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Overview

The Solar Endowment was an initiative by the Midwest Renewable Energy Association (MREA) with support from the U.S. Department of Energy SunShot Initiative. The purpose of the project was to showcase the investment and programmatic potential of on-site solar energy projects to university governance boards in an effort to generate investment through university foundations, advance favorable board policies to govern investments in solar assets, and provide a roadmap for universities across the country to deploy solar photovoltaic energy (PV) on their campus and make investments that advance their foundation and sustainability goals.

Section 1: Campus PV Development Team

1.1: Key Points of Contact
The Solar Endowment team at Purdue University included undergraduate and graduate students supported by faculty.
- Professor William Hutzel – Principal Investigator – hutzelw@purdue.edu
- William Arnett – Graduate Research Assistant – arnettww@purdue.edu
- Dan Schuster – Senior Energy Risk Engineer, Purdue Energy Office - deschuster@purdue.edu
- Undergraduate interns

1.2: University Business Relationships
- Duke Energy – Utility company that provides electrical needs beyond Purdue’s own combined heat and power plant, the Wade Utility Plant
- Indiana Utility Regulatory Commission (IURC) – Public utilities commission that regulates Duke Energy
- Inovateus, Telamon, and Solar City – Solar development companies involved in PV site assessments
- Purdue Energy Office – Staff/faculty that defined electrical limitations of PV sites and provided input
- Purdue Investment Office – Branch of Purdue Research Foundation that invests annually in Purdue University
- Purdue Office of the President – Provided input on PV deployment and promoted the project
- Purdue Office of Treasurer and Chief Financial Officer – Treasurer, responsible for approving financing models for PV deployment
- Purdue’s Master Planning Staff – Purdue’s Senior Director of Asset Management, assisted in developing potential PV sites
- Purdue Office of Sustainability – Provided project input and support
- Purdue Physical Facilities – Vice President of Physical Facilities, provided input on potential PV sites
- Purdue Research Foundation (PRF) – Chief Entrepreneurial Officer, of the Foundation that owns and manages real estate on the West Lafayette campus
- Purdue Academic Departments
  - Agricultural Economic Professor - Developed feasibility financial models for PV deployment
  - Business Management Professor - Recruited business students to assist the project
- State Utility Forecasting Group – Provided information on state utility regulations and
utility rate projections

- TurningPoint Energy – Clean energy company that provided PV consultation services
- University Resources Policy Committee, Purdue Student Government, and Graduate Student Government - Faculty and student organizations in support of the project

1.3: Student Engagement, Retention, and Incentives
The Principal Investigator and Research Assistant recruited undergraduate and graduate students to assist the Solar Endowment project. Students typically participated in the project for at least one semester and stayed active based on interest. Some students participated for course credit through the Krannert School of Management’s Experiential Learning Initiative (ELI). Other students participated through the Discovery Park Undergraduate Research Initiative (DURI) to gain research experience and insight into designing solar equipment. Along with receiving credit, the project provided students with relevant technical experience. Students also had the opportunity to receive free training through the MREA’s Professional Certificate Programs.

1.4: Stakeholder Incentives
One of Purdue’s long-term goals is to have 10% of its total energy demand met by renewable energy by 2025. Solar PV deployment would contribute to achieving this campus-wide goal. Stakeholder participation in the effort demonstrated commitment to achieving sustainability goals put forward by the Purdue planning staff.

1.5: Professional Development Needs
Solar Endowment team members received assistance through the MREA, campus personnel, stakeholders, and third party contractors specializing in PV design and deployment. Team needs included how to access information on legal considerations, permitting, and financial analysis of priority sites.
Section 2: Decision-Making Process and Key Stakeholders

2.1: Identification of Key Offices, Positions, Committees, and Individual Contacts
Figure 1 is a list of individual contacts, key offices, and committees involved with the decision-making process for solar PV project investment. Final site selection will determine Duke Energy’s involvement in the decision-making process.

Figure 1 - Stakeholder Hierarchy

<table>
<thead>
<tr>
<th>Tier 6</th>
<th>Board of Trustees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 5</td>
<td>University President</td>
</tr>
<tr>
<td>Tier 4</td>
<td>University Treasurer</td>
</tr>
<tr>
<td>Tier 3</td>
<td>Duke Energy Research Foundation Physical Facilities</td>
</tr>
<tr>
<td>Tier 2</td>
<td>Faculty &amp; Staff Graduate Student Government</td>
</tr>
<tr>
<td>Tier 1</td>
<td>Solar Endowment Team</td>
</tr>
</tbody>
</table>
2.2: Key Concerns and Responsibilities
The following flow chart in Figure 2 highlights the key concerns and responsibilities based on each tier group from Figure 1.

