I.A. Project Proposal
District Use Case: University of Central Florida

Team MARYLAND

UNIVERSITY OF MARYLAND

U.S. Department of Energy Solar District Cup Collegiate Design Competition

U.S. DEPARTMENT OF ENERGY SOLAR DISTRICT CUP COLLEGIATE DESIGN COMPETITION

April 2021

Table of Contents

LAND ACKNOWLEDGEMENTS

University of Maryland

Every community owes its existence and strength to the generations before them, around the world, who contributed their hopes, dreams, and energy into making the history that led to this moment. Some were brought here against their will, some were drawn to migrate from their homes in hope of a better life, and some have lived on this land for more generations than can be counted. Truth and acknowledgment are critical in building mutual respect and connections across all barriers of heritage and difference.

At the University of Maryland, we believe it is important to create dialogue to honor those that have been historically and systemically disenfranchised. So, we acknowledge the truth that is often buried: We are on the ancestral lands of the Piscataway People, who were among the first in the Western Hemisphere. We are on indigenous land that was stolen from the Piscataway People by European colonists. We pay respects to Piscataway elders and ancestors. Please take a moment to consider the many legacies of violence, displacement, migration, and settlement that bring us together here today.

University of Central Florida

The University of South Florida acknowledges that it resides on the traditional Homelands and territories of the Seminole, as well as other historical groups including the Calusa and Tocobaga. Today, the state of Florida is home to the Seminole, Miccosukee, Muscogee, and Choctaw, and to individuals of many other Native groups.

We recognize the historical and continuing impacts of colonization on Indigenous communities, their resilience in the face of colonial and state sponsored violence, and fully support Indigenous Sovereignty. We will continue work to be more accountable to the needs of American Indian and Indigenous peoples.

List of Figures

List of Tables

Chapter One:
Project Proposal & Executive Summary

I. EXECUTIVE SUMMARY

Team Maryland from the University of Maryland (UMD) has created a District Grid Design for the University of Central Florida (UCF) case as assigned. UCF is a public research university in unincorporated Orange County, Florida. According to the case, Team Maryland took three locations into consideration: rooftops of ten buildings and parking lots, an uncleared green space at the southern part of campus, and a small pond potentially to be used for a floating photovoltaic system. Our goal is to build a system that has the highest efficiency and highest wattage production as possible through the selection of photovoltaic panels and roof positioning appropriate to these criteria.

System Design Summary of Approach and Solution

Team Maryland's solar energy system design consists of solar panel arrays on the roofs of 12 buildings in the UCF campus (see figure 1, table 5), and a floating photovoltaic system on Lake 2-H, which is northeast of the main campus (See figure 2). PV modules are connected to inverters with a DC/AC ratio of 1.2, the industry standard for commercial systems. Each rooftop PV system is connected to the building's energy grid to offset its energy consumption.

Another goal of the campus is to create an attractive, functional, and sustainable urban area. The Team Maryland use of PV on existing campus building rooftops will remove from sight the majority of PV capacity from the campus viewshed. However, Team Maryland also included the use of novel floating PV arrays on Pond 2-H to the northeast of the central campus. UCF students in the Mechanical Engineering Department deployed a floating PV array in 2016 on Pond 2-H. The experimental array could power an average home producing more than 5,000 watts (Orlando Sentinel, April 16, 2016)2.

Equipment Selection

The rationale for the equipment selection process and solar panel positioning is to build a system that has the highest efficiency and wattage production as possible. When selecting panels and inverters to propose, Team Maryland compared the top available models on the market, and selected the best equipment calculating the benefits of high-quality equipment vs. the costs, privileging benefits over costs. When designing panel placement, we ensure each had a solar access percentage of at least 95% and we maximized the number of panels on appropriate roof space. Because our panels were placed on flat roofs, we did not orient them with tilt because that would require more spacing between panels. The PV system is designed with an 18-inch spacing between rows of panels to allow for maintenance, as well as 6 feet of distance between the solar arrays and the edges of rooftops. Aurora Solar has been used to design the layout of our PV systems and generate production profiles from the PV arrays. When generating production profiles, location-specific Perez irradiance data and TMY3 The Typical Meteorological Year (TMY) dataset was used. The feasibility of this solar array depends on proper financing over a period of 20 years. Individual System Plans and Irradiance analysis are available in figures 3-27. PV Summaries for individual buildings are available in tables 6-18, in the Conceptual Design Narrative.

The average total system size is 299,930 (DC W) and the aggregate system size of all rooftops is 2,999,300. The total production also varies per building but the total production from all rooftop systems is 13,661 (kWh per kW DC) and the average is 1,366.

Specific models and pricing are sourced from direct calls to vendors in Florida with companies called Vinyasun. They roughly estimated that our panels Sunpower x21 360 com is $317 per panel and the Sunpower x21 470 com is $352 per panel. Online vendors price our Fronius Symo Inverters at $3960. We have added the cost of new transformers since the current models would not be able to transfer the load supplied by the new systems.

Please note that we were supplied two utility usage datasets for the same building, e.g., the Student Union. The datasets provided separate measurements based on sections of the building. For the Student Union, Team Maryland only considers and models the parts of the building that are using the most energy in the entire year (i.e., Student Union 0052E0). Our justification is that, due to the comparative heavy utility use, these building sections will benefit most from a PV system. As for the College of Health Professionals & Science building and the Technology Commons I and II buildings, Team Maryland combines all the production data into one aggregate model.

Upgrading Transformers

After reviewing individual system plans and the current size of transformers at those locations, Team Maryland found that transformers for 6 sites (see table 3) were insufficiently sized to handle the increased power. We researched and selected SquareD's PowerDry 480V to 12kVA model, which comes in a variety of ratings from 125 kVA to 1400 kVA. Our Financial Analysis was then updated to include those costs.

Innovation: Floatovoltaics

Floatovoltaic systems are PV systems that float on bodies of water, making use of space that cannot otherwise be built upon. At UFC there is currently a small floatovoltaic system on the lake to the Northeast of central campus (System #13: Lake 2-H). This system is isolated from the power distribution system of the campus and uses DC power to directly power pumps in the lake to aerate this body of water, which has many environmental benefits. We have proposed adding a second floatovoltaic system to the larger section of the lake directly south to the existing PV system. We have designed a 1.4MW array that will be used to generate power for campus buildings. It will be connected to an addition transformer near 375 feet to the south near the softball field. Due to the size of this system that transformer will need to be upgraded to meet the generation of the proposed floatovoltaic system. Floatovoltaic systems require a floating racking system that is moored in place by use of weighted anchors so that the array orientation does not change due to wind or water conditions.
a floating array on the Lake. While we had originally planned in this final deliverable to complete the designs and planning for the carports, and systems in the green space, we found that these areas were not necessary to collect solar energy sufficient to power the buildings. The total system size is separately calculated for each building's roof, resulting in varying sizes for each system.

II. Team MARYLAND table 1

Name	Role	Field/Discipline	Academic Unit
Favour Nerrise	Team Leader, Student	Engineering/Comp. Science	Clark School of Engineering
Jakob Brinkman	Co-Leader, Student	Engineering	Clark School of Engineering
Tali Kirshenboin	Student	Landscape Architecture	College of Agriculture & Natural Resources
Pamela Mountain	Student	Mechanical Engineering	Clark School of Engineering
Cade Stanfield	Student	Chemistry	
Yasmin Molkara	Student	Business/Finance	Financials
Jonathan Yee	Student	Computer Engineering	Construction Plan
Joey Moore	Student	Engineering	Conceptual & Distribution
Bryan Quinn	Lead Advisor	Electrical Engineer	All
Patricia Cossard	Advisor	reACT Living Laboratory	All
Hosam Fathy	Advisor	Mechanical Engineer	Batteries
Peter May	Advisor	Environmental Science	Site Plan
Garth Rockcastle	Advisor	Architecture	Construction Plan

III. Distribution System Voltage Impact

We used OpenDSS to model the voltage impact of our proposed system. This was an intense learning experience as no one on our team had used software for this purpose before. We ran into several issues with system overloading, and are still working on fixes, and possible upgrades to our system, but mostly struggling with integrating those approaches into our system in OpenDSS.

IV. Financial Modeling

Financial models are based on the 12 building rooftops and the floatovoltaics on Lake 2-H, separate models and each contain slightly different financial data based on production and system size. Since we needed to upgrade 6 transformers for 6 sites, those costs have been added to the overall construction costs. However, state, federal, and other tax incentives are the same since all projects are on the same campus. The projects will take advantage of the federal level "Business Energy ITC", MACRS, and the state level Solar and CHP Sales Tax Exemption where there are no sales tax for solar equipment. All projects on campus provide a leasing opportunity and avoid any land purchase costs. Cash purchase agreement calculation was tasked for each system. Total of agreement is calculated by taking the system's installation cost and then a 10% developer margin is added.

V. Development considerations (zoning, permitting, conformity with district master plan)

Construction limitations for ground mounts include a height limit of 8 feet and requiring a wall of 6 to 8 feet surrounding the panels. Rooftops need a minimum building setback of 5 feet from side/rear property lines and when installing the panels, they will need a balance system. Some permitting considerations include Electrical Permit OR Sun Permit are needed for solar development. The UCF campus also requires a building permit for rooftop work and parking garage work. Finally, the project requires Florida Solar Energy Center (FSEC) "Photovoltaic System Approval Certificate" documentation. According to the district use case, our limit on PV output, cannot surpass the daytime minimum load -- approximately

8000kWh in a 15-minute interval. -- ~30000kW. This consideration will apply to all PV systems from rooftops to ground mounts.

