iSEE Carbon Offset Program

Technology Research and Options

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Tree Planting

Deforestation increases concentrations of carbon dioxide in the atmosphere and contributes to global warming by intensifying the greenhouse effect. Planting more trees can offset carbon dioxide emissions because the average tree absorbs approximately **22 pounds of carbon dioxide per year for the first 20 years** (Bernet, 2021). Trees are a reliable method of sequestering atmospheric carbon, while also promoting biodiversity and improving complex ecosystems.

Tree planting is currently being invested on the University of Illinois campus and the surrounding communities. The University has developed a tree inventory that contains detailed information, such as calculated benefits and type of species, for all current trees with the exception of those located in the arboretum. The arboretum staff is currently working on inputting the size and species of these trees. As for the area of land reserved for tree planting, there is not a specific boundary for reservations but the staff are open to planting trees all over campus. They are currently looking at planting trees in the open space used for tailgating at Kirby and Oak Street. Planting a tree costs the F&S crew about **$500**. Hiring a landscape contractor will likely be more in the range of **$750 or more**. According to the University's tree inventory, the cost of planting and maintaining trees is compensated because the total yearly eco benefits of **18,171 trees is $1,521,993.66** with **3,400,603.95 pounds** of carbon dioxide sequestered.

In Champaign, the Champaign Park District maintains around **700+ acres** of park ground They have reported in their tree inventory that the trees in the Champaign Park District removed about **31, 399,079.89 lbs of carbon dioxide** from the atmosphere, which given the social cost of carbon at $51.27/ ton, can be valued at **$730,216.91** (values represent the carbon sequestered from 2020-2021 and do not account for annual sequestration rates of other ecosystem services). A tree costs **$200-$250 on average** (not including delivery or pick-up costs from the nursery), staff costs **$50-$75**, and fuel for travel and planting is about **$40**.

In Urbana, the Urbana Park District plants trees in vacancies created by recent tree losses, or when there is a space that can provide for a tree without impacting space kept open for athletic activities. Most of their plantings come through their tribute/memorial tree planting program and are on a case by case basis. The City of Urbana and the park district partner on a tree inventory that includes calculations of carbon offsets. For this program, the Urbana Park District charges **$300** to cover the cost of the tree and maintenance. For the 14,741 calculated trees in the city of Urbana, the total yearly eco benefits is **$1,684,100.50** and **4,184,194.37 pounds** of carbon dioxide was sequestered.

Prairie Restoration

With grass and prairie lands making up 20% of the Earth's surface and 10% to 30% of global carbon stocks, prairies make for an excellent source to store carbon (Cahill, et al., 2009). Not only do prairies provide extensive area and storage, but they prove to be much more reliable than trees as carbon is locked in the soil for centuries and not at risk of being released during wildfires. Pristine prairie land, or land that has not been tilled or overgrazed, has the potential to store **5 tons of carbon per acre**; in fact, it is estimated that all native grasslands in the country could store up to 1 billion metric tons of carbon every year (Gahan, 2020). In comparison, total global emissions in 2018 were estimated to be 7 billion metric tons.

Prairie restoration is a conservation practice to restore crop fields into prairieland. However, the classification of prairie land is dependent on many factors such as biodiversity and native species presence. Beyond the initial conversion cost of roughly **$2,000 per acre**, labor and maintenance are the main cost. Due to the constant threat of invasive species causing competition for resources and the threat of health and longevity of native species, prairies require continuous maintenance and care to maintain its full potential as a carbon sink.

On campus, there are currently **5.7 acres** of prairie kept by the facilities and services department and student volunteer groups. The F&S department also maintains **81.8 acres** of low mow zones which are mowed only 1 to 2 times per year, making these areas prime for prairieland conversion. At a cost of $2,000 per acre of restoration and 5 metric tons of carbon dioxide offset per acre, on campus prairies hold the potential to offset **437.5 metric tons of CO2 per year**.