**Figure 2 - Key Concerns and Responsibilities**

<table>
<thead>
<tr>
<th>Tier 1</th>
<th>Tier 2</th>
<th>Tier 3</th>
<th>Tier 4</th>
<th>Tier 5</th>
<th>Tier 6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Concerns</strong></td>
<td><strong>Key Responsibilities</strong></td>
<td><strong>Key Concerns</strong></td>
<td><strong>Key Responsibilities</strong></td>
<td><strong>Key Concerns</strong></td>
<td><strong>Key Responsibilities</strong></td>
</tr>
<tr>
<td>• Future land development</td>
<td>• PV priority site selection</td>
<td>• Project barriers</td>
<td>• Promotion of PV deployment to student body</td>
<td>• Interconnect issues</td>
<td>• Approval from each office</td>
</tr>
<tr>
<td>• Interconnection location(s)</td>
<td>• Obtaining stakeholder input</td>
<td>• Stakeholder engagement</td>
<td>• Input on selected PV site(s)</td>
<td>• Approval of selected site(s)</td>
<td>• Approval of PV site(s)</td>
</tr>
<tr>
<td>• PV mounting style(s)</td>
<td>• Consulting third-party contractors</td>
<td>• Approval of selected site(s)</td>
<td>• Financial structuring</td>
<td>• Student body support</td>
<td>• Financial justification of project</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Confirmation of financing model</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Agreement of selected site(s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Project approval</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Meeting with Board of Trustees</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Project justification</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Project implementation</td>
</tr>
</tbody>
</table>
Section 3: Priority PV Development Sites

3.1: Analysis of Electrical Rates and Usage

An analysis of Purdue’s electrical consumption and rates were compiled from data supplied by the Wade Utility Plant. Obtaining and normalizing Purdue’s consumption data generated a graph of Purdue’s seasonal energy usage. Figure 3 shows Purdue’s seasonal and hourly energy use. Although summer has a higher average consumption, it does not have the highest peak due to student absence on campus.

With the deployment of solar power at Purdue, there would be consistent reduction in campus power consumption. Any residual PV generation would be used to offset purchased power, essentially allowing the PV generation to be valued at the real-time pricing (RTP) cost of grid electricity. This would give PV production an average value of $0.05-0.06/kWh. These values are according to the RTP analysis shown in Figure 3 as any energy is likely to be generated during the hours of 9:00 am to 3:00 pm when electricity costs are between $0.05-0.06/kWh.

Figure 3 – Purdue’s Seasonal Hourly Energy Consumption

The scatter plot in Figure 3.1 lists individual consumption (kWh) readings from 2014, along with a cumulative consumption rate and average electrical RTP usage and price.
Figure 3.1 – RTP Price and Consumption Relationships

Figure 3.2 summarizes a year’s worth of RTP energy consumption data and compares it to the annual RTP. As seen from the table, the average peak consumption is during peak sun hours from 9:00 am to 3:00 pm. A PV system generates the most energy during this time period. In addition, PV systems could offset substantial costs since the RTP rate is near its highest point at this time.

Figure 3.2 – 2014 Summary of Energy Consumption and Pricing
3.2: Potential PV Locations
PV system generation was estimated using the National Renewable Energy Lab’s (NREL) PVWatts® software. PVWatts® is a free online software for projecting PV output potential. TurningPoint Energy provided the estimated cost per watt to improve students’ predicted project costs. All carbon offsets were calculated as a comparison with coal energy generation, with an assumed carbon savings of 2,240 pounds of CO₂ per 1,000 kWh generated.

As the structural integrity estimations of rooftops on campus are subject to change, all roofs should be professionally inspected before implementation and all racking systems engineered beyond recommended values to account for environmental factors.