VI. Summary Tables

Table 2: Project Internal Rate of Return and Net Present Value

Building Name	Project IRR	Project NPV @ Investor Hurdle	Viable system as of now?
Classroom Building	-0.43%	($179,021)	No
Psychology Building	8.62%	$17,594	Yes
Student Union	-12.39%	($544,248)	No
College of Health Professionals and Sciences combined	1.66%	($336,776)	No
Engineering Building 2	1.94%	($324,665)	No
Fairwinds Alumni Center	0.00%	($71,657)	No
Career Services and Experiential Learnings	-1.59%	($128,782)	No
Theater Building	-5.50%	($118,503)	No
Technology Commons I and II	-2.92%	($193,903)	No
College and Science	-2.74%	($209,623)	No
Building Total	--	($2,107,178)	--
Building Average	-1.34%	($210,717.80)	--

Table 3: System Sizes, Productions, and Cash Purchases Agreements

Building Name	System Size (DC W)	Production: Est. P50 Annual Production (kWh per kW DC)	Cash purchase agreements
Classroom Building	368,480	1,363	$659,072.70
Psychology Building	256,620	1,368	$395,655.70
Student Union	503,800	1,355	$865,665.90
College of Health Professionals and Sciences	604,800	1,333	$1,179,898.50
Engineering Building 2	611,900	1,360	$1,065,490.80
Fairwinds Alumni Center	72,400	1,370	$217,982.60
Career Services and Experiential Learning	85,500	1,358	$181,164.50
Theater Building	65,800	1,345	$144,103.30
Technology Commons I and II	193,600	1,359	$352,343.20
College and Science	236,400	1,450	$258,119.40
Building Total	2,999,300	13,661	$5,319,496.30
Building Average	299,930	1,366	$531,949.66

Chapter Two:
Conceptual Design

System Design Summary of Approach and Solution

Team Maryland's solar energy system design consists of solar panel arrays on the roofs of 12 buildings in the UCF campus (see figure 1, table 5), and a floating photovoltaic system on Lake 2-H, which is northeast of the main campus (See figure 2). PV modules are connected to inverters with a DC/AC ratio of 1.2, the industry standard for commercial systems. Each rooftop PV system is connected to the building's energy grid to offset its energy consumption.

Equipment Selection

The rationale for the equipment selection process and solar panel positioning is to build a system that has the highest efficiency and wattage production as possible. When selecting panels and inverters to propose, Team Maryland compared the top available models on the market, and selected the best equipment calculating the benefits of high-quality equipment vs. the costs, privileging benefits over costs. When designing panel placement, we ensure each had a solar access percentage of at least 95% and we maximized the number of panels on appropriate roof space. Because our panels were placed on flat roofs, we did not orient them with tilt because that would require more spacing between panels. The PV system is designed with an 18-inch spacing between rows of panels to allow for maintenance, as well as 6 feet of distance between the solar arrays and the edges of rooftops. Aurora Solar has been used to design the layout of our PV systems and generate production profiles from the PV arrays. When generating production profiles, location-specific Perez irradiance data and TMY3 The Typical Meteorological Year (TMY) dataset was used. The feasibility of this solar array depends on proper financing over a period of 20 years. Individual System Plans and Irradiance analysis are available in figures 3-27. PV Summaries for individual buildings are available in tables 6-18.

Upgrading Transformers

After reviewing individual system plans and the current size of transformers at those locations, Team Maryland found that transformers for 6 sites (see table 3) were insufficiently sized to handle the increased power. We researched and selected SquareD's PowerDry 480V to 12kVA model, which comes in a variety of ratings from 125 kVA to 1400 kVA. Our Financial Analysis was then updated to include those costs.

Innovation: Floatovoltaics

Floatovoltaic systems are PV systems that float on bodies of water, making use of space that cannot otherwise be built upon. At UFC there is currently a small floatovoltaic system on the lake to the Northeast of central campus (System #13: Lake 2-H). This system is isolated from the power distribution system of the campus and uses DC power to directly power pumps in the lake to aerate this body of water, which has many environmental benefits. We have proposed adding a second floatovoltaic system to the larger section of the lake directly south to the existing PV system. We have designed a 1.4MW array that will be used to generate power for campus buildings. It will be connected to an addition transformer near 375 feet to the south near the softball field. Due to the size of this system that transformer will need to be upgraded to meet the generation of the proposed floatovoltaic system. Floatovoltaic systems require a floating racking system that is moored in place by use of weighted anchors so that the array orientation does not change due to wind or water conditions.

Energy Storage System Selection and Sizing

Different technology choices exist for stationary battery storage systems, including lithium-ion batteries, vanadium redox flow batteries, and other battery chemistries. Tradeoffs exist between these technologies, including the tradeoff between the commercial readiness of traditional lithium-ion batteries versus the future promise of alternative chemistries (including redox flow chemistries). The proposed system design will utilize commercial, off-the-shelf lithium-ion batteries, thereby benefitting from the technological maturity of these batteries. Batteries used in hybrid electric vehicles or portable electronics typically employ chemistries that maximize energy density, one example being the lithium cobalt oxide (LCO) chemistry. We propose to forego this choice in favor of chemistries that have slightly lower energy densities but longer cycle lives, such as the lithium iron phosphate (LFP) chemistry or the lithium titanate (LTO) battery. The elimination of cobalt as a key cathode material has important environmental benefits. Moreover, both the LFP chemistry and the LTO chemistry have longer cycle lives, and are therefore better-suited for stationary storage applications. Commercial suppliers of the LFP chemistry include A123, and commercial suppliers of the LTO chemistry include Toshiba (through its SciB battery). We propose to integrate these batteries directly into the DC side of the campus PV power system, through DC-DC converters connecting the batteries to the PV stacks. This makes it possible to utilize the battery pack DC-DC converters for photovoltaic maximum power point tracking (MPPT). It also reduces the required sizing of the PV stack solar inverters, which is beneficial from a system cost and efficiency perspective. Commercial, safety-certified battery management systems exist for enabling this functionality, with typical DC pack operating voltages in the 400-600 Volt range.

Table 4: PV Panel Equipment Selection

PV Panel Selection		
Specification		
Make	X21-470-COM	X22-360-COM
Manufacturer	Sunpower	Sunpower
Size	470 W	360 W
Efficiency	21.7%	22.2%
Material	Monocrystalline	Monocrystalline
Cell Type	N-Type	N-Type
Warranty	25 years	25 years

Table 5: Inverter Equipment Selection

Inverter Selection	
Specification	
Make	Symo Advanced 15.0-3 480
Manufacturer	Fronius
Efficiency	97.5% CEC
Warranty	10 years
Connection Type	String
NEMA Class	4X
Size	12-19.5 kW DC

Table 6: Upgraded Transformer Equipment Selection

Building #	Building Name	Rating (kVA)	Transformer (V to kVA)	Design Life (yrs.)	Make	Model
2	Technology Commons 2	125	480-12	20	Square D	Power-Dry
7	College Health & Public Affairs 1	275	480-12	20	Square D	Power-Dry
8	College Health & Public Affairs 2	275	480-12	20	Square D	Power-Dry
10	Classroom Building 1	400	480-12	20	Square D	Power-Dry
12	Student Union	750	480-12	20	Square D	Power-Dry
13	Lake 2-H	1400	480-12	20	Square D	Power-Dry

Table 7: Storage Equipment Selection

Storage Selection	
Specification	
Make	
Manufacturer	
Efficiency	
Warranty	
Connection Type	
NEMA Class	
Size	

Table 8: PV System Size and Generation

Building Number	Building Name	PV System Information			Load Data	
		Module Count	System Size (kW)	Annual Output (kWh)	Building Load (kWh)	% Load
1	Technology Commons 1	147	69.1	93,585	212,881	44
2	Technology Commons 2	265	124.5	169,765	398,430	43
3	College of Sciences	503	236.4	320,352	611,312	52
4	Theatre	140	65.8	88,478	192,000	46
5	Career & Experiential Services	182	85.5	116,158	247,170	47
6	Fairwinds Alumni Center	154	72.4	99,193	247,170	40
7	College Health & Public Affairs 1	1,069	348.8	513,230	1,274,805	40
8	College Health & Public Affairs 2	611	220.0	292,742	1,054,004	28
9	Engineering Buildings 2	1,302	611.9	832,031	1,867,221	45
10	Classroom Building 1	784	368.5	502,139	978,261	51
11	Psychology Building	546	256.6	350,936	894,902	39
12	Student Union	1,072	503.8	682,554	737,269	93
13	Lake 2-H	3,042	1,400	2,049,953	0	N/A

Site Plans: Northeast Campus and Lake

Figure 1: Northeast Section of Campus

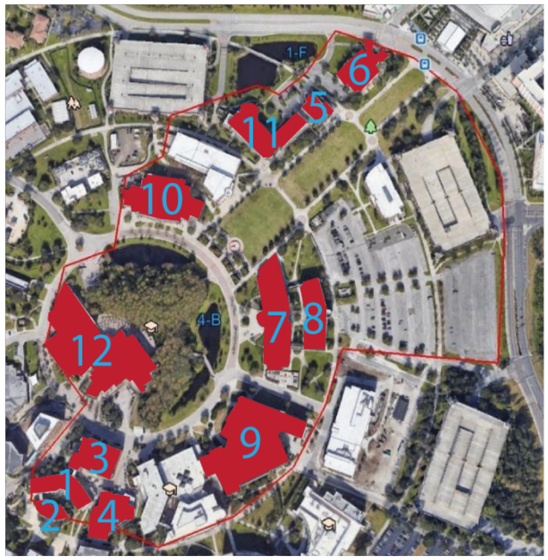

Table 9: Northeast Campus Legend

1. Technology Commons 1	7. College of Health Professionals & Sciences 1
2. Technology Commons 2	8. College of Health Professionals & Sciences 2
3. College of Sciences	9. Engineering Building 2
4. Theatre Building	10. Classroom Building 1
5. Career Services & Experiential Learning Bdg	11. Psychology Building
6. Fairwinds Alumni Center	12. Student Union

Figure 2: Pond east of the stadium open for solar development (tertiary competition area)

