Performance, at the end of Initial Payable Period, and as applicable each Subsequent Payable Period as defined in Article 5 of this Agreement, attesting to the current condition of the Project and the number of REC(s) the Project delivered. Company shall register whole solar and wind REC(s) with PJM’s GATS, and then issue to Customer a payment within 60 business days equal to the number of whole REC(s) generated multiplied by the purchase price.

11. Payment (Non-solar/Non-wind): Customer shall create and maintain a PJM’s GATS account and/or M-RETS account to facilitate the transfer of REC(s) which are neither solar or wind to the Company’s PJM’s GATS account. Company shall issue payment within 60 business days to Customer for non-solar or non-wind whole REC(s) once such REC(s) are received and accepted in the Company’s PJM’s GATS account.
12. Termination: Customer may terminate this Agreement at any time, by giving the Company sixty days’ written notice. This Agreement shall immediately terminate upon the following occurrences: (i) Project ceases to be a permanent fixture on Customer owned property; (ii) Project materially fails to function in such a manner as to produce renewable energy megawatt hours for a payable period; (iii) Commission revokes the Project’s certification; (iv) Commission disallows cost recovery for any REC(s) that were properly registered in PJM’s GATS or M-RETS which the Company purchased in connection with this Agreement, and would otherwise qualify to meet the Company’s statutory requirements and applicable Commission rules and regulations; or (v) the expiration of this Agreement.

13. Limitation of Liability and Indemnification: Customer shall assume all liability for and shall indemnify Company for any claims, losses, and reasonable costs and expenses of any kind or character, other than the costs of defending an action or claim made by a third person, to the extent that they result from Customer’s negligence in connection with the design, construction or operation of the Customer’s Project. In no event shall Customer be liable for consequential, special, incidental or punitive damages, including, without limitation, loss of profits, loss of revenue, or loss of production. The Customer does not assume liability for any costs for damages arising from the disruption of the business of the Company or for the Company’s costs and expenses of prosecuting or defending an action or claim against the Customer. This paragraph does not create a liability on the part of the Customer to the Company or a third person, but requires indemnification where such liability exists. Notwithstanding the foregoing, Customer shall reimburse the Company for any regulatory penalties assessed against the Company for non-compliance with alternative energy benchmarks due to the negligence of the Customer.

14. Notices: Unless otherwise stated herein, all notices, demands, or requests required or permitted under this Agreement must be in writing and must be delivered or sent by overnight express mail, courier service, electronic mail, or facsimile transmission addressed as follows:

If to the Customer:

[Customer Name]
[Address]
[Telephone]

If to the Company:

FirstEnergy Service Company
76 South Main Street
Akron, OH 44308
Attn: Dana J Parshall, Director, Energy Efficiency Program Development
Telephone: 330-761-4491
Fax: 234-678-2140
Email: energyefficiencyrec@firstenergycorp.com

or to such other person at such other address as a Party may designate by like notice to the other Party. Notice received after the close of the business day will be deemed received on the next business day; provided that notice by facsimile transmission will be deemed to have been received by the recipient if the recipient confirms receipt telephonically or in writing.
15. Entire Agreement: This Agreement contains the Parties' entire understanding with respect to the matters addressed herein and there are no verbal or collateral representations, undertakings, or agreements not expressly set forth herein. No change in, addition to, or waiver of the terms of this Agreement shall be binding upon any of the Parties unless the same is set forth in writing and signed by an authorized representative of each of the Parties.

16. Assignment: Customer may not assign any of its rights or obligations under this Agreement without obtaining the prior written consent of the Company, which consent shall not be unreasonably withheld. No assignment of this Agreement will relieve the assigning Party of any of its obligations under this Agreement until such obligations have been assumed by the assignee and all necessary consents have been obtained.