In the surrounding Champaign community, both the Champaign County Forest Preserve District and the Champaign Parks District have completed various conservation efforts and have displayed strong interest in prairie restoration. To date, the CCFPD has converted **565.2 acres** of prairie across the Lake of the Woods, Sangamon River, Homer Lake, River Bend, and Middle Fork River forest preserves which has the potential to offset **2,826 metric tons of CO2 per year**. The CPD currently maintains **55 acres** of tallgrass restoration which are still in the beginning stages of becoming a diverse prairie.

Though it may not be feasible to implement solely prairie restoration to meet the iCAP offset goals, a conservation program would surely supplement a combination of other offset technologies as well as improve the quality of the environment and educate the surrounding community.

Solar

Solar power is the energy taken from the sun. Through the absorbtion of energy from sunlight into photovoltaic cells in solar panels, solar energy can be converted into thermal or electrical energy (SEIA, 2022). Throughout their **lifetime of about 30 years**, they produce a total emissions of **40g CO2 per kilowatt-hour** (NREL, 2012).

When it comes to the pricing of solar panels, the average cost for a residential system can cost **$3~5 per watt**, while an average **5-kW** residential system will cost between **$15,000 and $25,000**.

On campus, there is the potential for solar farm installation on the south farms of the Urbana- Champaign campus located north of Curtis Road between First St and the railroad tracks. The University has already installed such systems on campus such as Solar Farm 1.0 and Solar Farms 2.0. Due to the unknown stability and condition of most campus rooftops, the installation of solar panels on the roofs of existing campus buildings is unachievable. This leads the team to believe that creating another solar farm on the campus premises would be the only feasible option for creating carbon offsets through solar energy. Based on the data gathered from Solar Farm 2.0 which has a **10kw** capacity and produces **20,000 MWH/ year** at **$3 per watt** of solar power, the implementation of another solar farm on campus able to offset enough carbon to meet the iCap goal would offset a total of **2,204,634 lbs of CO2** per year.

In the Urbana-Champaign community, there is potential for the implementation of solar panels within Willard airport and the neighborhoods of Urbana- Champaign. Willard airport is part of the University of Illinois at Urbana-Champaign, however, it is not part of the campus. Although the exact number of potential solar power for generation has not been determined yet, Willard airport is an option to consider as seen in the *Volaire Aviation Strategic Plan 2020* (CMI, 2020). The rooftops in the neighborhoods of Urbana-Champaign are another feasible option for obtaining solar power and achieving carbon offsets. Today's imaging technology is able to calculate the total roof space available for the installation of solar panels in the community. When considering the total amount of roof space available, there has to be consideration for the roofs that are too old or unable to handle the panel load. For this reason, data must be divided by 2 in order to give a more accurate estimate of available roof space. Based on imaging technology and the consideration that not all roofs are in the right condition for solar panel installation, the city of Urbana has about **7.05 M sq ft** available for solar panel installation. On the other hand, the city of Champaign has about **14.7 M sq ft** available for the installation of solar panels. If all the viable solar panel installations were completed, the city of Urbana would avoid **99,500 metric tons of CO2** emissions, while the city of Champaign would be able to avoid **210,000 metric tons of CO2** emissons.

Through several meetings with solar energy experts in the Urbana-Champaign area, such as Tess Scott and Peter Murphy the team was able to determine several potential sources of solar panels from different countries. Among the most popular are the Chinese, Korean and American panels, each one ranging in cost and efficiency. While Chinese panels are the cheapest, the Korean ones offer the highest efficiency, while the American ones are locally sourced with varying efficiencies. Due to carbon emissions associated with the transportation of solar panels, the team recommends the purchase of **locally sourced panels** from the United States.