Individual System Plans, Shading (Irradiance), & PV Summary

Figure 3: System for Building 1, Technology Commons 1

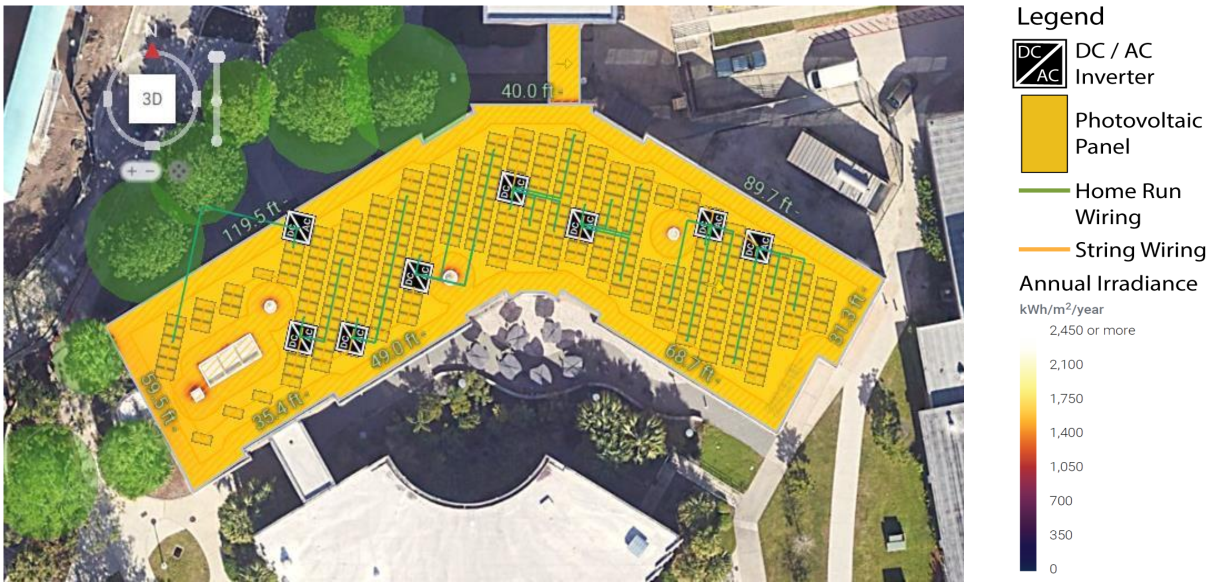

Figure 4: Shading, Building 1

Table 10: PV Summary, Building 1

Array	Panel Count	Azimuth (deg.)	Pitch (deg.)	Annual TOF (%)	Annual Solar Access (%)	Annual TSRF (%)
1	4	149	1	92	100	92
2	143	-	0	91	99	90
Weighted Average/ Panel Count	-	-	-	-	99.4	90.5

Figure 5: System for Building 2, Technology Commons 2

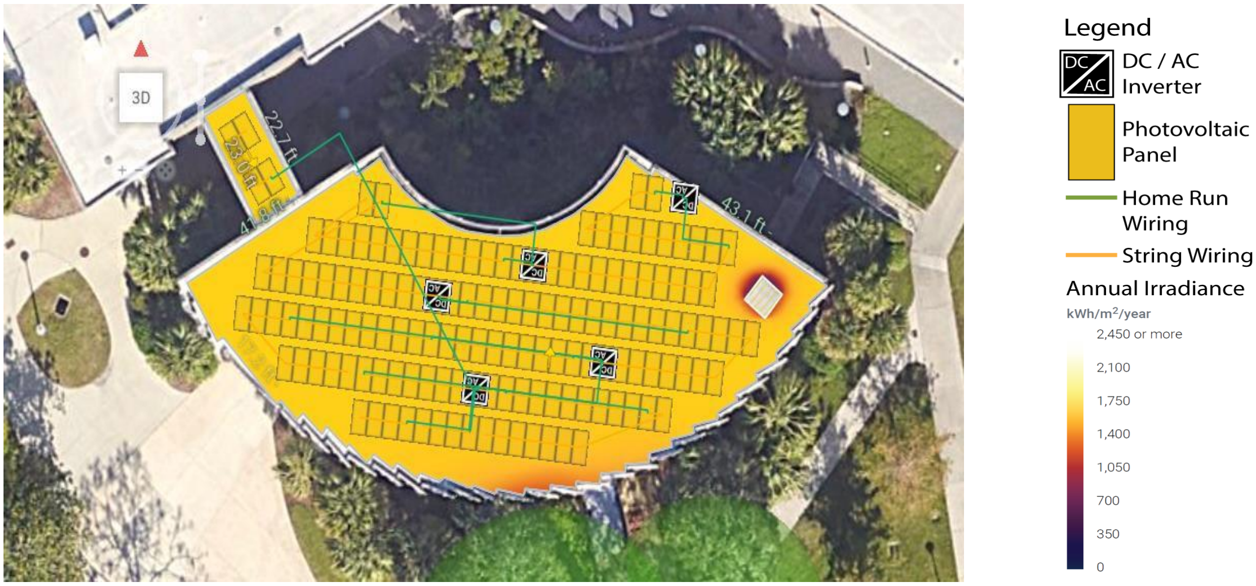

Figure 6: Shading, Building 2

Table 11: PV Summary, Building 2

Array	Panel Count	Azimuth (deg.)	Pitch (deg.)	Annual TOF (%)	Annual Solar Access (%)	Annual TSRF (%)
1	265	-	0	91	100	91
Weighted Average by Panel Count	-	-	-	-	99.8	90.8

Figure 7: System for Building 3, College of Sciences

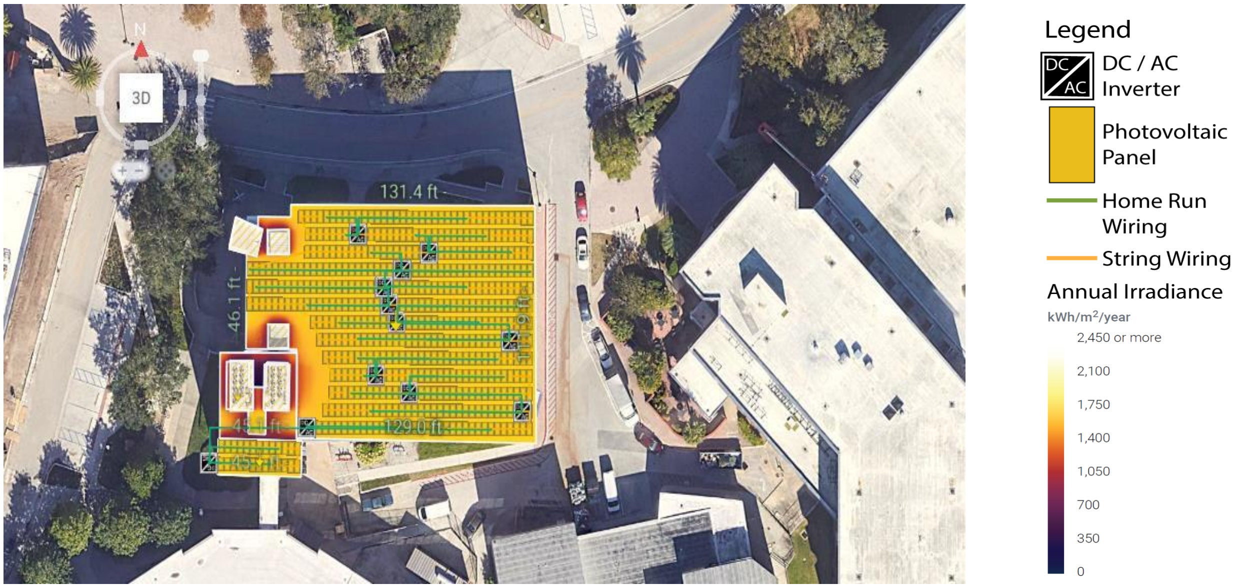

Figure 8: Shading, Building 3

Table 12: PV

Array	Panel Count	Azimuth (deg.)	Pitch (deg.)	Annual TOF (%)	Annual Solar Access (%)	Annual TSRF (%)
1	26	-	0	91	99	91
2	477	-	0	91	100	91
Weighted Average by Panel Count	-	-	-	-	99.7	90.7

Figure 9: System for Building 4, Theatre

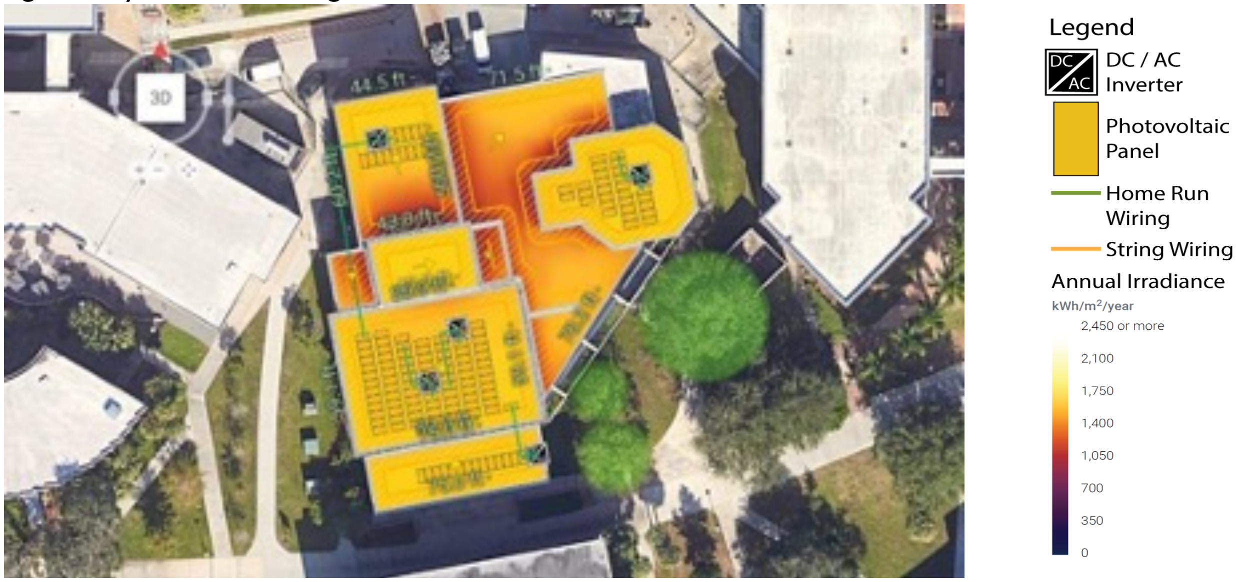

Figure 10: Shading Building 4

Table 13: PV Summary Building 4

Array	Panel Count	Azimuth (deg.)	Pitch (deg.)	Annual TOF (%)	Annual Solar Access (%)	Annual TSRF (%)
1	84	-	0	91	98	89
2	14	-	0	91	99	90
3	14	-	0	91	98	89
4	28	-	0	91	99	90
Weighted Average	-	-	-	-	98.5	89.6

Figure 10: System for Building 5, Career Services and Experiential Learning Building

