**University of Illinois at Urbana Champaign**

**Campus Clean Energy Scoping Document**

**ABE 469**

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**Introduction**

The purpose of this team was to recommend a plan to Facilities & Services at the University of Illinois Urbana-Champaign in regards to the scope of their proposed clean energy plan. Through the past fourteen weeks, the team has interviewed and researched possible technologies to be included in a new clean energy plan for the future of this University. In our plan this team recommends using a combination of renewable energy solutions and improving the current conservation of energy on the campus. Conservation has not been a focus in previous energy master plans and the team believes that prioritizing energy conservation is essential if the University wants to achieve their commitment of becoming carbon neutral. Throughout the course of three months this team interviewed an extensive list of subject matter experts. Linked [here](https://docs.google.com/document/d/1TUJGaJxu5pedDMjREZqBQAC_LIRpDJZRyYL4XxZVC6A/edit?usp=sharing) is a list of these subject matter experts and a brief summary of said interview. The team also gathered information from outside sources and peer Universities and that information can be found below.

**Research**

During the past fourteen weeks the team has conducted multiple different forms of research in order to give an accurate recommendation for the University. This research can be broken down into two categories, subject matter expert interviews and peer institution comparisons. The team reviewed other universities’ carbon zero plans specifically, Stanford, Ball State, and the University of Iowa along with a few smaller universities in the midwest. The team looked at Stanford due to their use of solar panels and solar farms on their campus. It was determined that due to Stanford’s climate they could rely more heavily on photovoltaics compared to the University of Illinois. Ball State uses a centralized geothermal system for their campus. This was a very enticing solution despite some of the issues that Ball State is having with their system, but due to land and space restrictions the University of Illinois would not reasonably be able to solely use geothermal energy. The University of Iowa has a slightly different plan, their goal is to be zero coal not zero carbon. To reach this goal they burn a combination of miscanthus grass and high density energy pellets at their power plant. Abbott Power Plant leadership has looked into similar technologies, but they were deemed inferior at the time. This was found when speaking with the Director of Facilities and Services, Rob Roman.

The other form of research the team conducted was subject matter expert interviews. The team interviewed ten subject matter experts across varying degrees of expertise. These interviewees were asked a variety of questions pertaining to their opinions on the University’s plan for clean energy and questions more tailored to their expertise. Listed below are the individuals interviewed and the dates of their interviews, as well as a link to the team’s notes for each conversation. [Link to Interview Notes](https://uofi.box.com/s/xo2h89fzkcr4oz9wetcb8sz7s9onyewv)

2/25/22: Bill Rose - *iCAP Energy Team Co-Chair*

2/25/22: Andrew Stumpf - *iCAP Energy Team Co-Chair*

3/8/22: Ximing Cai - *CEE Professor, Former Associate Director of iSEE*

3/11/22: Maria Maring - *SSLC iWG Representative*

3/11/22: Gabriel Kosmacher - *SSLC Member*

3/22/22: Rob Roman - *F&S Director of Utilities & Energy Services*

3/24/22: Scott Willenbrock - *Former Physics Professor, UIUC Solar Farm Involvement*

3/28/22: Cynthia Klein-Banai - *Director of Sustainability at UIC*

3/31/22: Caleb Brooks - *NPRE Professor, UIUC Micro-Nuclear Involvement*

4/5/22: Clark Bullard - *Former MechE Professor, Experience in Thermal Systems*

4/5/22: Xinlei Wang - *ABE Professor, Experience in Renewable Energy Systems*

4/5/22: John Zhao - *ABE Doctorate Student, Research in Geothermal Systems*

4/7/22: Mike Larson - *F&S Director of Utilities Production*

4/8/22: Paul Foote - *Energy Efficiency and Conservation Specialist*

4/8/22: Karl Helmink - *F&S* *Associate Director of Utilities and Energy Services*

The team took this information gathered from the interviews and research and used it to craft this recommendation.