17. Acceptance: The parties hereby acknowledge their acceptance of the terms of this Agreement by signing below:

<table>
<thead>
<tr>
<th>Customer Name (Print)</th>
<th>Company Representative (Print)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Signature</td>
<td>Company Representative (Signature)</td>
</tr>
<tr>
<td>Address Line 1</td>
<td>Address Line 1</td>
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FORM OF AFFIDAVIT

State of __OHIO__________:

______ ss.
(Town)

County of _____________:

__________, Affiant, being duly sworn/affirmed according to law, deposes and says that:

1. I am the duly authorized representative of [the Project].

2. I have personally examined and am familiar with all information contained in the foregoing Statement, including any exhibits and attachments, and that based upon my inquiry of those persons immediately responsible for obtaining the information contained in the Statement, I believe that the information is true, accurate and complete.

3. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

The Statement:

As of ________________, continued to be in
(Date) (Project)

good working order with no material corrective actions pertaining to safety and/or operation warranting attention. Further, [the Project] delivered [Quantity of REC(s)] and I now assign those RECs to the Company.

Meter Read Date

__________________________ Start: ________________ __________

End: ________________ __________

Sworn and subscribed before me this _____ day of _____________.

________Month/Year

Signature of Affiant & Title

__________________________

Notary Signature

__________________________ Print Name and Title
### Alternative Payment:

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</table>
2. Author’s Resume

THOMAS J. DACEY

Current Address:  
1020 Lowerline Street  
New Orleans, LA 70118  
tdacey@tulane.edu

Permanent Address:  
28 Crooked Lane  
Duxbury, MA 02332  
(339) 933-2942

EDUCATION

Tulane University, Tulane School of Architecture  
New Orleans, LA  
Master of Sustainable Real Estate Development  
• GPA: 3.42

Denison University  
Granville, OH  
Bachelor of Arts, Majors: Economics and Environmental Studies  
• Recipient of the Denison Alumni Award Scholarship, based on academic achievement, leadership, and personal merit

Phillips Academy  
Andover, MA  
Post-Graduate

WORK EXPERIENCE

New Orleans Redevelopment Authority  
New Orleans, LA  
Graduate Intern  
September 2014-April 2015
• Worked directly with the land management and real estate teams within the agency
• Performed correspondence for agency’s financing and post-closing operations
• Recorded utility billing information and data for certain properties using agency’s funding sources

Champion Builders, Inc.  
Kingston, MA  
Developer/General Contractor Assistant  
• Preformed research and analysis for multiple stages throughout the develop process
• Managed development’s open house showings and open house marketing
• Prepared houses for building inspections, landscaped yards, and maintained jobsite appearance

Denison University Varsity Athletic Department  
Granville, OH  
Assistant to the Athletics Strength and Conditioning Coach  
September 2012-May 2013, January 2014-May 2014
• Structure training programs for student athletes
• Coach various men and women’s varsity teams with sport-specific athletic training

Millie’s Restaurant  
Nantucket, MA  
Food Runner and Busser  
Summer 2013
• Delivered food to restaurant patrons and bussed tables
• Unpacked and prepared food for kitchen

Cape Cod Express  
Nantucket, MA  
Delivery Driver  
Summers 2010-2013
• Packaged, loaded, and delivered freight, food, and beverage to businesses and homes island-wide
• Compiled and assembled orders for convenience stores and small restaurants
• Assembled furniture and products that required a “white-glove” delivery

LEADERSHIP EXPERIENCE

Sigma Chi Fraternity  
Granville, OH  
Vice President  
February 2013-February 2014
• Supervise executive duties and ensure members’ satisfaction
• Direct post-initiation training for new active members of the fraternity

Derby Days Philanthropy Chairman  
Granville, OH  
February 2013-May 2014
• Coordinated the organization and setup of the fraternity’s largest yearly philanthropy event benefitting the Children’s Miracle Network Foundation and The National Brain Tumor Society
• Communicated all needs for participation and involvement with Denison’s Greek life

Media Chairman  
Granville, OH  
September 2012-February 2013
• Created all fraternity-related philanthropy advertisements and updates
• Administered and communicated the fraternity’s social networking websites and public announcements

ATHLETIC INVOLVEMENT

Denison University Big Red Football  
Granville, OH  
August 2010-November 2013
• Defensive Lineman 2013, Offensive Lineman 2010-2012
• Member of the Big Red Football Warriors Club, based on personal weightlifting and conditioning records