Figure 11: Shading Building 5

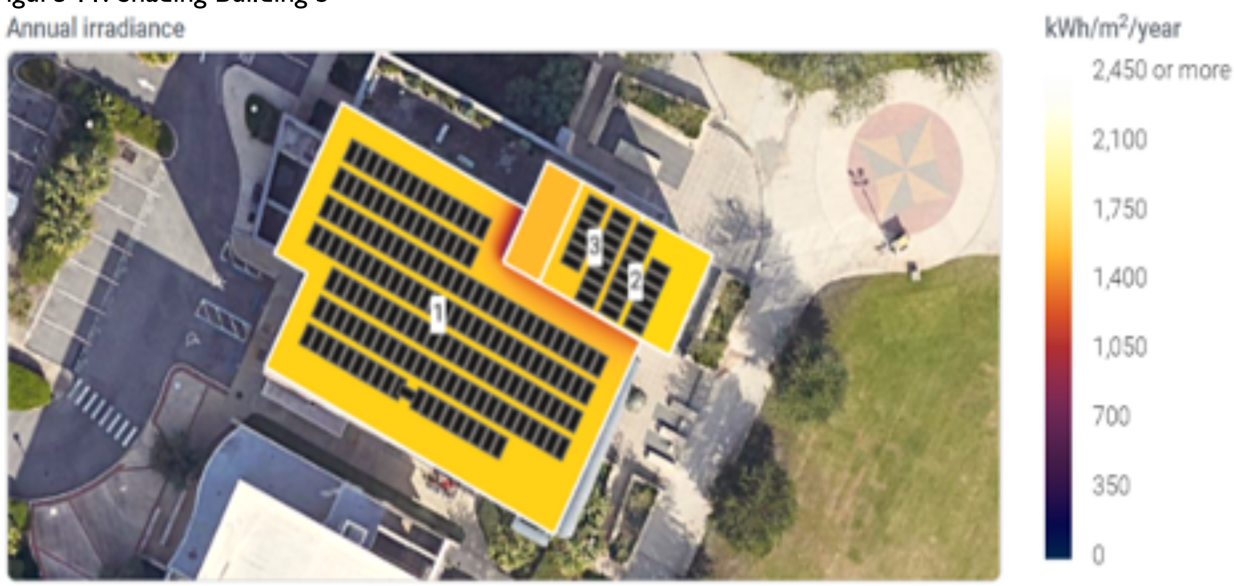

Table 14: PV Summary Building 5

Array	Panel Count	Azimuth (deg.)	Pitch (deg.)	Annual TOF (%)	Annual Solar Access (%)	Annual TSRF (%)
1	154	-	0	91	99	90
2	14	116	7	93	100	93
3	14	296	7	89	100	89
Weighted Average by Panel Count	-	-	-	-	99.5	90.5

Figure 12: System for Building 6, Fairwinds Alumni Center

Figure 13: Shading Building 6

Table 15: PV Summary Building 6

Array	Panel Count	Azimuth (deg.)	Pitch (deg.)	Annual TOF (%)	Annual Solar Access (%)	Annual TSRF (%)
1	98	118	1	91	98	89
2	42	117	25	94	100	94
3	14	-	0	91	98	90
Weighted Average by Panel Count	-	-	-	-	98.7	90.6

Figure 14: System for Building 7, College of Health Professionals and Sciences 1

Figure 15: Shading Building 7

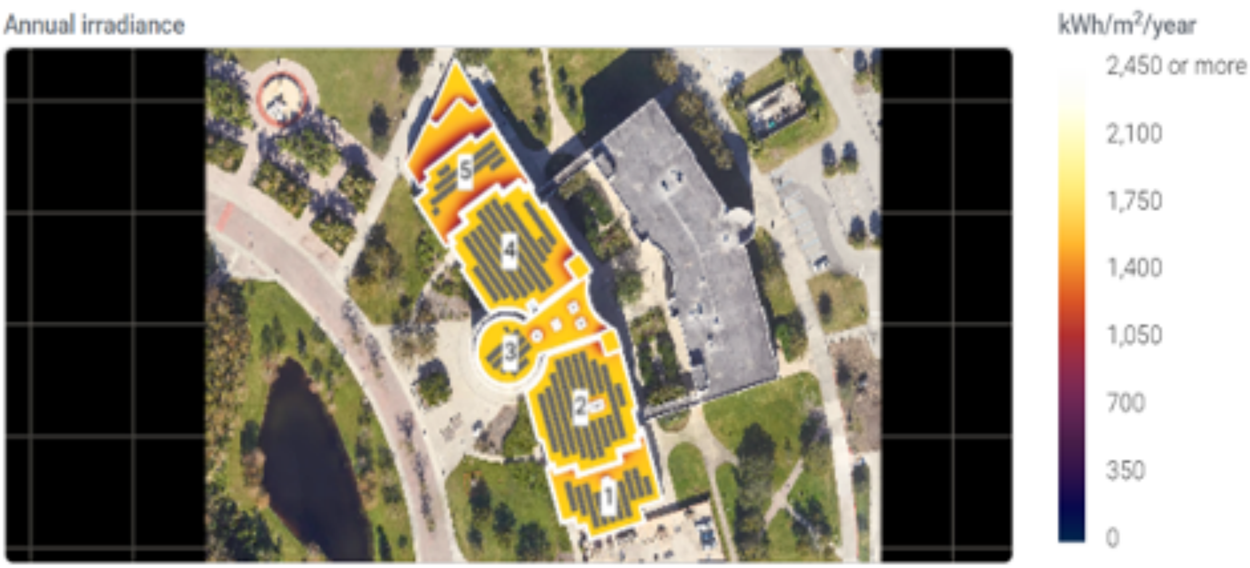

Table 16: PV Summary Building 7

Array	Panel Ct	Azimuth	Pitch	Annual TOF	Ann. Solar Access	Ann TSRF
1	84	-	0	91	99	90
2	196	-	0	91	100	91
3	42	-	0	91	100	91
4	196	-	0	91	100	91
5	56	324	2	90	98	88
Weighted Average	-	-	-	-	99.4	90.4

Figure 16: Building 8, College of Health Professionals and Sciences 2

Figure 17: Shading Building 8

Table 17: PV Summary Building 8

Array	Panel Count	Azimuth (deg.)	Pitch (deg.)	Annual TOF (%)	Annual Solar Access (%)	Annual TSRF (%)
1	540	-	0	91	99	90
2	5	74	3	91	100	91
3	5	52	2	90	100	90
Weighted Average by Panel Count	-	-	-	-	99.3	90.4

Figure18: Building 9, Engineering

Figure 19: Shading Building 9

Table 18: PV Summary Building 8

Array	Panel Ct	Azimuth	Pitch	Ann TOF	Ann. Solar Access	Annual TSRF
1	322	-	0	91	99	90
2	182	315	1	91	100	91
3	70	225	1	91	98	89
4	252	-	0	91	100	91
5	406	-	0	91	100	91
6	70	-	0	91	99	90
Weighted Average	-	-	-	-	99.6	90.7

Figure 20: System for Building 10, Classroom

Figure 21: Shade Building 10

Table 19: PV Summary Building 10

Array	Panel Ct	Azimuth	Pitch	Ann. TOF	Annual Solar Access	Annual TSRF
1	686	-	0	91	100	91
2	42	-	0	91	98	89
3	56	91	1	91	98	89
Weighted Average	-	-	-	-	99.7	90.7

Figure 22: System for Building 11, Psychology

Figure 23: Shade Building 11

Table 20: PV Summary Building 11

Array	Panel Ct	Azimuth	Pitch	Annual TOF	Annual Solar Access	Annual TSRF
1	238	-	0	91	100	91
2	98	170	1	92	100	92
3	182	-	0	91	100	91
4	28	-	0	91	98	90
Weighted Average	-	-	-	-	99.9	91.1

Figure24: Building 12, Student Union

Figure 25: Shade Building 12

Table 21: PV Summary Building 12

Array	Panel Ct	Azimuth	Pitch	Ann. TOF	Ann. Solar Acc	Annual TSRF
1	566	-	0	91	99	91
2	20	-	0	91	99	90
3	104	-	0	91	98	89
4	77	-	0	91	98	89
5	220	-	0	91	100	91
6	28	-	0	91	98	89
7	17	-	0	91	97	89
Weighted Average	-	-	-	-	99.2	90.2

Figure 26: Floating System for Lake 2-H

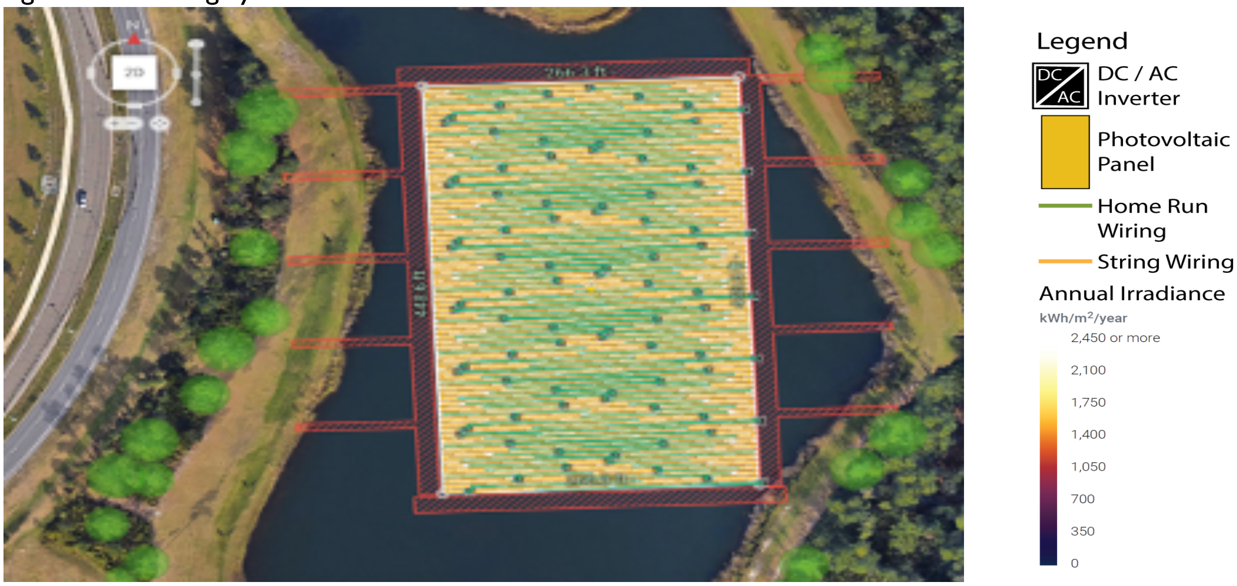

Figure 27: Shade Lake 2-H

Table 22: PV Summary Lake 2-H

Array	Panel Count	Azimuth (deg.)	Pitch (deg.)	Annual TOF (%)	Annual Solar Access (%)	Annual TSRF (%)
1	3042	178	10	96	99	95
Weighted Average by Panel Count	-	-	-	-	98.6	94.6

Chapter Three:
Distribution Analysis

Summary of the simulation methodology applied for analyzing the distribution system impact of the PV sizes and interconnection locations

For our exploration into the analysis of the distribution system on the UCF campus, we utilized the OpenDSS software recommended by the competition organizers. This software is free to use and open source, making it the perfect starting point for analysis of systems. We came from a variety of backgrounds, but none of us had ever worked with this kind of analysis software before, so the initial learning curve was steep to say the least. Despite that, we were able to create a rough model of our proposed PV system.[1] We started by exporting all available irradiance profiles out of aurora solar, and using those .csv files to create loadshapes for all 13 proposed systems, spanning 10 buildings and the lake to the north east of the UCF campus.

```
New LoadShape.Student_Union_load
npts=10950
minterval=60
mult=(File=Hourly-Production-Estimate-Student_Union_1605406396.csv,
col=5,
header=yes)
Action=Normalize
```

We created our load shapes using a model similar to this one representing the Student Union on campus. The .csv file mentioned is the one exported out of Aurora Solar. AuroraSolarexports its irradiance data in hour intervals, so npts over the year is 10950 and its 60 minute intervals. We use the action = Normalize in order to make sure the peaks in the irradiance profiles don’t exceed 1.0.