**Site I - Mackey Arena Parking Lot**

<table>
<thead>
<tr>
<th>Mounting Style</th>
<th>System Size (kW DC)</th>
<th>Annual AC Energy (kWh)</th>
<th>Area (m²)</th>
<th>$/WDC</th>
<th>System Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canopy</td>
<td>3,137</td>
<td>4,181,811</td>
<td>20,911</td>
<td>$2.75-3.25</td>
<td>$5,960,300</td>
</tr>
</tbody>
</table>

The 3,137 kW DC canopy array would be located over the Mackey Arena parking lot. The system would cost $2.75-3.25/WDC to install and would have underground interconnections to a nearby substation. Issues at this site could include potential development plans for the parking area as well as resurfacing during the lifespan of a solar array.

The proposed system would generate 4,181,811 kWh of energy annually, offsetting an estimated 7,996 pounds of CO₂ each year compared to a coal-based system. Along with environmental benefits, this system would have high visibility for university promotion and brand-enhancement.
Site II - Southern Parking Lot

The 3,924 kW DC canopy array would be located over the southern parking lot on campus. It would cost $2.75-3.25/WDC to install and would have underground interconnections to a nearby substation. Though this parking lot is one of the largest potential sites for solar development, it is currently unpaved and may see further development in the future. In the recently expanded region of Discovery Park, this plot should be carefully considered to eliminate potential conflicts with planned development or expansions.

The single location system would generate 5,133,289 kWh of energy annually, offsetting an estimated 10,002,747 pounds of CO₂ each year compared to coal power.

Site III - Hilltop Apartments
The 179 kW DC rooftop array would be mounted on the three rooftops of the Hilltop Apartments on campus. The system would cost $2.80/WDC to install and would have interconnections to a nearby building. The interconnection costs are low and the energy this system produces would primarily be used at the site. The site area calculations only included south-facing roofs and currently do not have any plans for redevelopment. As these apartment buildings were constructed in the 1940s and 1950s, contractors will need to check the integrity of the roofs before finalizing plans to ensure good compatibility with solar panels.

The multiple location system would offset an estimated 456,292 pounds of CO₂ each year compared to coal power. The system would generate 242,476 kWh annually.

**Site IV - France A. Cordova Recreational Center**

![System Capacity: 2,069.2 kW DC (13,795 m²)](image)

This 2,069 kW DC rooftop array would be mounted on the France A. Cordova Recreational Sports Center. The system would cost $1.90/WDC to install and would have interconnections to a nearby building or substation. As the building was recently renovated and expanded, the flat roof should be structurally sound for roof-mounted solar.

The single location system would generate 2,536,096 kWh of energy each year and offset an estimated 5,274,129 pounds of CO₂ annually compared to coal power. Installing a PV system at this location adds visibility value and can serve as a public-facing example of Purdue’s commitment to renewable energy, energy efficiency, and sustainability.
Site V - Western Field

This 2,239 kW DC ground-mounted array would be on the campus’ western field. The system would cost $1.90/WDC to install and would interconnect with a nearby substation. This site would make an excellent location for a ground-mounted PV system due to the absence of redevelopment plans and location outside of the main housing and academic buildings.

The single location system would annually generate 3,792,904 kWh of energy and offset an estimated 5,707,480 pounds of CO₂ annually compared to coal power. Along with these environmental benefits, the simple integration into the electrical grid and low risk installation are attractive to outside investors.

3.3 PV Site Suitability Ranking
Systems were ranked based on cost, magnitude, alignment with existing university policy, ease of installation and integration, potential for carbon offsets, and compatibility with the university development plan. The ground-mounted systems for PV arrays are preferable to stakeholders due to their lower cost and greater size potential. The sites are ranked as follows from most to least suitable:

1. Site V, Western Field
2. Site III, Hilltop Apartments
3. Site II, Southern Parking Lot
4. Site I, Mackey Arena Parking Lot
Section 4: Costs and Risk: Approvals and Legal/Regulatory Considerations

4.1: Utility Interconnection Requirements and Fees
There are two possibilities that have been considered for system interconnection. The first involves connecting the solar array to Purdue’s in-house substations. This option will not have any establishment or interconnection fee. The second involves connecting the array to one of Duke Energy’s substations. After contacting representatives from the company, it was found that Duke Energy does not currently charge an interconnection fee.