**Energy Generation**

Campus energy generation is a crucial aspect of the transition to clean energy. Producing energy allows the University to have control of what powers the campus, which creates a major opportunity to transition to renewable sources and become carbon neutral. This opportunity goes hand in hand with the challenge of implementing the best technologies for the UIUC campus based on demand and climate conditions. Below is the team’s recommendation for energy generation techniques and technologies to be evaluated in the clean energy plan. A diversified combination of technologies should be implemented to ensure the University is not reliant on a sole source.

*Recommended Solutions*

1. **Conversion of Steam Heating System to Hot Water System**

 The current campus heating system is reliant on steam that is produced by the Abbott cogeneration system. While the burning of fossil fuels at Abbott is an efficient system, it is not a clean solution unless significant carbon capture efforts are implemented or a renewable natural gas becomes available. This issue raises the question of how the campus will heat buildings from net zero carbon energy sources. Because the provided steam is at a much higher temperature than what is necessary to heat the buildings, the steam system is inefficient and outdated. If the University wants to be up to date and efficient, the conversion from steam to hot water heating should be considered. A hot water system is efficient, compatible with cleaner generation technologies, and has the potential for energy storage capabilities. The downfall of this conversion is the cost of making the transition, but there is potential to utilize existing steam or Campus Chilled Water System infrastructure (piping, building connections, etc.) for the hot water system. To combat the cost of this transformation, it could be done on a smaller scale in the most compatible buildings, and be spread to the remainder of the campus over time. This conversion would create a modern campus heating system that is not reliant solely on the burning of fossil fuels.

1. **Air Source Heat Pumps**

 One potential technology to address inefficient heating on campus is air source heat pumps. This technology uses the temperature of the outside air to heat or cool a space, allows for the electrification of heating (instead of the current burning of fossil fuels), and would be compatible with both steam and hot water district infrastructure. Air source heat pumps could be installed at a centralized location or directly to a building, which allows for versatility in design. The main setback of this technology would be inefficiency in the colder months, but it is regardless a good option for heat generation for a campus with a desire to move towards carbon neutrality.

1. **Geothermal**

Similar to air source heat pumps, geothermal technology is a ground source heat pump that also transfers heat instead of producing it. The main difference is that geothermal is much more efficient because the ground source is able to maintain a constant temperature regardless of the season, whereas the air temperature used in air source heat pumps changes with the seasons drastically. The use of water to transfer thermal energy is also much more efficient than the use of air. There is huge potential for geothermal to be a key technology on campus, due to its efficiency in both heating and cooling, low operational costs, and compatibility with both steam and hot water systems. Geothermal must be installed underground near the building it will be serving to reach the heat exchange borefield, so it is important to note that this technology will likely need to be implemented on a building by building basis. Important variables to consider when determining building compatibility is the amount of underground space near a building, the geology of an area, the heating/cooling load of a building, and access availability for potential future repairs. The Campus Instructional Facility is currently the fifth and largest geothermal installation on campus. This building can be used as a case study, which will contribute valuable data in determining feasibility for the campus in the coming years.

1. **Solar**

 Solar energy remains to be a proven resource that can be highly efficient in alleviating the energy load across campus. This solution can be applied in the short term, and there are proven cases in existence that can be used as successful examples of its success. Some of the primary examples are the existing Solar Farms 1.0 and 2.0, which are mid-sized farms located on the Urbana campus and connected directly to the campus electrical grid. Solar Farm 2.0 is being proven to be financially feasible. These farms were developed and constructed by private solar developers, and the University owns the right to purchase and use this clean energy on campus, including the associated environmental attributes, such as Renewable Energy Certificates. According to iCAP, “The $20.1M contract is anticipated to save the University $300,000 in the farm’s (Solar Farm 2.0) first year compared to electricity purchased from the wholesale MISO market” ([Illinois Sustainability](https://icap.sustainability.illinois.edu/project-updates-by-place/6364?page=2)). Solar farms are now affordable on a large scale, so solar farms would be an advantageous generation technique in comparison to rooftop solar, which would be individualized to each building and be significantly more expensive.