We then created PVSystem objects in openDSS using a line similar to the following:

```
New PVSystem.Student_Union phases=1
bus1=Node_116
kVA=503.8
```

[1] Our Student Team leader, Tim Owoeye, has suffered 2 hospitalizations and has had to withdraw from courses for medical reasons. A great deal of knowledge needed to be reassembled as well as having to recruit new members who did not participate in the first deliverable. We've had to reassemble files and write new code for OpenDSS since progress was lost due to the illness of our Team Leader.

pf=1
irradiance=1
Pmpp=2000
yearly=Student_Union_load

We propose a single phase system, with a 1.0 power factor. We were also able to use 1 for our irradiance value due to the fact that we normalized our loadshapes. We used a Pmpp value similar to the examples in the webinar, though still are not exactly positive if this is the value we should be using. The yearly irradiance profile is defined in the loadshape so we use just that data. While adding the PVSystems to our openDSS software, we realized we did not have a good idea of where to connect the systems. So we tried to find existing transformers nearby to any given system as a starting place.

Our irradiance and load profiles

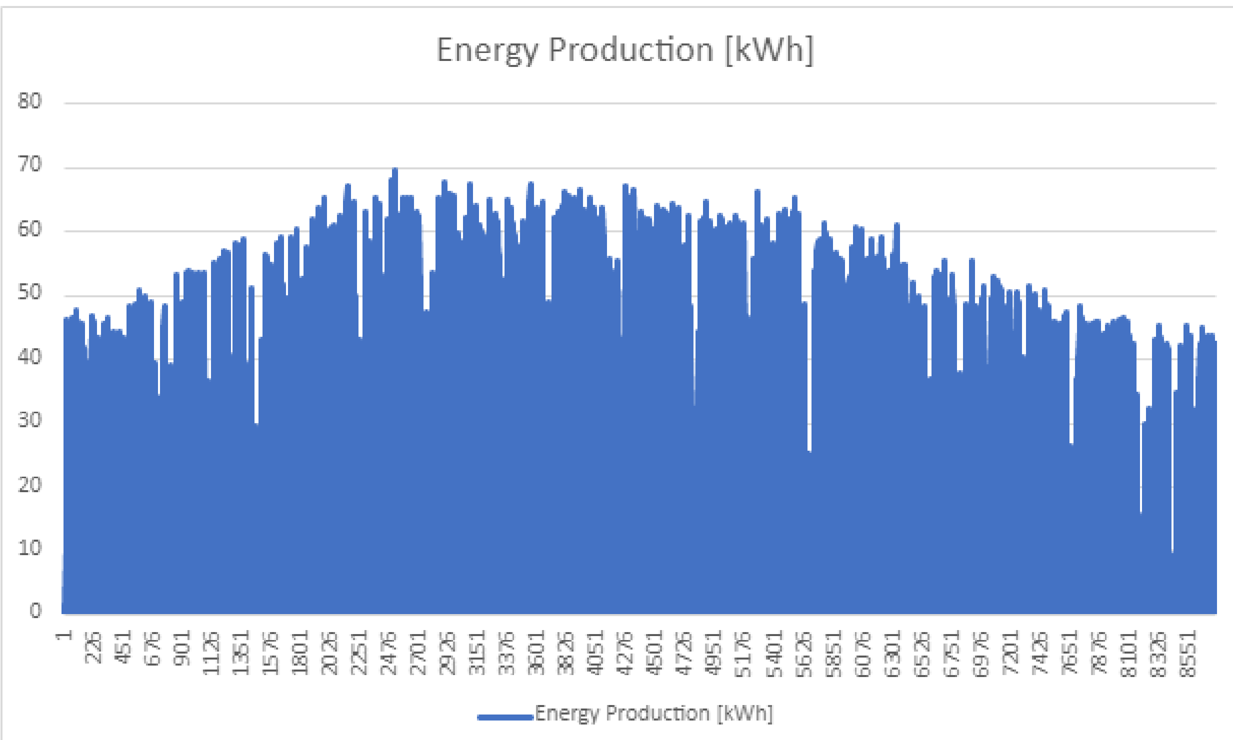

Table 23: Energy Production (kWh)

Our energy production follows a fairly standard irradiance curve across the year, with dips to zero at night, and a general trend upwards in the summer months.

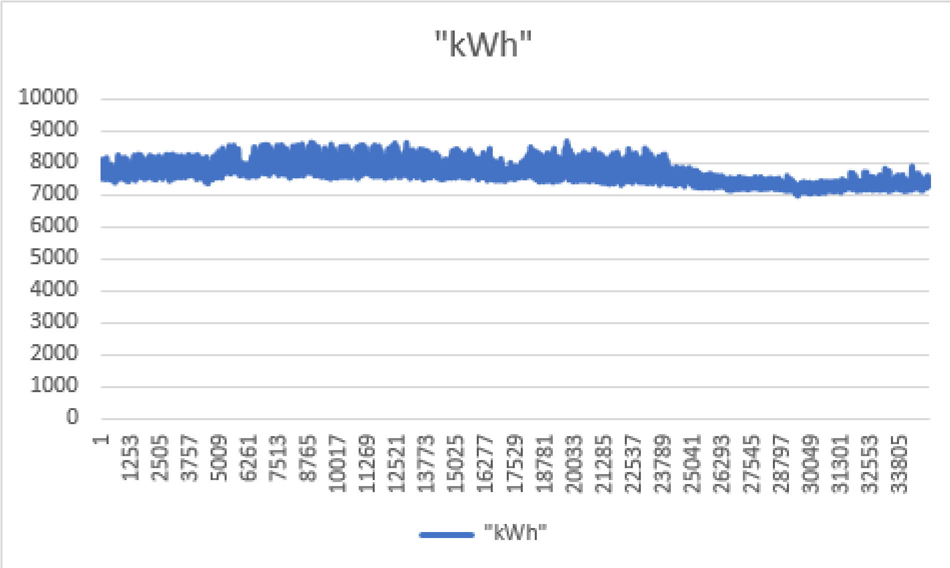

Table 24: kWh

Our consumption data from the OpenDSS base case show a minimum load of around 7500-8500 KWh over a 15 minute period. Because of the constraints of our use case, that makes ~7500kWh in a 15 minute period our main design constraint, as we are not allowed to surpass that amount with our integrated systems.

The irradiance profile is taken from Aurora Solar through the software's own means, mapping out power generation in hourly periods. To help import this data into OpenDSS, we defined our PV systems with normalizing them to 1, reflecting the irradiance profile from 0 (night) to 1 (day). We defined the max size of the system by multiplying it by the normalization, making all the more workable within OpenDSS.

Maximum PV system capacity limit given distribution system constraints and without upgrades

The maximum capacity of our PV systems is dependent on the maximum KVA or kW. According to the OpenDSS code, our PV systems generate 503.8 KVA. The energy meter total for the maximum KVA of our base case is 9160.10363810747. This maximum only allows for a maximum of 18 PV systems. This is a simplified estimate of the maximum PV system capacity. The amount of inverters and transformers also has an effect on the PV system capacity.

Summary of the impact of PV system interconnection on the distribution system

After implementing the PV system, the feeder meter file logged overloading for the "kWh Normal." When we ran our openDSS simulation, we saw that we clearly have overvoltages and overloading of key transformers and lines. This means that we will clearly have to make changes to our implementation of our system in the form of added transformers, smart control inverters, or a myriad of other upgrades possible. For the time being, we recognize that we have consistent overloads of 4-6% in the first transformer subtree, and an incredible amount of overvoltage on several key lines.

Factors that impact PV System hosting capacity on the distribution system

Our PV system hosting capacity is impacted by our inverters settings, the system size and its location on the circuit. Our battery storage will also have an effect. In addition, as equipment is replaced due to wear and tear the hosting capacity will be affected by how well the new equipment can be integrated into the system. The timing of upgrades to this system will also matter. We plan to explore test worst case scenarios with concervative changes in device operations using Snapshot Hosting Capacity analysis. We are also looking at testing interconnections while taking advantage of the autonomous feature of our smart inverters using Uncoordinated Dynamic Hosting Capacity analysis. We will aim to simulate various levels or risky scenarios including possible natural disasters like a hurricane. We will also look into testing flexible interconnection where inverters have a high level of communications capabilities using Coordinated Dynamic Hosting Capacity analysis. Evidently, we understand that a key limit to our design is the size of rooftops and the size of the lake and also cost.

Impact of using smart inverter control modes on the distribution system

We decided to use the Fronius Symo 15.0-3-M. We know that smart inverter controls will play a big role in our PV system hosting capacity. Smart inverters are a form of power electronics that will respond to the environment and make decisions accordingly. Their autonomous decision making abilities allow our distribution system much needed flexibility. In the past inverters were not equipped to deal with small fluctuations in the grid and shut down prematurely. We should not have this issue with smart inverters. Smart inverters have the basic functions of old inverter designs but now it can act based on electrical data and even supplemental data like pricing, temperature or time.