In conclusion, with the use of solar energy for carbon emissions, it can be estimated that an acre of solar panels would amount to **400kW capacity** and produce around **600,000 kWh per year.** Such a production amounts to **425 metric tons of CO2** according to the EPA greenhouse gas equivalencies calculator. At $1/ W for utility scale solar, that would cost around **$400,000.**

Geothermal

Geothermal energy is the heat radiating from the Earth's core, or stored heat from the Sun. It is a reliable, constant source of renewable energy that can be used for heating, cooling, electricity production, or for both heat and power generation combined (Energy.gove, 2021). It can be accessed anywhere with geothermal heat pumps and requires less above ground landusage. In general, the temperature of the Earth (and the amount of available geothermal energy) increases with depth, at an average rate of 25 to 30 °C per kilometer. This is a long term solution as it lasts for about 50-100 years. Studies have shown that energy produced by natural gas and geothermal energy is very comparable over a long period of time (EIA, n.d).

For on campus implementation, F&S, the Illinois Geothermal Coalition, and several partners conducted a feasibility study of large scale geothermal energy implementation on campus. This requires establishing **5-6 doublet wells** that are about **5,745 feet deep** to access geothermal energy with a temperature of 115 degrees Fahrenheit from the Mount Simon Sandstone(Figure 1). The feasibility study outlined the wells to be along the southern part of the ACES Legacy Corridor between the intersections of Old Church Road and Race Street and Curtis Road and Race Street (Figure 2). These wells will be connected to pipes that will direct the thermal energy to buildings all throughout campus. Completing the injection wells will be $3.8 million dollars. The hydronic piping system will be $850,000 along with trenching that will be $750,000. Lastly, the cost estimate for heat pumps, heat exchangers and other building implementations will be $3.7 million. Mass commercial use on campus including all the piping will be estimated at roughly **$27.5 million** dollars and will offset about ⅔ of $C0_2$ emissions per building on campus. This will have a payback period of **15-20 years** and can last up to 50-100 years**.** The annual operating costs will be $272,868 with a net present value of -$18,914,638. (Vance, et al., 2018). This structured hybrid plant is shown in Figure 3 below. This solution will have the most carbon sequestration as this can be implemented into all buildings on campus with proper piping and installation. The challenges with one mass hybrid plant is the high upfront costs with additional piping, stronger pumps as the heat will travel further, using more antifreeze and chemicals, and city laws and regulations of having a mass system underground. If implemented on every building on campus, the total amount of geothermal offset potential can be **227,734.89 MTC02/ year** with an **average building sequestration potential of 349.82 MTC02/yr**(Figure 4). In order to meet the iCAP goal of squestering 30,000 MTC02/yr this must be implemented into **86 buildings** on campus. Given from iCAP 2020, UIUC in 2008 emitted 575,088 MTC02/year. This has the **potential to eliminate total UIUC carbon emissions by 40%**.

Partners included Illinois Geothermal Coalition, Illinois State Geological Survey, Prairie Research Institute. The main points of contact are Andrew Stumpf and Ryan Dougherty. Some potential funding sources include the USDOE and SSC.

Extraction Well

The final well diagram for the extraction well is shown below in Figure C1.1.

