2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC

Host Sponsor UNC Charlotte

Paper ID #53804

Project-Based Learning in Action: Leveraging the Solar District Cup to Foster Systems Thinking and Renewable Energy Design Skills in a Capstone Course

Dr. Tony Lee Kerzmann, University of Pittsburgh

Dr. Kerzmann is actively involved in advancing engineering education, sustainability, and clean energy initiatives. He serves as the Best Paper Awards Chair for the ASEE North Central Section and contributes to the ASEE Energy Conversion and Conservation Division. At the University of Pittsburgh, he is a member of multiple committees supporting undergraduate education, sustainability, and advising. Beyond campus, he collaborates with municipalities, nonprofits, and industry partners on renewable energy and community sustainability projects. Dr. Kerzmann also leads outreach efforts through the Mascaro Center for Sustainable Innovation and the Regina Coeli Creation Care Team, promoting environmental stewardship and education.

John Robert Ufer, University of Pittsburgh
Dalia Chemaitilly, University of Pittsburgh
Dr. David V.P. Sanchez, University of Pittsburgh

David V.P. Sanchez is an Associate Professor in the Swanson School of Engineering's Civil & Environmental Engineering department and the Associate Director for the Mascaro Center for Sustainable Innovation at the University of Pittsburgh. He serves as the Program Director for the Master's in Sustainable Engineering, the Undergraduate Certificate in Sustainability, the John C. Mascaro Faculty Fellows, and the Sustainability Global Engagement grant. He is a faculty lead in the Frederick Honors College Scholar Community.

His research lab, Sustainable Design Labs (https://www.sustainabledesignlabs.com/), focuses on fusing analytical chemistry, sustainability design principles and data analytics to address Water and Sustainability grand challenges. Current thrusts focus on Smarter Riversheds, Microbial Fuel cells and advanced oxidation and separation processes.

Focused on co-creating long term partnerships that synergize community vision with Pitt's core competencies of research and education, Sanchez has built up Pitt Hydroponics in Homewood, founded Constellation Energy Inventor labs for K-12 students, and re-created the Mascaro Center's Teach the Teacher sustainability program for science educators in the region.

As a teacher he designed and created the Sustainability capstone course which has annually partnered with community stakeholders to address sustainability challenges at all scales. Past projects have included evaluating composting stations in Wilkinsburg, studying infrastructure resilience in Homewood, enabling community solar in PA, improving energy efficiency in McCandless Township, and improving water quality in our rivers. He teaches core Sustainability courses, labs in the Civil & Environmental Engineering Department, electives in the Innovation and Entrepreneurship program, the First-Year Engineering program, and International Study Abroad programs.

Project-Based Learning in Action: Leveraging the Solar District Cup to Foster Systems Thinking and Renewable Energy Design Skills in a Capstone Course

Abstract

The U.S. Department of Energy's Solar District Cup (SDC) provides an excellent experiential learning framework for multidisciplinary student teams to design solar energy systems for real-world locations. At the University of Pittsburgh, the SDC was integrated into a senior-level Sustainability Capstone course as an engaging student project focused on renewable energy design, project development, and systems thinking. This paper examines the educational outcomes and lessons learned from combining a student capstone project with a national competition where a team successfully completed learning objectives and were national runners-up for the competition.

Students assumed the role of solar developers, creating a 26 MW photovoltaic proposal for the Penn State Health Milton S. Hershey Medical Center. Through the competition, students developed comprehensive deliverables including conceptual system design, distribution system impact analysis, financial modeling, and development planning, all of which closely align with real world professional engineering practices. The submitted project proposal incorporated agrivoltaics, rooftop solar, and parking canopies which required technical, environmental, and economic trade-off analyses to complete.

Key educational outcomes from competing in the Solar District Cup included enhanced understanding of solar engineering design principles, the use of industry-standard modeling tools such as Helioscope, OpenDSS, and NREL's Solar Advisory Model, and experience in communicating technical results to a diverse set of judges and stakeholders. Students also gained insight into permitting, zoning, and energy equity considerations. Faculty mentorship and industry collaboration further enhanced the learning process, fostering student confidence and workforce readiness in the clean energy sector.

Integrating the Solar District Cup within a sustainability curriculum provides a highly effective model for project-based engineering education that integrates technical design, interdisciplinary collaboration, and real-world application. These educational elements are fundamental to preparing the next generation of sustainable solar engineers to lead the global clean energy transition.