 While the economics seem to be reasonable, there are certain technical issues that may indicate some disadvantages to solar. Primarily, the photovoltaic generation systems are extremely efficient, but these benefits are largely negated by the lack of viable storage systems. Market batteries are currently too expensive to be implemented on a mass scale, and the leading technology lithium-ion batteries exhibit tendencies to occasionally break down or explode. For this reason, solar farms are useful only during peak seasons and hours, but during evening hours and seasons with less insolation, they become extremely unreliable, thus the University would *need* to rely on other resources. In terms of ways we could improve on some of these issues, there has been research in regard to alternative batteries (i.e. sodium-ion), which are far cheaper than lithium-ion. Some steps that the University could take would be to research these efficiencies and how financially viable they can be on a mass scale. Furthermore, it is important to consider the overall pollution that may be caused from the mining of such materials, in comparison to the pollution associated with fossil fuels. If researchers can develop a stronger understanding of such batteries, there is potential to have more financially viable options, which would immensely improve solar energy’s capacity to be a primary source of energy.

 If the University were to plan a Solar Farm 3.0 on the campus grid, it would be highly important to consider these battery considerations. An additional solar farm may be an extremely beneficial generation resource during peak seasons, but there needs to be alternative options prepared for non-peak solar hours. Additionally, the University needs to consider the importance of land efficiency, and if it would be worthwhile to create this farm on-campus or off-campus. The primary downside of off-campus solar would be the costs of energy transportation-- however, based on our team’s research-- this is still a viable option despite the added expense. The above factors should be the primary considerations for solar energy.

1. **Nuclear**

While nuclear does not seem to be a realistic option *right now* due to its extremely expensive start-up cost, this generation technique is definitely believed to be the future of clean energy, and has the capacity to be the *primary* clean energy source due to its efficiency, emission free technology and abundance. The University could look into micro-nuclear reactors, which could potentially be connected to the Abbott Power Plant and provide *both* thermal and electrical energy for the University. Each micro-nuclear reactor can provide around 20MW of clean energy, would have a lifetime of about 10-20 years and would not require a close proximity to a large body of water. In terms of some negative perceptions regarding nuclear waste and radiation, it is strongly believed that the technology has improved to a point where this would not have a significant negative effect on ecosystems and the inhabitants. Both of these values are quite minimal, and are considered to be not threatening by many professionals and scientists within the field. Perhaps a change in the general public perception of these effects would contribute to potentially gaining more support for nuclear.

The viability of nuclear power is currently in the research stage. Micro-nuclear reactors have only been developed for less than a decade, but these technologies would be highly advantageous due to their ability to be fully factory fabricated. There was hope to secure a grant from the U.S. Department of Energy to help subsidize the implementation of a working nuclear reactor on campus. Although this grant was not awarded in the initial submittal, the University did receive a grant to research and develop these technologies. Our team believes that continuing this research should be a primary focal point in the plan to achieve the iCAP goals, as nuclear power seems to have the capacity to be one of the most reliable and efficient resources of clean energy. An ultimate long-term goal that is to be strived for would be to connect a nuclear reactor to Abbott Power Plant, thus fulfilling the campus’s thermal and electrical needs, while also alleviating the current fossil fuel requirement. It can be roughly estimated that such nuclear generation systems could be viable and commercialized by around 2030.

*Less Feasible Solutions*

1. **Biofuels**

As an alternative to fossil fuels, biofuels have been considered as an alternative fuel for Abbott Power Plant. The team has found this is not the best solution due to certain logistical issues; for example, this technology is considered to be inefficient on our campus due to the energy lost during transportation (from the farms to the plant), which would significantly negate the actual quantities of energy generated. Generating biofuels additionally uses a large amount of land, which would be inefficient as it takes away from other important needs of land (agriculture/food, structures, natural habitats, etc).In terms of both economics and sustainability, biofuels are not the most compatible for use in generating energy on campus.