According to the Indiana Administrative Code 170 IAC 4-4.3-4, a utility may charge an application fee of $100 plus $2/kW for a potential solar PV project. For a 5 megawatt (MW) project, this would equal $10,100 if they were to charge. The utility may also charge fees for engineering studies such as system impact studies or facilities studies, not to exceed $100 per hour. Studies typically take between 16 and 52 hours to complete depending on complexity. As a customer, Purdue would also be responsible for the cost of any system upgrades needed to accommodate the introduction of new large-scale generation into the current distribution system.

A Duke Energy representative commented that a 5 MW system would likely need to be analyzed by the utility to ensure that the specific location can support the load. If connecting at a distribution level voltage of 12 kilovolt (KV) or similar, there would need to be a distribution-level transformer in the substation. If connecting at a transmission level voltage of 138 KV or above, it is likely that an Independent System Operator (ISO) such as Midcontinent Independent System Operator, Inc. (MISO), would process the interconnection request. Interconnection fees would then be assessed based on site location, distance to substations, and time of implementation.

4.2: Permitting and Inspection Requirements and Fees
Beyond utility interconnection requirements and upgrades, permits and inspection requirements for a large-scale PV system would need to be handled through the local, state, and federal authorities. At a local level, development at Purdue may be subject to local zoning ordinances.

4.3: Planning and Zoning Restrictions
The planning and zoning restrictions for the desired site locations include aesthetics, weight-bearing issues, interconnection concerns, and remodeling dates. All zoning and planning must comply with local, state, and federal guidelines including the National Electric Code (NEC).

4.4: State and Federal Policies/Incentives
Net Metering
Net metering is a billing mechanism that credits renewable energy system owners for the surplus electricity they add to the utility grid. This allows customers to offset the cost of power drawn from the utility. The Indiana Utility Regulatory Commission (IURC) adopted rules for net metering to all electric customers. The maximum net metering rules apply to renewable energy resource projects with a maximum capacity of 1 megawatt (MW).

As of May 2017, Senate Bill 309 mandates the subsequent phase out of retail net metering to
occur by July 2022. Those who currently have a net metering contract or enter before December 2017 will be able to continue their contacts until July 2047. After 2022, solar investors would be compensated at wholesale rate plus 25% compared to full retail price.

Business Energy Investment Tax Credit (ITC)
The Business Energy Investment Tax Credit (ITC) is a 30% federal tax credit claimed against the tax liability of residential and commercial investors in solar energy property. The value of the investment tax credit will depreciate after December of 2019 until it reaches 10% value as demonstrated in Figure 4. The eligible solar energy property includes equipment that uses solar energy to generate electricity, to heat or cool a structure, or to provide solar process heat. The use of the equipment must begin with the taxpayer or the system must be constructed by the taxpayer. The energy property must be operational in the year in which the credit is first taken. Purdue is unable to take part in ITC, unless a third party financing structure is pursued.

Figure 4. Yearly Value of ITC

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PV, Solar Water Heating, Solar Space Heating/Cooling, Solar Process Heat</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
<td>26%</td>
<td>22%</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Renewable Energy Credits
Utilities may purchase, sell, or trade Renewable Energy Credits (RECs), defined as 1 MWh of clean energy generation or 3,412,000 British Thermal Units (BTUs). Any excess amounts of clean energy supplied during a specific goal period or any RECs purchased from another supplier may be counted toward the next goal period. All clean energy sources must be in service, purchased, or contracted for by the effective dates of the Clean Energy Portfolio Standard (CPS) program goals. This program sets a voluntary goal of 10% clean energy by 2025 based on the amount of electricity supplied by the utility in 2010. Indiana's participating utilities receive an incentive to increase the amount of renewable energy sources in their portfolio. RECs can be purchased and sold in state markets when utility companies need to meet their solar CPS goal or have surplus RECs.

Purdue would be unable to claim the RECs generated from the PV system if the university were to engage in a land leasing financing option.

4.5: Utility Tariffs and Incentive Programs
State incentives for net metering are mandated up to 1 MW. Any additional energy production sold to the local utility, Duke Energy, will be at a reduced rate by default. This default option can be overridden to provide a larger net metering option with an agreement between Purdue and Duke Energy. According to Duke Energy, they do not offer a feed-in tariff incentive.

4.6: Campus Rules and Procedures
The campus rules and procedures are primarily concerned with the selection of the site and the orientation of the mounting style. Ground-mounted solar arrays must not be above sewers,
power cables and/or underground utility lines. Rooftop systems must pass structural integrity assessments. Future site plans need to be discussed with Purdue’s planning staff.