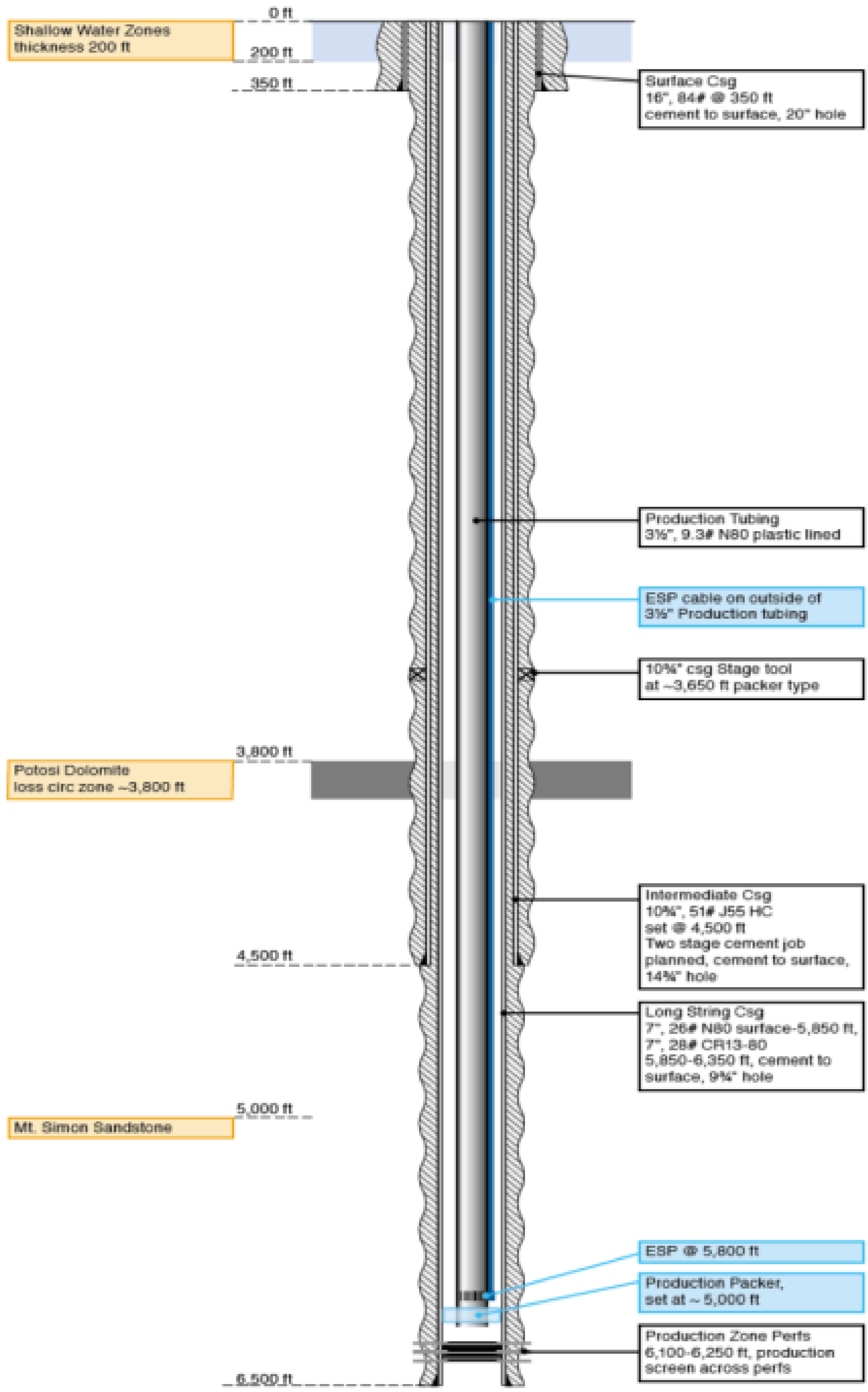


Figure C1.1. Extraction Well Diagram Extraction Well Details

Figure 1: Doublet Wells 5,745 Feet Deep (Vance, 2018)