Summary of systems operation, detailing configurable settings for the PV system, capacitor banks, and voltage regulators used for the simulation study

As of now, we have not included any capacitor banks or voltage regulators. Our solar panels are connected to active transformers. Our PV systems are currently based on the hourly production information from Aurora solar.

Summary of the methodology used for any system upgrade detailing any component that was upgraded

As of now, we do not have any upgrades. There are two versions of capacitor banks that we can choose from. The first is a MV capacitor bank. This is built outdoors and is usually delta connected. The second is a LV capacitor bank which is used indoors. Voltage regulators will be implemented if there is an overflow of voltage from the PV systems. We will update the transformers and buses for our PV systems.

PV Sizing Methodology

The methodology behind the system sizing was a simple one. We wanted the ability to cover our roofs and other areas with as many panels as possible while making sure that they operate and generate as much power as they can. We formatted our modeling to disallow panels in locations below a 90% solar access, while maintaining a horizontal tilt and panel spacing of zero. While we cut ourselves off from certain areas within our plots, we maximize the space that we have left over, leading to roofs covered with as many panels as can cover them absorbing close to as much sun as they can.

Reference:
Capacitor Banks

Chapter Four:
Site Conditions and Plans

Identification of applicable land use and zoning ordinances and analysis of compliance

The Authority having jurisdiction (AHJ) for our District Use case is Orange County Florida[1]. The main area that is being considered for PV development lies within the northeast section of the University of Central Florida (UCF) campus. Team Maryland proposes to fit rooftop and floating lake PV systems to their applicable locations as seen below in Figures 5A-1 through 5A-4. While we were provided instructions to consider secondary spaces over parking lots and campus forests, we have found sufficient power generation from the rooftop arrays in the campus center and the deployment of a novel floating PV system on Pond 2-H to the Northeast of the central campus.

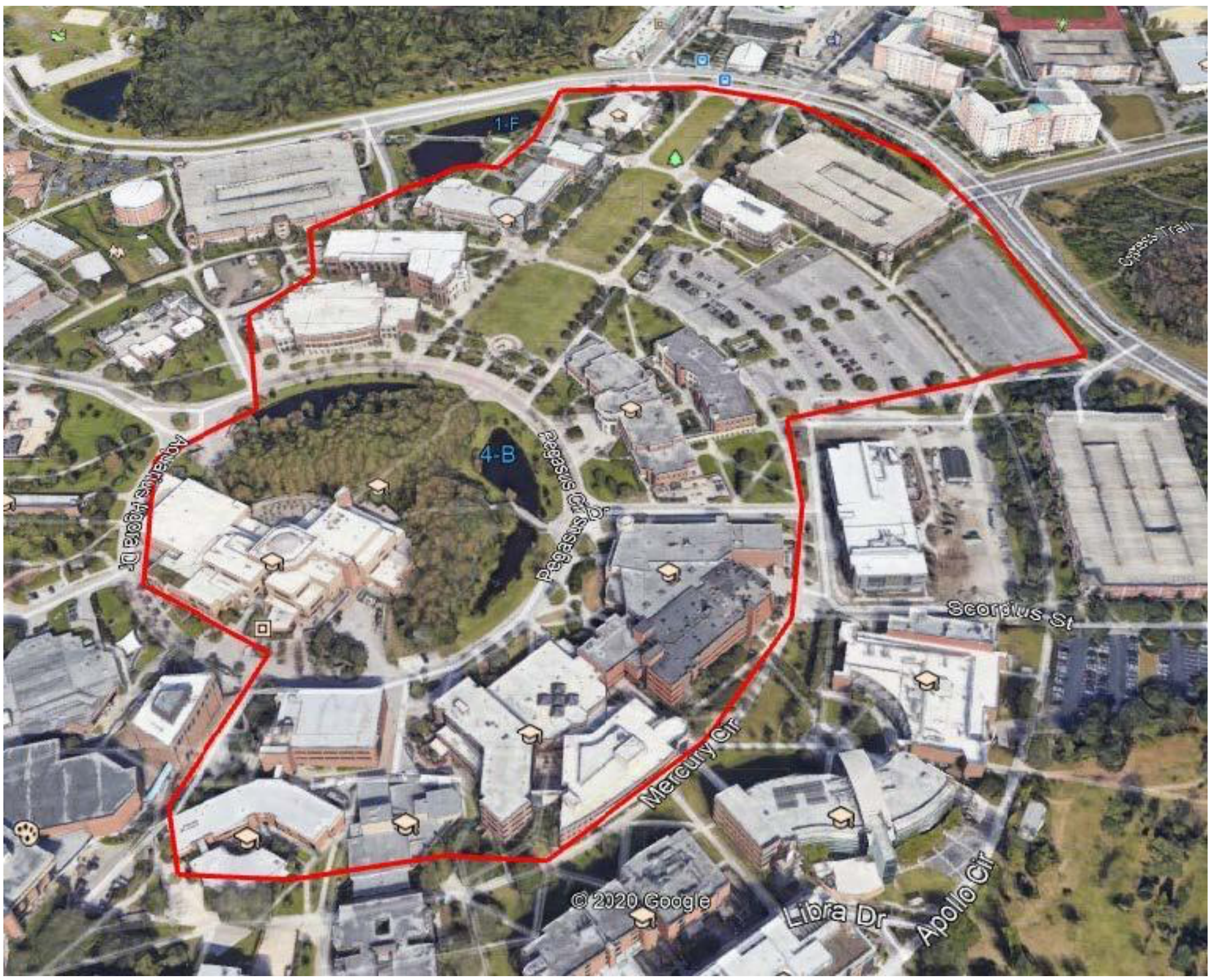

Figure 29: UCF northeast section of campus (primary competition area on building rooftops)

The main area of UCF is classified as a (Residential) multi-family dwelling District with the zoning code R3[1]. Compliance to this zoning is uncertain since the highlighted areas did not contain dormitories

---

[1] Property Record 03-22-31-0000-00-005 https://prc.ocpafl.org/Searches/vabparcel.aspx/PDF/false/PID/312203000000005

however it still falls under the zoning code found in the Orange County directory. All campus construction is controlled through the Building Department. UCF implements the Florida Building Code and applies the performance-based standards contained within.

Figure 30: Aerial view of Pond 2-H

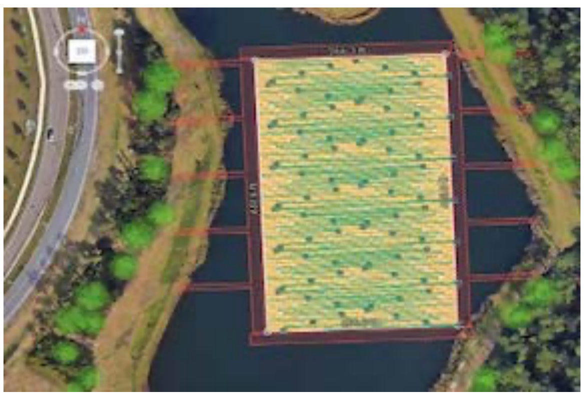

Figure 31: PV System Plan for UCF Pond 2-H

Figure 32: Irradiance visualization of UCF Pond 2-H

Analysis of aesthetic appearance in surrounding viewshed

Our team chose to preserve an existing forest not only based due to the ecological benefits gained from protecting the green infrastructure, but also for the aesthetic value that forests provide. In a dense urban campus, trees and vegetation provide a break for the eye because of their color, form, and movement. Green infrastructure introduces vibrant colors into the palette of otherwise often muted architectural tones in a landscape. Their irregular and organic forms break from the rigidness created by the built environment. And relative to static structures, their freeform sways provide motion and interest to an otherwise stationary view. These visual values have evolved over the lifetime of this planet and exist originally and uniquely in nature. We chose to preserve the forest on our site because in addition to all other benefits provided by forests, we also appreciate how these aesthetics values can benefit urban landscapes and on the UCF campus the students that interact with them.

Another goal of the campus is to create an attractive, functional, and sustainable urban area. The Team Maryland use of PV on existing campus building rooftops will remove from sight the majority of PV capacity from the campus viewshed. However, Team Maryland also included the use of novel floating PV arrays on Pond 2-H to the northeast of the central campus. UCF students in the Mechanical Engineering Department deployed a floating PV array in 2016 on Pond 2-H. The experimental array could power an average home producing more than 5,000 watts (Orlando Sentinel, April 16, 2016).[2]

The Team Maryland proposal would massively increase the area of floating PV arrays on Pond 2-H as that was a part of the UCF student's original intent to ultimately power the entire adjacent sports stadium. Additionally, aquatic benefits of shading of the pond would reduce the light penetration that stimulates nuisance algal growth and increases the pond's water temperatures which would benefit aquatic life in the pond.

The floating arrays would provide a unique viewshed to the students which would be articulated through interpretive signage of a novel ecotechnology in action. The floating PV arrays would be utilizing open water space in an energy efficient and productive way that does not require the destruction of adjacent and productive forest area. It is believed that the UCF pilot floating PV arrays already positioned on the pond were the first use by a campus in the United States, something the campus should be very proud of.. The cooler temperatures from the pond would also provide an anticipated increase in PV efficiency by lowering the temperature of the PV arrays themselves.

Analysis of Financial Forest Value on UCF campus

Table 25. A tabulation of forest ecosystem services quantified by an analysis conducted by University of Maryland Department of Environmental Science and Technology for the State of Maryland.[3]

Table	Ecosystem Service	Public Value per Acre per Year
10.2	Forest Sequestration of Carbon	$121.41
11.2	Groundwater Recharge	$193.70
11.3	Stormwater Mitigation	$290.30
12.3	Soil Building	$89.00
12.3	Erosion Prevention	$855.00
13.2	CO Removal	$0.23
13.2	NO2 Removal	$6.50
13.2	O3 Removal	$138.73
13.2	SO2 Removal	$27.91
13.2	PM10 removal	$21.29
14.1	Pollination by Wild Insects	$0.58
Total:		**$1,744.65**

[4]

2 https://www.orlandosentinel.com/business/os-ucf-solar-floating-on-pond-20160415-story.html

3 Ecosystem Based Approach to Developing, Simulating and Testing a Maryland Ecological Investment Corporation that Pays Forest Stewards to Provide Ecosystem Services (Tilley, et al., 2011)

The natural public value of ecosystem services that come with keeping forest resources untouched can be monetarily amounted to $1,744.65 per acre per year (about $34,893 per acre over the average 20-year lifetime of an acre of solar panels). This value was calculated by researchers at the University of Maryland's Department of Environmental Science and Technology and restoration ecologists and ecological engineers at the national environmental consulting firm *Biohabitats* for the State of Maryland. It can be assumed that the values from Table 5A-1 are a very conservative estimate, as the mid-Atlantic temperate climate of Maryland has a greatly reduced growing season from that of central Florida which would provide year-round photosynthesis.