The Purdue Energy Office provided input on potential PV sites, eliminating those lacking structural integrity and interconnection potential. All sites listed in this document meet the general requirements explained by the university. Before a PV system is implemented, a qualified solar contractor will need to review the sites with Purdue’s Facilities Department.

4.7: Related Liens, Restrictions, and Agreements Affecting Property Use
All priority sites are Purdue owned, eliminating permission for land use but requiring. Any related liens are unknown and negligible for current PV site development. Final approval for the selected site(s) will be approved by the university Board of Trustees, President, Treasurer, and the Purdue Energy Office. Duke Energy will be involved if interconnection is to the local utility’s grid.

4.8: Characteristics Influencing Cost or Risk
Large ground-mounted arrays will need to be discussed with Purdue’s Master Planning staff to determine potential land use conflicts. The Purdue electrical grid substations are relatively far from the proposed sites for rooftop systems, increasing the cost of the system. The weight of a rooftop system will also need to be considered. In general, the cost per kW is more expensive for rooftop arrays. Lastly, the height and complexity of structural engineering requirements of canopy-style arrays increases system cost by 20-30%. In return, proper site selection could promote PV deployment, enhance Purdue’s branding as a “green” school, and improve campus aesthetics.

4.9: Draft Policy Recommendations for Campus PV Projects
Policy decisions will be made with the approval of the university stakeholders, including but not limited to:

- Purdue Energy Office
- Director of Campus Master Planning and Sustainability
- Purdue University Board of Trustees
- President of Purdue

Stakeholders will make decisions based upon the best interests of the university, and they must sign off on any plans before the bidding process can start. Finally, any constructed solar arrays will be maintained and monitored by the owner of the array. This will largely be determined by the interconnection location of the array. If an array ties into the university grid, it will be monitored by the Purdue Energy Office. Interconnection to the local utility will be monitored by Duke Energy and potentially the university for student education purposes. Product selection is based on the discretion of the owner and the bidder, including preference for U.S.- made products.
Section 5: Project Financial Goals and University Investment Opportunities

5.1: Description of Financial Models and Considerations
The financial model with the least financial risk for Purdue is a land lease option where the University would lease land to Duke Energy for them to construct the PV system. This option involves minimal risk because Duke Energy would be the owner of the system, making them responsible for all cost and expenses regarding operation and maintenance. Although this option offers the lowest financial returns, the revenue generated starts from the beginning of the installation.

With more risk but higher potential for financial benefits, a third-party such as Purdue alumnus or other private party could fund the system and sell the power back to Purdue at a discounted rate (compared to projected future electricity costs). Under this option, Purdue provides land to the third party under a power purchase agreement (PPA). A PPA defines the contract between the buyer and the seller of electricity. It specifies all the terms for sale and secures the payment stream between the two entities. The third party would sell the electricity produced by the solar PV system while also taking advantage of federal tax incentives. This option would likely provide the greatest financial returns by eliminating upfront installation costs.

The specific federal and state tax incentives for commercial entities in Indiana that can be leveraged under this financing mechanism include the Business Energy Investment Tax Credit previously stated in Section 4.4. Additionally, the Modified Accelerated Cost Recovery System (MACRS) allows businesses to recover solar energy investments in certain property through depreciation deductions for five years. The owner of the PV system equipment can use the Investment Tax Credit, but must reduce the project’s depreciable basis by one-half the value of the 30% ITC. This means the owner is able to deduct 85% of his or her tax basis.

Other state incentives include the Renewable Energy Property Tax Exemption. This excuses any solar thermal, photovoltaic, and other solar energy systems installed after December 31, 2011 from property taxes based on its assessed value. There is also the Indiana Sales Tax Incentive for Electrical Equipment, exempting equipment, machinery, and tools used in the production of renewable electricity. Coal has traditionally been the cheapest energy source in Indiana, currently generating about 95% of the state’s electricity. Purdue’s Wade Utility Plant provides roughly 30%-50% of annual electricity consumed by Purdue and can be produced cheaply compared to the local utility price. This low cost of electricity poses a barrier to renewable energy adoption.