1. **Wind**

Utility-scale wind is not a feasible option for on-campus generation due to the lack of space and restrictions due to proximity to the Willard Airport. That being said, purchasing electricity from large scale wind farms through Power Purchase Agreements is a potential avenue to obtain more green electricity. These wind farms are able to operate at an economy of scale, making them more efficient than if the University were to install turbines near campus. It is important to note that as long as Abbott Power Plant is operating as a cogeneration system due to campus dependence on steam, the University will have a source of electricity for approximately half the annual electrical energy needs.

**Energy Conservation**

The clean energy plan can not just depend on transitioning the energy generation. It is crucial that there is a stronger emphasis on energy conservation, especially in the short term (next ~10 years), while generation technology is developing.

1. **Minimizing Building Growth**

Although changes must be made to accommodate the growing University, new buildings should only be constructed when absolutely necessary. The University has a Net Zero Space Growth Policy. However there have still been a number of new buildings constructed on campus in the past decade. This is despite the abundant unoccupied space in existing buildings. Updating these older spaces needs to take precedence to new additions.

When additional buildings are added, they need to be constructed under strict environmental considerations and energy efficiency guidelines. This is including but not limited to:

* Platinum LEED certification
* Recycled/recyclable building materials, preferably from local manufacturers, to reduce transportation emissions
* Highly insulated building envelope (efficient windows, adequate insulation, white reflective roofing to keep the building cool
* Roof structured to support possible future solar projects
* Efficient lighting system (sensors, scheduling, bulb efficiency)
* Heat recovery chillers for chilled water and heat recovery wheels
* Chilled water for air conditioning, hot water for heating
* HVAC sensors and scheduling

 These changes can all be seen in the recently constructed Electrical and Computer

Engineering Building on campus. This building could potentially serve as a model for

future buildings. Additionally, it is recommended that the University only accepts these large donations for new buildings, on the condition that the donor also supplies a certain amount for old building updates/renovations.

1. **Updating Existing Building Technology**

The University currently has a retrocommissioning group to update existing buildings for energy conservation. This group averages 25% energy savings per building and has saved the University over $100 million of utility bills to date. This work includes implementing HVAC and lighting sensors and scheduling, surveying the buildings for mechanical issues causing energy losses and doing some level of equipment repair and replacement. The University should continue these efforts and increase funding and support, so that more buildings can be retrofitted in less time.

1. **Renovating Existing Buildings**

Along with updating current systems, many buildings (especially older buildings) need extensive mechanical renovations. The University has let millions of dollars of deferred maintenance pile up. This includes mechanical replacements (air handling units, variable air volume boxes, reheat coils, duct work), as well as replacing leaky windows with efficient ones, roof repairs, and insulation updates. This should be focused on building by building (with several buildings being worked on per year), starting with the buildings with the poorest energy efficiency. It is also suggested that when a building that currently uses steam goes through these renovations, the mechanical updates needed to transition from steam to hot water are made during this renovation period.

**Other Changes**

The team would like to emphasize the need for institutional changes as well. The transition to clean energy will take money, and it is important that significant investments are made to create a cleaner future for this campus, even if it may not be the most economical energy source at the time. Additionally, the University should create policy that ensures community members are conscious of their energy use. A potential option would be to place energy responsibilities on individual departments on campus, giving an incentive to save energy whenever possible. Finally, as the campus continues to grow, there should be a commitment for new buildings to be net-zero so as to not add to the energy load.

**Conclusion**

The team has taken all of the information they gathered and compiled it in this report. With the technologies described above, the University of Illinois Urbana-Champaign will be able to make a leap towards their goal of being a net zero carbon institution. In the short term, the University should focus on solar energy and conservation efforts to work towards fixing and updating the current buildings on campus. This will also include implementation of heat pumps, both air-source and geothermal, on a building by building basis on both existing and new construction projects. The University should also begin the transition from a steam to a hot water system. In the long term, the University should invest in micro nuclear reactors, with the target goal being to connect to the Abbott Power Plant in order to generate both thermal and electrical energy as needed.