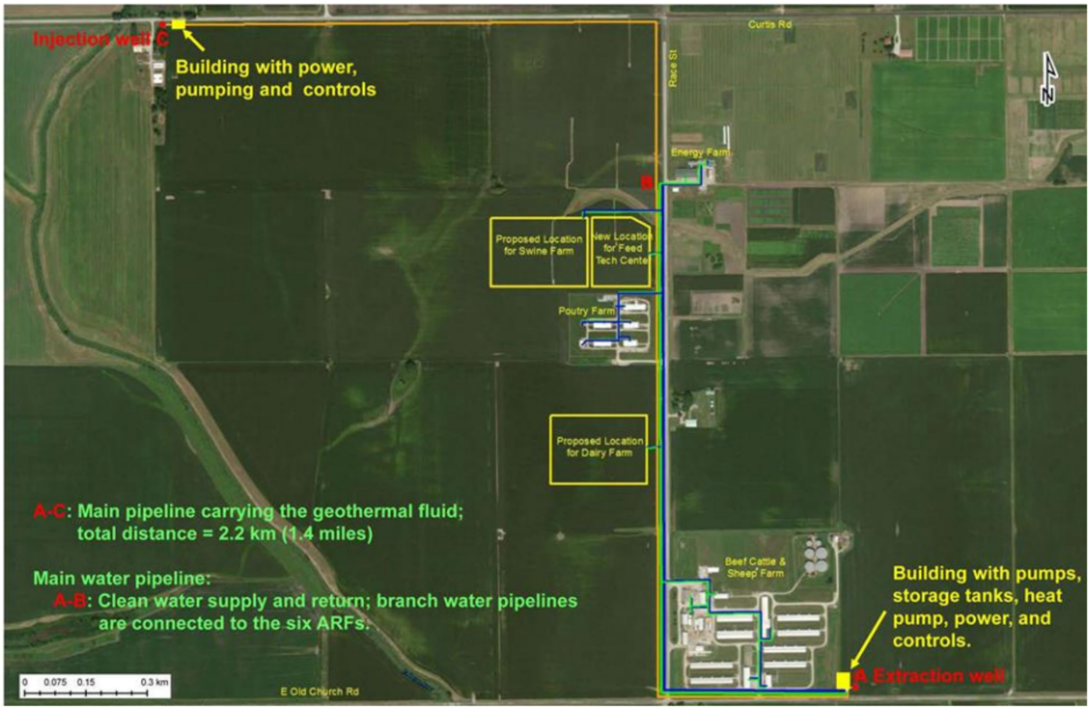


Figure 2: Site Scoping for Hybrid Plant implementation (Vance, 2018)

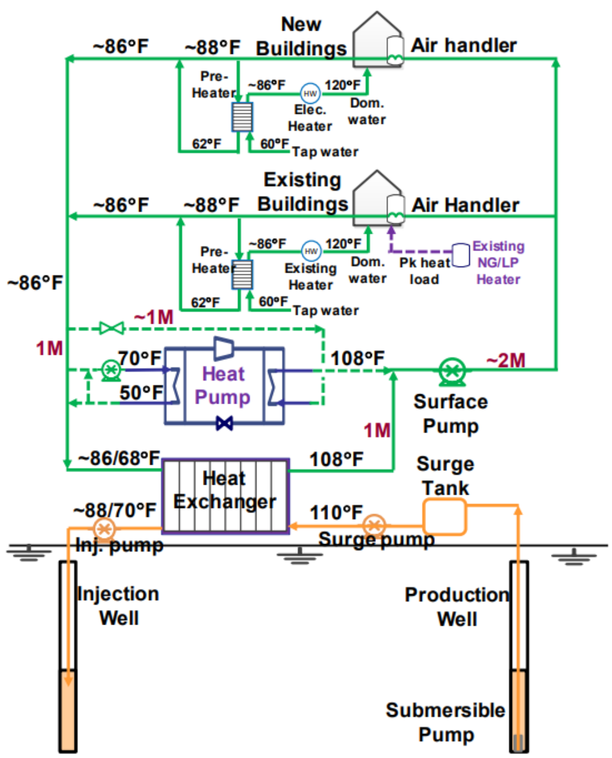


Figure 3: One Hybrid Plant for UIUC Building Implementation (Kirksey, 2019)

Carbon Emissions (MTC02/yr)	
UIUC FY08	575,088.1 (iCAP, 2020)
Air Conditioning, heating, and water heating emissions	345,052.86
Geothermal Offset Potential	227,734.89
Average Sequestration per building	349.82
Remainder needed for NetZero	347,353.21