Figure 5 summarizes the results generated by the economic model called the Solar Economic Evaluation Modelling Spreadsheets (SEEMS), developed to evaluate a number of financial scenarios in Real Time Pricing for universities. The table compares the financing structures and defines the potential of integrating solar on campus. Values for the land leasing structure are given in ranges because a location for the PV system has not yet been defined.
### Figure 5 – Financing Structures

<table>
<thead>
<tr>
<th>Financing Structures at $1.35/W</th>
<th>Net Present Value (NPV)</th>
<th>Annualized Payment</th>
<th>Internal Rate of Return (IRR)</th>
<th>Probability of Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Leasing</td>
<td>$281,266 - $843,798</td>
<td>$19,829 - $59,486</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>University Direct Purchase</td>
<td>$ (204,348)</td>
<td>$ (15,985)</td>
<td>5%</td>
<td>24%</td>
</tr>
<tr>
<td>Third Party Purchase (RTP)</td>
<td>$1,028,165</td>
<td>$80,430</td>
<td>18%</td>
<td>75%</td>
</tr>
<tr>
<td>Third Party PPA at $0.075</td>
<td>$1,071,917</td>
<td>$83,853</td>
<td>30%</td>
<td>75%</td>
</tr>
</tbody>
</table>

The third party option, for both RTP and PPA, provides the highest returns of the financing structures tested. The $0.075 PPA rate was selected for comparison because both values have similar NPV and annualized payments. The main difference between these two options is the IRR because they increase at different rates.

#### 5.2 Financial Analysis of Project Benefits

Although the precise specifications of this project are yet to be confirmed, the project will require the consideration of several factors including size, location, and array type. It is estimated that the capital investment required for this project could range anywhere between $200,000 and $16,000,000 depending on system size.

Other factors to consider include the utility inflation rate, required installation labor, and operation and maintenance costs. Based on a Purdue graduate student’s financial analysis completed in Spring 2015, the total cost of a 5 MW solar energy system would be roughly $9,500,000 or more depending on interconnection costs. The net present value of this project under a PPA is estimated to be $3,750,000 with a payback of 8.5 years. These projections are based on the assumptions that the PPA rate is $0.06/kWh, solar panel have 20-year lifespans, and the utility inflation rate is 2.0%.

#### 5.3 Budget, Priorities, and Process for Capital Investments

Purdue is considering developing the 500 acres surrounding the Purdue airport into a mixed-use innovation hub that includes housing, retail, and research space. With the new buildings being built in this location, there are prime opportunities to integrate solar into building designs and use additional land unsuitable for buildings for a large-scale solar array.

The Board of Directors of the Purdue Research Foundation establishes the investment policy. Subsequently, the Investment Committee and the Chief Investment Officer are delegated the authority by the Treasurer of the Foundation. The Purdue Investment Pool (PIP) worth $2.397 billion and the Purdue Investment Pool- Cash (PIPC) worth $1.514 billion are managed by the Office of Investments according to the Board of the Purdue Research Foundation under the direction of its Investment Committee. The priority and approach of the Investment Committee involves taking a diversified investing approach that balances the goals of maximizing returns and preserving purchasing power. The Investment Committee intends to enhance PIP’s and PIPC’s real market value and provide a significant long-term funding source for Purdue’s spending requirements by diversifying asset classes and rebalancing toward policy target allocations. Current managed funds include endowed funds, trusts, annuities, and cash. The PIP and PIPC are broken down as follows:
### Figure 6 – Purdue Investment Pool Target Allocation Percentage

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>Target Allocation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>18.0%</td>
</tr>
<tr>
<td>Non U.S.-Equity</td>
<td>13.0%</td>
</tr>
<tr>
<td>Emerging Markets</td>
<td>5.0%</td>
</tr>
<tr>
<td><strong>Total Equities</strong></td>
<td><strong>36.0%</strong></td>
</tr>
<tr>
<td>Hedge Funds</td>
<td>25.0%</td>
</tr>
<tr>
<td>Private Equity and Venture Capital</td>
<td>10.0%</td>
</tr>
<tr>
<td>Real Estate</td>
<td>7.0%</td>
</tr>
<tr>
<td>Natural Resources</td>
<td>7.0%</td>
</tr>
<tr>
<td><strong>Total Alternatives</strong></td>
<td><strong>49.0%</strong></td>
</tr>
<tr>
<td>Fixed Income, High Yield and Cash</td>
<td>15.0%</td>
</tr>
</tbody>
</table>

A solar energy investment would be classified under the Alternative Investments category and the Real Estate or Natural Resources subcategory.