The forests provide the public value of these ecosystem services without regular maintenance or upkeep and are financially more valuable than going through the process and costs of deforestation, tree/stump removal and land leveling needed for the construction of the solar panels on the previously forested land. An additional ecosystem service not quantified in Table 5A-1 would be the loss of evapotranspirative[5] microclimate modification and the increase of the urban heat island effect on campus.

Demonstration of compliance with district use case master plan

In the University of Central Florida 2020-2030 master plan, the institution has outlined that they consider sustainability an important tenant that "touches every element" of their plan but lacks explicit goals. So, in essence, Team Maryland's development plan is "in compliance" with the campus' goals as the energy offset provided by the panels will benefit the campus in the long term and supports its general sustainability goals of their master plan.

Demonstration of Compliance with District Use Case of the UCF Master Plan[6]

Objective 1.0 of the UCF Master Plan reads "*to promote future land use development on campus that provides for a full range of land uses and intensities of use consistent with the Goals, Objective, and Policies of the UCF Master Plan*" **Proposal Guiding Principles of Team Maryland's Proposal**

1. Pg. 2 of the Master Plan specifies that utilities use will be at intensities averaging 1.0 FAR (Floor Area Ratio) **The Utilities Use Classification identifies areas of campus where topography, soil conditions, adjacent land uses, and existing and proposed development patterns, are appropriate for utility development and telecommunications facilities and can best serve the existing and projected demands for facilities on the campus.**

   The Team Maryland PV plan calls for using existing building rooftops which are appropriate for utilities use and siting. Additionally, Team Maryland will be utilizing available open water/lake area for the novel use of floating PV arrays.

---

[5] **Evapotranspiration** (ET) is the sum of water evaporation and transpiration from a surface area to the atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies.

[6] UCF 2020-2030 Campus Master Plan. https://www.fp.ucf.edu/mp2020/

Archaeological and historic sites must be considered: Incorporate our consideration of native people's land by

- **reaching out to local tribes?**
- **Contacting Building Department if there is documentation of other archaeological finds in this part of campus**
- **Contacting the Anthropology department if they are aware of any likely archaeological sites**

2. Pg. 2 **Conservation Use:** There shall be no construction in the conservation area outlined in figure 4-1 (posted below): **Our plan has no panels being installed in conservation areas**
3. Or the arboretum site as specified in Policy 1.1.4 (pg. 3) **We explicitly decided not to build in the green areas to not have to remove any trees**
4. Pg. 3 Policy 1.1.2 "UCF shall review all available and economical options before any construction is authorized and a plan of development is approved" **We already did this so could we include this as a bonus or no because UCF will have to do the same amount of work regardless**
5. Pg. 4 Policy 1.2.4 (1) perform reasonable site-specific environmental analyses including water quality impact analyses, and alternative location assessments. **Unnecessary because water is not impacted, only utilizing rooftop and parking lot arrays**
6. Pg. 5 Policy 1.3.6 "In order to preserve the open space nature of the campus and to minimize impervious surface needs, parking lot areas will continue to be consolidated into structured parking garages as budgets permit. **Don't plan to build on any parking areas so lots could be converted into garages or garages raised**
7. Pg. 6 Policy 1.4.1 Projects that propose increases to campus infrastructure, utilities, facilities, or services shall be approved only if such facilities are funded and already on-line to accommodate the need or will be on-line prior to occupancy of any structure to be served by such infrastructure, utilities, facilities, or services. **We explicitly address priorities 1 and 3 of policy 1.4.2; Eliminate existing deficiencies, which may prevent future development, and expand systems to accommodate campus needs**
8. Pg. 9 GOAL 2: To maintain a commitment to the protection of campus ecosystems and lands of significant environmental importance and to ensure that these resources are protected for the benefit of present and future generations, while accommodating the continued development and expansion of the man-made environment of the campus. **Rationale behind the plan**
9. Pg. 10 "academic and support programmed spaces are growing into a larger proportion of the total amount of land'. **Our system will help support this growth in an environmentally conscious way. Our plan to primarily build on roofs and augment with a novel floating pond array will optimize the land available for further development**

10. pg. 5 of 29 (2.0 Intro)[7] "The mixed land use category allows for an assortment of facility types in a specific area". **Academic + support/utilities in the same area**

11. pg. 7 of 29 (2.0 Intro) Policy 1.5.1: Projects that propose increases to campus infrastructure, utilities, facilities, or services shall be approved for construction only if such facilities are funded to address concurrency with infrastructure, utilities, facilities, or service needs. **Following UFC Building Departments Policies and Processes**

12. pg. 12 of 29 (2.0 Intro) Objective 1.6: Develop energy-efficient campus facilities, as detailed in the UCF standards. **The extra energy we provide and the fact that they take up no ground space allows this to be maximized**

Demonstration of compliance with other land-use or building restrictions or regulations

1. General Solar development requirements (described in Construction plan)
   - Solar Certification[8]
   - Photovoltaic System Approval Certificate[9]
   - Building Permitting[10]
2. Other restrictions: **Must comply with Orange County Code of Ordinances[7]**
3. Article II - Building Code Division 1. - Building Subsection 110.1.1

   Don't let debris from construction spread. clean-up and removal of all construction debris Is the responsibility of the contractor and/or owner.

   Sec. 30-246 - Conservation areas - "all development shall be consistent with the conservation element of the county comprehensive policy plan and the conservation regulations as shown in this Code."

   Section 38-79 subsection 16 "A permanent emergency generator for emergency use only shall be permitted as an ancillary use during an emergency period in all zoning districts, subject to the noise control ordinance and the following requirements:"

   Compliance

   We aren't developing anything on forest conservation areas
   Must comply with building height limitations[11]
   A maximum solar panel height limit: 8 feet
   6 ft to -8 ft wall required for Ground-mounted panels
   Residential: Panel area must not exceed 25% of the area of the principal structure (Does not count towards allowed area for other structures.)
   Minimum building setback: 5 feet from side/rear property lines

---

[7] UCF 2020-2030 Campus Master Plan. Update. https://docs.google.com/document/d/1tKc3XcfhrOBSs4RscRLzlU8DNSRLWb6Fid2cCFQpGIA/edit

[8] Solar Constructor Application Center http://www.floridaenergycenter.org/en/certification-testing/pv/index.htm

[9] Photovoltaic System Certification. http://www.floridaenergycenter.org/en/certification-testing/pv/PVsystems/index.htm

[10] UCF Building Department. Permitting Procedures. 2020. https://www.buildingdepartment.fs.ucf.edu/

[11] Orange County Code of Ordinances. https://library.municode.com/fl/orange_county/codes/code_of_ordinances

End Notes

Property Record 03-22-31-0000-00-005
https://prc.ocpafl.org/Searches/vabparcel.aspx/PDF/false/PID/312203000000005

Orlando Sentinel, April 16, 2016. https://www.orlandosentinel.com/business/os-ucf-solar-floating-on-pond-20160415-story.html

Ecosystem Based Approach to Developing, Simulating and Testing a Maryland Ecological Investment Corporation that Pays Forest Stewards to Provide Ecosystem Services (Tilley et al., 2011)

UCF 2020-2030 Campus Master Plan. https://www.fp.ucf.edu/mp2020/

UCF 2020-2030 Campus Master Plan. Update.
https://docs.google.com/document/d/1tKc3XcfhrOBSs4RscRLzlU8DNSRLWb6Fid2cCFQpGIA/edit

City of Creswell Park Gazebo PV System http://solarenergydesign.com/project/city-of-creswell/

Solar Constructor Application Center http://www.floridaenergycenter.org/en/certification-testing/pv/index.htm

UCF Building Department. Permitting Procedures. 2020. https://www.buildingdepartment.fs.ucf.edu/

Orange County Code of Ordinances.
https://library.municode.com/fl/orange_county/codes/code_of_ordinances

Chapter Five:

Construction Plan

Table 26: Construction Schedule

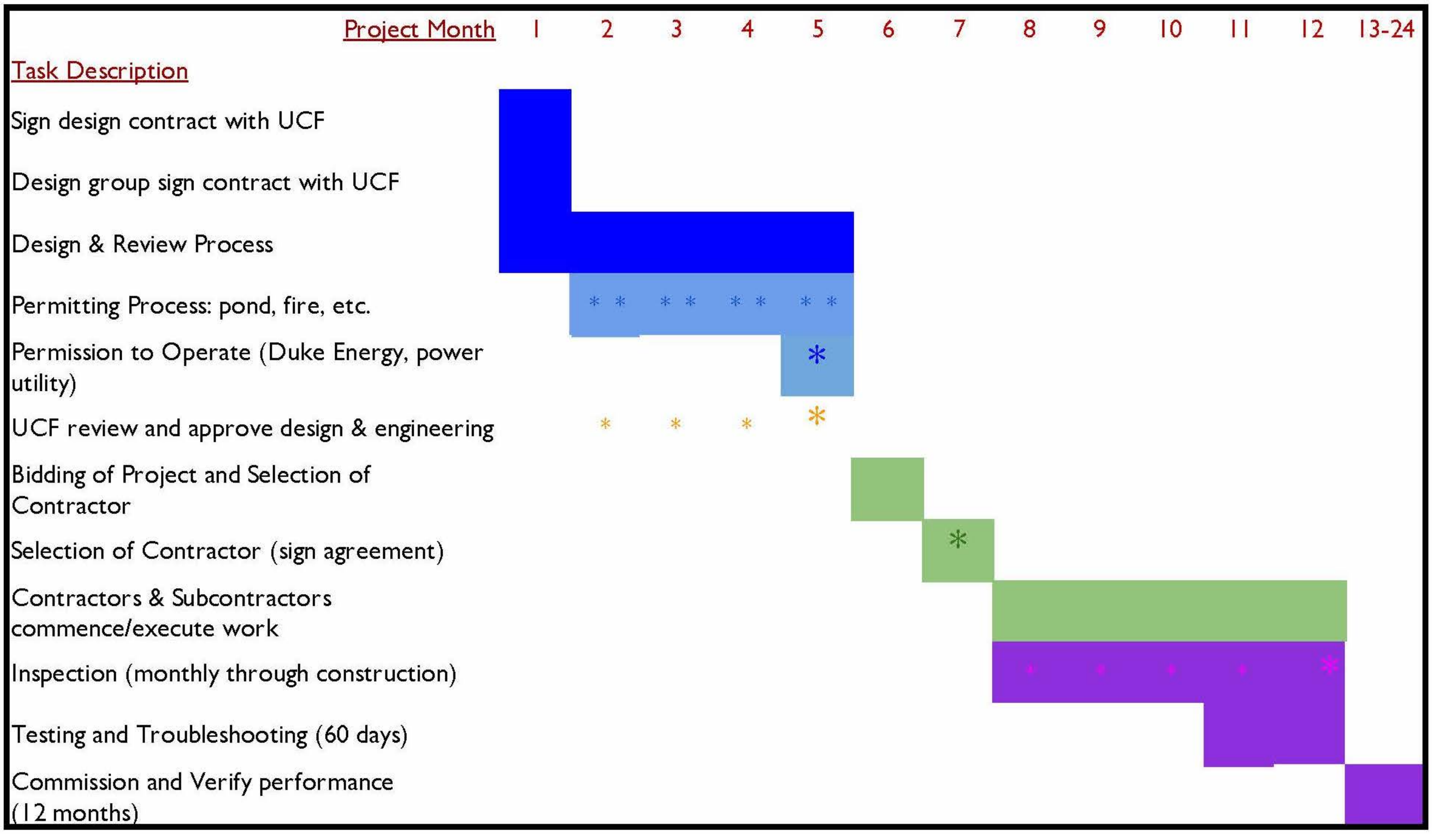

Table 27: Legend for Construction Schedule

Legend	
*	Individual Permits
*	Permission to Operate from Power Utility
*	Monthly reviews by UFC
*	UFC Final review and approval
*	Contractor Agreement Signed
*	Monthly Inspections
*	Final Inspection prior to Commissioning

Construction Plan

Approach to procure necessary permits and comply with local codes. There are two campus construction sites: Northeast section of Campus (see Conceptual Map 1) and Lake 2-H (see Conceptual Map 2). The Northeast section of Campus requires standard construction permitting, however, the Floating arrays on Lake 2-H will need additional permits.

Proposed timeline for permitting, construction, and interconnection

Team Maryland has proposed that the permitting process be conducted simultaneously with the Design & Review Process, see Table 1 above. We allow 4 months to acquire all necessary permits based on application review times for typical government permits.

We would likely allow 8-12 months for construction of the PV systems on rooftops and the lake. The lake has the added benefit of being available for construction at all times, with limited interruptions. We also have the advantage of being in a very temperate climate meaning weather challenges will be minimal outside of the occasional storm.

Applicable local permitting and codes

1. Permit Procedures: The University of Central Florida Building Department is responsible for campus building code enforcement to safeguard life and welfare in the construction setting within the UCF community. UFC implements the Florida Building Code and applies the performance-based standards contained within.

   For Team Maryland's design, the following permits will be gained during the project's months 2-5.

   a) The State Fire Marshal's Office must complete a plan review in accordance with Chapter 633, Florida Statutes (F.S.) prior to work commencing. There are 5 categories of permits: Design Development, 100% Construction Documents, Permit Revisions, Shop Drawings, and other. Team Maryland Design group will apply during design development.

   - Fee: Construction Cost x .0025
   - Time to approval: 7-14 business days

   b) Certificate of Completion is necessary to specify the main parties of the project and all the details, including dates when the work commenced, the final date that major work is going to be completed and the total cost to be paid or to be owed to the contractor. Permit applications are submitted online through the Citizenserve portal.

   c) Certificate of Occupancy, This document proves the building complies substantially with the plans and specifications that have been submitted and approved by the local building or zoning authority. Permit applications are submitted online through the Citizenserve portal.

   After all final inspections have been passed, upload the following documents with your application.

   - A letter from the permit holder stating the construction has been completed in accordance with the approved plans and specifications
   - A letter from the Architect or Engineer of record stating all Code
   - related RFI's have been submitted as revisions and approved by the UCF Building department.
   - A copy of the State Fire Marshal's final Inspection approval letter.
   - A copy of the Elevator Inspectors approval report
   - A preliminary commissioning report approved by the Engineer of record.
   - All special inspector or threshold inspector final reports.
   - Additional documents may be required.

2. Inspection Procedures: Each permit fee covers a limited number of inspections per permit category. These inspections are covered under the Building Department Permit Fees and represent no charge to the contractor. All construction work for which a permit is required shall be subject to inspection by the Building Official and/or designated Building Inspector. Construction work shall remain accessible and exposed for inspection purposes until approved. The applicant is required to provide access to the area including all associated ladders, lifts or similar support equipment on the scheduled day of inspection. All test equipment shall be provided by the contractor. Inspections shall be requested a minimum of 48 hours in advance. Schedule inspections through the Citizenserve portal.

State Permits

Florida Solar Energy Center: Photovoltaic System Approval Center

The 2017 Florida Legislature, through HB 1021, amended the Solar Energy Standards Act of 1976 that governs the certification of solar energy systems manufactured or sold in Florida. The system approval process was mandated by the Florida State Legislature as part of the Solar Energy Standards Act, which required that beginning in 1980, all solar energy systems manufactured or sold in Florida meet standards established by FSEC. The FSEC standards program has been designed to meet the intent of the legislation while also helping the Florida solar industry to develop quality products, aiding building departments in product approval, and instilling confidence in the consumer who chooses to use solar energy in their residence or business.

- FSEC Standard 203-10: Procedures for Photovoltaic System Design Review and Approval: This evaluation covers any type of photovoltaic system that is either interconnected with the utility grid or is a stand-alone system that falls within the parameters described below. These system evaluations are based on the complete design and documentation packages that accompany the application for design review. This evaluation covers any type of photovoltaic system that is either interconnected with the utility grid or is a stand-alone system that falls within the parameters described below. These system evaluations are based on the complete design and documentation packages that accompany the application for design review. Items evaluated include safety and code compliance of the overall design, individual components and their interactions with one another, and completeness of instructions, diagrams and schematics for system installation, operation and maintenance. This review and approval procedure does not cover site specific requirements or issues, nor do these approvals replace or exempt any requirements of electric utilities or local jurisdictional authorities such as permitting, inspections or utility interconnection agreements as required for PV system installations.
- Fee: $250-500, with annual renewal $25.

Utility Permits

Duke Energy Interconnection Process & Queue

The interconnection process is defined by state utility commission or FERC-approved procedures. These procedures provide governing standards that an Interconnection Customer must follow in order to connect a Generating Facility to a utility's system. Large Distribution Interconnections (>20 kW) are required to apply. The applicable set of procedures is determined by the nature and location of the Generating Facility. UCF's distribution system is owned by the university but operated under contract by Duke Energy, one of the utilities serving the Orlando area.

The Duke Energy interconnection queues reflect the status of generators that have requested interconnection at distribution or transmission voltage levels with generation capacity greater than 20 kilowatts (kW). The distribution and transmission queue reports are updated twice per month on approximately the 1st and 15th days.

Table 28: Interconnection Process

Distribution Project Lifecycle			
1. REVIEW	**2. STUDY**	**3. CONSTRUCTION**	**4. POST PROJECT**
Renewable Service Center (RSC)	**Customer Account Specialist (CAS)**	**Contract Analyst/Account Manager**	**Contract Management Group**
- Pre-Request (NC Only) - Pre-Application - Interconnection Request - 3-Day Letter - 10-Day Letter	- Fast Track - Supplemental Review - System Impact Study - Customer Options Meeting - Scoping Meeting	- Facility Study - Construction Planning Meeting - Interconnection Agreement - Standard Purchase Power Agreement - Permission to Operate	- Negotiated Purchase Power Agreement - REC only Agreement - Contracts Database - Billing - Post Commercial Operations
REVIEW covers new IRs and any body of work related to being processed once a project has been submitted	*STUDY covers any body of work being processed while a project is in the study phase*	*CONSTRUCTION covers any body of work being done once a project is out of the study phase through the facility receiving their permission to operate*	*POST PROJECT covers any body of work being done after the project is generating power, including but not limited to contract management*

Both the state and FERC interconnection procedures require Duke Energy to study all Interconnection Requests based on the order in which requests enter the Queue. This is often referred to as a serial queue study process. Under North Carolina and South Carolina state procedures, projects are deemed to be interdependent where an upgrade or the interconnection facilities necessary for the Generating Facility are impacted by another Generating Facility. Interdependency Status is assigned after the Interconnection Request is deemed complete and is used to indicate interdependence of projects in the queue.

UCF's distribution system is owned by the university but operated under contract by Duke Energy, one of the utilities serving the Orlando area.

Electrical Permits

We anticipate that the Solar subcontractor will obtain the Electrical permit for the photovoltaic system. A separate Electrical permit will be obtained by the Electrical Contractor for all wiring on the load side of the power conditioning unit (inverter). Applications are available from Orange County at https://www.orangecountyfl.net/PermitsLicenses/Permits.aspx

Building Permits

We anticipate that the Team Maryland Design Team will obtain Orange County Building Permits through the Division of Building Safety, which is charged with the responsibility of reviewing plans, issuing permits and performing inspections for vertical construction to ensure compliance with the Florida Building Codes and local construction ordinances. The types of permits the Division issues issue are building, electrical, gas, mechanical, plumbing, and roofing.

Community Impact fees -- not applicable since the resources made are for the university and will not be a cost burden to residents.

Wetland Permits

This is the required permit for constructing the floating array on Lake 2-H. Orange County Code Chapter 15 Article X, Orange County Code, a Conservation Area Impact (CAI) permit is required prior to any proposed wetland impacts. Depending on the wetland system being impacted, some of these permits require approval by the Orange County Board of County Commissioners.

- Application can be mailed, delivered or faxed to Orange County Environmental Protection Division (EPD), 3165 McCrory Place, Suite 200 Orlando, Florida 32803. Fax: (407) 836-1499.
- Forms that are required with the permit application are:
    a) Agent Authorization Form.
    b) Relationship Disclosure Form - Development Related.
    c) Specific Expenditure Report Form.

Future Land Use

Only Lake 2-H will have any change in use, this is not yet planned for in the Comprehensive Master Plan,

Figure 44: UFC Future Land Use