Figure 4: Carbon Emissions and Geothermal Carbon Sequestration Potential

For potential Champaign Urbana Implementations, the city of Urbana and Champaign has created a "Geothermal Urbana-Champaign 2.0" education program to educate the community on geothermal implementation in addition to establishing business partners to make implementation and use of thermal energy more convenient and affordable. This program will have third party ownership to make the bulk purchasing program more affordable. On the geothermal Urbana Champaign website homes can be site evaluated and given an at-home cost estimate of geothermal implementation. This type of geothermal thermal implementation will be vertical loop (Figure 5). This can be done on most buildings in the community. Prices vary by case and range from **$20,000-$40,000** for individual home implementation. This will offset ⅔ of C02 emissions per building and has a payback period of **15 years**. (Urlaub, 2021). This type of implementation for individual buildings on campus is not feasible due to the amount of space required and the close proximity to buildings on campus versus a community home.

Partners for the Urbana Champaign Community include: Geothermal Urbana-Champaign, City of Urbana, Illinois Geothermal Coalition, Sierra Club Illinois, Geoexchange, F&S, MTD, CCNetPrairie Rivers Network, and Urbana Park District. The main point of Contact is Scott R. Tess who works for the City of Urbana.

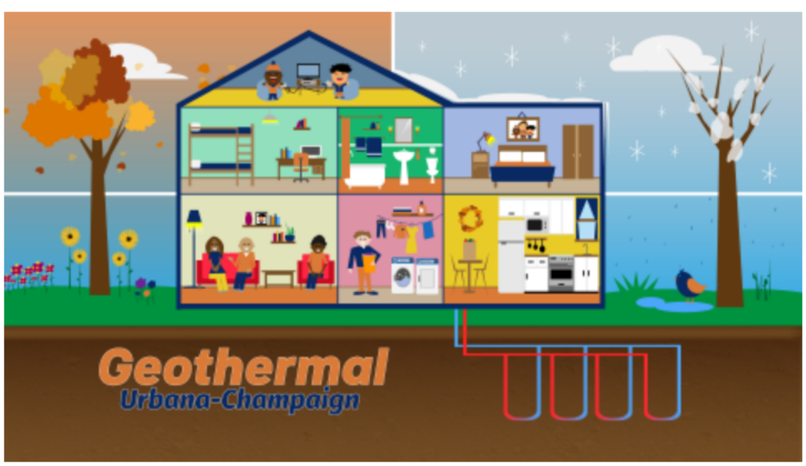


Figure 5: Individual Vertical Loop Building Implementation (Tess, 2022)

Biodigester

A biodigester system produces fertilizer and biogas from organic waste, mainly animal and human excreta. A biodigester is an airtight, high-density polyethylene container in which excreta is continuously diluted with water and fermented by microorganisms found in the waste. It is advantageous to the environment to keep organic materials out of landfills as well as mass amounts of extreta out of sewage systems. Methane can be released into the air and contribute to climate change if these items are allowed to decay in landfills. Another disadvantage of landfilling organic materials is the loss of important nutrients to our ecosystem. The nutrients included in digestate can be utilized to feed and enrich the soil once these components have been digested.

Implementing the biodigester on campus would have an upfront cost of **$10,000,000** (Duffy, 2017). This cost is a result of needing at least two on campus, one in Urbana and one in Champaign, due to the large amounts of energy that would be needed in University facilities. The operating costs of this would be approximately **$25,000 per year** (Duffy, 2017). This cost comes from the maintenance fees that will be associated in order to keep the biodigester working at peak efficiency. This means that there would be an overall cost of approximately **$10,375,000** for a **15 year period**, as this is the estimated lifespan of a biodigester with proper maintenance (Systema.bio, 2021).