Introduction

The Sustainability Certificate at the University of Pittsburgh is a supplementary collection of courses taken in tandem with a student's primary degree to further integrate a wide range of sustainable development concepts into common collegiate degrees. This certificate is accessible to all students at the University of Pittsburgh, but primarily is taken by engineering and science students, therefore concepts such as clean energy generation, efficient manufacturing processes, and circular economics, to name a few examples, are incorporated into the curriculum. The sustainability capstone experiential course, ENGR 1907, is a project-based course that promotes student creativity, interdisciplinary collaboration, and working on external projects. By providing the ability for students to choose from a variety of diverse projects focusing on different economic, ecological, and social issues, students can understand how engineering knowledge from their traditional majors fits into larger systems. This not only broadens awareness of other disciplines but strengthens skills in technical thinking and interdisciplinary collaboration. These projects are structured in a manner similar to what is faced in industry, allowing students to experience a class that blends traditional academic instruction with career preparation for their time after the University of Pittsburgh.

In the Spring 2025 installment of ENGR 1907, participation in the Solar District Cup (SDC), a national collegiate competition hosted by the National Renewable Energy Laboratory (NREL), was utilized as a project for students to work on for the semester. The SDC focuses on the holistic planning and development of a solar photovoltaic power station aligned with set requirements and desires of the client. The team took on the role of solar developers and designed an innovative solar project for the Pennsylvania State Health Milton S. Hershey Medical Center using various design tools and financial models. The students were encouraged to explore agrivoltaics, solar parking canopies, rooftop solar, and other unique integrations of solar energy into pre-existing infrastructure within the campus boundaries. The specific needs of Penn State Health Milton S. Hershey Medical Center's medical infrastructure were stressed in the project guidelines, where it was important to consider the energy needs of the hospital, the terrain type, the weather conditions, and the community perspective of solar in the rural area.

The final deliverables package desired by the organizers of the SDC included a project proposal, conceptual system design, distribution system impact summary, financial analysis, and a development plan [1]. The conceptual design included the students' recommended locations for development and the size of each independent system, spatially and electrically, within the photovoltaic system. This included the electrical setup, inverter and panel arrangement, and whether the panels would serve additional purposes such as supporting agricultural yields or acting as a parking canopy. The distribution system impact summary acted as an analysis of preexisting electrical infrastructure and its compatibility with the proposed design with recommended adaptations to integrate the proposed photovoltaic design into the campus. The financial analysis aimed at developing a breakeven analysis for Penn State to prove economic viability and profit gained by the university in comparison to more traditional forms of energy generation. Lastly, the development plan included a timeline for construction of the team's proposed photovoltaic site, including land grading permeability testing and grid interconnection strategies. The project proposal acted as a summary of the aforementioned deliverables to highlight the most important and distinctive parts of the team's project.

Furthermore, more detailed aspects of photovoltaic design than standard electrical, civil, and economic constraints were required in the competition. Aspects such as panel degradation, damage, pairing losses, legal restrictions on development, and community impacts were assessed in the competition as well. Derry Township Pennsylvania, the ordinance responsible for zoning constraints within Penn State Health's campus, were studied by the SDC team to understand the true availability of solar development on the medical campus with regards to longstanding legal constraints. The differences between supplementary use solar such as agrivoltaics and rooftop solar and primary use solar in ground mount units determined the team's constraints when working with zoning laws, bringing into question acceptable obstruction limits, necessary distance from preexisting infrastructure, and tax exemption distinctions present within the legal code.

Additionally, the University of Pittsburgh SDC team identified the relevant authorities having legal jurisdiction over the construction and maintenance of the proposed photovoltaic design and further strengthened their abilities to integrate their engineering knowledge with judicial and legal restraints, an extremely important skill for any engineering profession. Abiding by OSHA standards for maintenance, regional fire and electrical safety organizations abiding over Pennsylvania electrical projects were also studied to ensure that the team's proposed photovoltaic system would be up to code if applied.