#### 5.4 Current University Foundation Portfolio

As of June 30, 2016, Purdue’s endowment held $2.3 billion. This investment pool distributes over $100 million annually for designated donor purposes. The endowment is subject to management under the Uniform Prudent Management of Institutional Funds Act (UPMIFA). Conditions under UPMIFA include protecting the donor’s gift and designated purpose as well as acting in good faith in accordance with the prudent person rule. Additionally, this act also requires the risk and return objectives of the fund be reasonably suited to the institution and specifies that distributions above 7% are not prudent.

The investment strategy for Purdue’s investment pool is that asset allocation decisions take the perspective of a long-term investor instead of a market-timer. The investment strategy makes the preservation of capital the top priority. The asset allocation decision-making strategy specifies $100 million annual spending distributions. Additionally, asset allocation decisions take into consideration the policy of annual returns greater than inflation plus all spending and are comparable to other billion dollar endowments.

#### 5.5 Potential PV Project Investment Scenarios

Renewable energy, specifically PV, is not defined under the investment offices specifics on return on investment (ROI). All renewable energy investment scenarios would require a ROI of 8-10%. Ideally, these would be accompanied by a short-term payback period. There are currently three potential PV investment scenarios:

**Scenario 1: Utility Scale and Land Lease**

Under this plan, Purdue University would lease at least 30 acres of land near the airport to Duke Energy. This amount of land allows for the integration of a 5 MW system and the cost of land leasing is projected in figure 7 below. The y-axis represents the net present value (NPV) of the system, while the x-axis is the dollars per acre on a monthly basis. At $300 per acre, this
financing structure would generate an estimated $562,500 in NPV. Additionally, all cost and maintenance expenses of the PV system would be the responsibility of Duke Energy.

Figure 7 - Land Leasing NPV Increases Linearly with $/Acre

**Scenario 2: Small Scale and Short Term**
This scenario would take 8 to 12 months from negotiation to commission. Under this plan, the PV arrays would be located on the rooftop of a building and would have the capacity of 50 kW to 2 MW of electricity and cost between $200,000 and $8,000,000. The donor would own the PV asset and earn a ROI on the order of 2.0%. Additionally, the donor would have to depreciate the asset before selling it to Purdue. The main incentive is that the donor would qualify for federal tax credits valued at 30% of the total project cost. Most of the risk in this option is mitigated because Purdue controls all aspects of the installation and operation.

**Scenario 3: Utility Scale and Long Term**
This scenario would take 18 to 24 months from negotiation to commission. Under this plan, the PV arrays would be installed in multiple locations across campus and would have the capacity of 3 MW and 8 MW of electricity, costing between $6,000,000 and $16,000,000. The donor would own the PV asset, earn a ROI on the order of 3.0%, and qualify for federal tax credits up to 30% of project cost. The assets would need to depreciate before being sold to the university to take advantage of the financial qualifiers. This option is more complex and will require more technical, logistical, and financial review.
Section 6: Recommendation and Conclusion

6.1: Technical Site Analysis and Qualification
A ground-mounted system at Site V: Western Field is the recommended site for PV deployment by the Solar Endowment Team. The array would connect to the nearest western substation. A connection here would tie into the university electrical grid and would need to comply with all university electrical requirements. In addition to university constraints, any local, state, or federal codes will need to be addressed, including the NEC.

6.2: Financing Structure
The recommended financing structure for the project is a land leasing agreement with Duke Energy. This structure would have Duke Energy absorb all taxes and fees. All initial costs for the system and risk would be the responsibility of Duke Energy. With this structure, the university would be immediately cash flow positive. The value of the land lease would be negotiated between Purdue and Duke Energy. No rough value has been provided by Duke Energy but would, at a minimum, cover the opportunity cost of the land. This could include recreational or farm land value.

6.3: Environmental Goals and Stakeholder Support
The goals set by the university, federal, or state government are driving factors to deploy PV. Purdue has a goal in place to partner with local utility suppliers to fund renewable and alternative energies on campus. This is a long-term goal set in place by the university to be completed by 2025. A PV array could also contribute to Purdue’s goal to supply 10% of its renewable energy.
Section 7. Project Executive Summary and Timeline

7.1: Project Recommendation and Financial Summary
To demonstrate the feasibility of solar electricity on a university campus, a 9 kW photovoltaic system was successfully installed on the roof of Knoy Hall by a team of Purdue faculty and students. All interconnections and standards were implemented based off university specifications. Once all the connections were made, the solar breaker was closed, allowing power to flow back into the building.