The site where this technology could be implemented on campus could be on the corner of East Windsor Rd and South 1st St as well as at the Dairy farm which already has an anaerobic digester proposed (Moore, 2020). With this digester already proposed and researched to have benefits in this location, there is a potential for the use of the digester to be expanded for the use of the University as well. Contacting Sarthak Presad, a former student and worker at the University, he believes that the Dairy farm would be an ideal location for the biodigester. This location would put the digester in close proximity to the cow manure so that there would not be excess methane allowed into the ecosystem in transportation.

According to Presad, the University currently sends excess food waste from the dining halls to the Sanitary District, but only **24,000 pounds** are allowed to be sent out at a time. This means that there is excess food that is just going to waste when instead, we could be using this food as energy on campus. With this in mind, if the Dairy Farm location expanded its digester so that we could use it on a University-wide scale, we would be able to input this excess food waste into the digester and power University facilities.

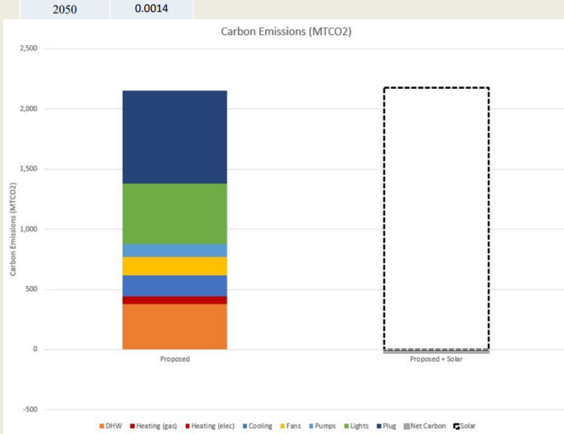
Although it may not be a feasible technology to implement immediately, with more research and time in place to implement this technology it will be beneficial for the University in the future.

What technologies will be implemented together?

Geothermal energy has a low carbon footprint: Emits 38 grams of C02 per kWH, making its sequester about 66%-75% of C02 emissions (Smoot, 2022). In order to reach zero net carbon emissions, the electricity needed to power geothermal energy pumps can be replaced with solar panels in the Urbana Champaign Community. For every one unit of power generated by solar energy, geothermal energy can produce 4 units of power for air conditioning, heating, and water heating (Dandelion Energy, 2019). In addition, solar energy will cover the electricity for plugs and lights that geothermal cannot cover, making each home run solely on renewable energy and independent of fossil fuels. This combination puts the total carbon emissions to under zero (Figure 6). This study was conducted by, Brian Urlaub, Director of Geothermal Operations MEP, a Salas O'Brien Company in EAU Claire, Wisconsin. Although this is an expensive solution, not only will implementation pay itself back in 15-20 years, but it will create energy that can potentially make money. Overall, it is better to invest now in solutions that create net zero emissions to reach the iCAP of a net zero campus by 2050.

LL97 Emission Limits	
Year	MTCO2/SF
2024-2029	0.00675
2030-2034	0.00407
2050	0.0014

Carbon w/ Solar



Carbon Emissions ($MTCO_2$)		
	Proposed	Proposed + Solar
DHW	378	378
Heating	65	65
Cooling	175	175
Fans	152	152
Pumps	106	106
Lights	505	505
Plug	769	769
Total	**2,151**	**2,151**
Proposed Solar Savings	-	2,178
Total Carbon	**2,151**	**-27**
GHG/ft²	**0.00109**	**0**

Figure 6: Zero Net Carbon Emission with Solar and Geothermal Energy (Urlaub, 2021)

Summary of Technologies (both Campus and CU contributions)

Offset Technology	Carbon Offset Potential (metric tons of CO_2)	Cost
Tree Planting	1,542.49	~9,000,000
Prairie Restoration	~3,000	~$50,000
Solar	425	~$400,000
Geothermal	227,734.89	$27.5 Million
Biodigester	N/A with current technological advancements	~10,375,000

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