The successful installation demonstrates how solar electricity can complement traditional sources of power. A grid-tied array has been operational on the roof of Knoy since 2013 and was recently expanded for research purposes. During that time, the PV system has operated as expected with the panels requiring minimal maintenance. The purpose of this demonstration system was to inform future large-scale solar planning through lessons learned from this smaller system.

The recent announcement of a billion dollar mixed-use development on the west side of campus could improve the potential for utility scale solar in the long run by offering a variety of siting options. This plan includes more than 500 acres of under-developed land to the west of campus. The integration of a 5 MW system into this development plan would reduce future costs of installation.

There are several financing options analyzed specifically for Purdue that can be used for PV implementation. A more detailed financial analysis needs to be performed over the following financing structures:

- Land leasing with local utility – While financial returns are limited, all risk is held by Duke Energy.
- Third party-owned (donor) - Allows a donor to take advantage of all tax incentives while mitigating university risk. Also a donor/alumni is more likely to offer a lower power purchasing price to Purdue.
- University-owned array – Highest risk financing option with high initial cost.

Based on discussions with university stakeholders, land leasing appears to be the appropriate option for Purdue University at this time. Since the university has not invested into renewables of this magnitude, risk mitigation is a highly desired and prioritized trait.

7.2: Description of Project Benefits and Risks
The deployment of large scale solar PV would provide significant financial, non-financial, and environmental benefits to Purdue. Purdue is continually striving towards offsetting their carbon footprint by fulfilling 10% of its energy consumption by renewable energies. Deploying a 5 MW PV system would contribute to this goal by generating an estimated 3% of Purdue’s electricity needs. An on-site PV system offers ample opportunity for Purdue to lead in renewables research, training, and curriculum integration, as well as branding opportunities from a highly visible system. Financially, the PV system would be a source of income based on implementation methods. Initially, Purdue would need to make a large investment to install the PV system but over time would benefit from cost reduction of electricity generation.
Owning the array would require the university to cover all operation and maintenance expenses, thus taking on all the risks. An alumni-owned system or land leasing agreement removes the risk from the university by passing it on to the third party entity.

7.3: Key Considerations for Maximizing Project Benefits
Key considerations for maximizing benefits and minimizing risks for this project include financial benefits, aesthetics, and student research opportunities. Maximizing financial benefits requires an appropriate financing structure. A tax-exempt university cannot benefit from system depreciation or the investment tax credit (ITC). To take advantage of these opportunities, another entity would have to finance the project and come to an agreement with Purdue to maximize cash flow.

An array located on a rooftop may be less appealing due to safety concerns, reduced visibility, and limited university access. A ground-mounted system does not interfere with building appearance, allows for larger amounts of PV, and offers greater access and visibility.

7.4: Recommendations for Project Financial Structure
Though there are two feasible models for Purdue to invest in a large-scale on-site PV system, due to the University’s prioritization of risk mitigation, the Purdue Solar Endowment team recommends a land leasing agreement with Duke Energy. Under this structure, Duke Energy assumes entire responsibility, including operations and maintenance, and Purdue receives positive cash flow throughout the entirety of the project. The secondary model for purchasing a system of this type is to find a donor (alumni, developer, or utility company) who would purchase the array, receive the tax credit, depreciate the system over time, and sell power back to Purdue through a power purchase agreement (PPA). The system assets could then be sold to Purdue beyond the power purchase agreement timeline.

7.5: Timeline and Benchmarks for Implementation
With the possible development of 500 acres of land near the airport, it is crucial to present findings to Purdue’s Master Planning staff for their consideration on solar PV deployment. Ideally, this would occur in early 2018 before further progress is made on land development. Future work considerations also include a more diverse financing structure analysis and the modification of the modeling platform. For example, modifying the financing structures to incorporate a third party purchasing system, then selling it to Purdue should be addressed before presenting any research to stakeholders.

It is unlikely that the deployment of solar PV will happen before the new net metering provisions begin in December 2017. The earliest realistic implementation date is late 2018 due to the revisions of Purdue’s Master Plan.