Local environmental effects of photovoltaic systems were also analyzed by the SDC team to emphasize the importance of often overlooked influences on panel efficiency. Stormwater management impacts from use of ground mount paneling and its reduction of permeable land were calculated by the team to ensure drainage of utilized land was still feasible for their proposed construction. Crop pairings with the team's agrivoltaics systems were analyzed in order to discern the best plants in terms of compatibility with the shaded parcels of land underneath the solar panels and to minimize shading losses for potential overgrowth of plant systems. These smaller, but still pertinent influences on the SDC team's solar design allowed the team to develop realistic photovoltaic projects including more niche studies impacting the viability of solar design.

Due to the large and multifaceted scope of this project, an interdisciplinary group of students with varying interests in sustainability was optimal to effectively design all aspects of the photovoltaic project. The shared interest of sustainable development between the students with all distinct academic paths provided a unique opportunity for students to provide their own expertise in their study of focus but simultaneously learn from each other's skill sets and grow as a student without a traditional lecture style. This provided a basis of autonomy from the SDC's open-ended problem statement of developing a solar project for Penn State Health and allowed students with differing base levels of competence in different regions of the project to focus their abilities on and achieve interrelated goals with their peers of differing expertise. These three pillars of relatedness, autonomy, and competence (Figure 1a) provide a framework for the students' motives in ensuring the progress and excellence of their project through the Self Determination Theory [2]. Through application of the Self Determination Theory through means of participating in an intercollegiate competition, students within the University of Pittsburgh SDC team found enjoyment and interest in furthering their understanding of photovoltaic energy to compete at a high level against other universities.

Participation in the SDC, as with any competition, also improved retention of learned information more than in a traditional academic setting through experiential learning. Through analysis of Edgar Dale's Cone of Experience [3], passive methods of education like lecture often incorporate learning stimuli that are poorly retained from students. The Cone of Experience acts as a framework for comparison of different teaching methods regarding teaching efficacy. The more often students directly apply their recent findings in the form of experience and demonstration, the more likely they are to remember basic content and further progress in that field of knowledge. The SDC's in depth use of photovoltaic modelling software like Aspen and Helioscope, financial planning documents, and conversations with experts in relevant fields provided opportunities for strong knowledge retention in the renewable energy sector located at the base of The Cone of Experience (Figure 1b) for students to integrate into their education and professional experience.

(a) **(b)**

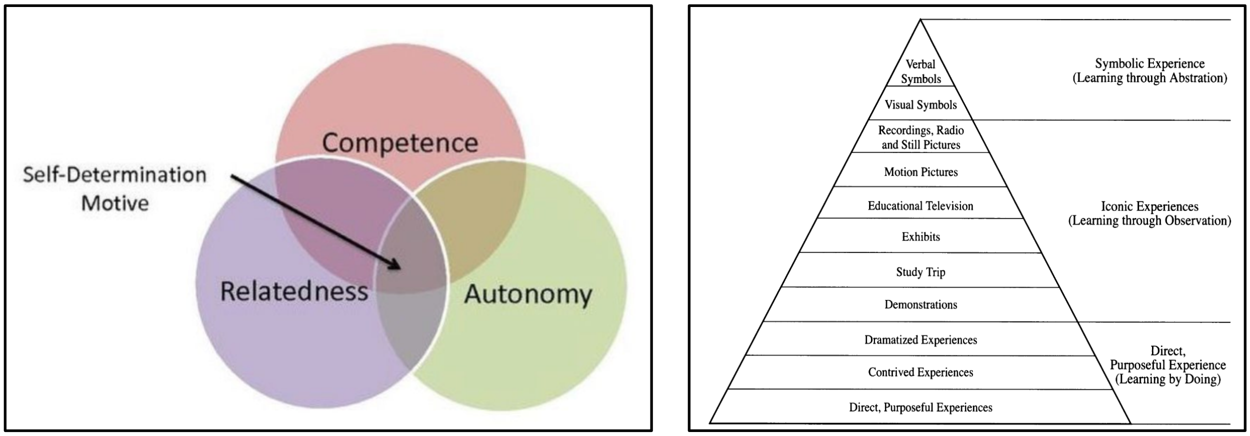

Figure 1. Visual representations of the educational theories applied during the SDC. (a) Self-Determination Theory, illustrating that the intersection of competence (student understanding), relatedness (relation to the project), and autonomy drives intrinsic motivation, especially in a competition setting. (b) Dale's Cone of Experience, demonstrating that active participation and simulation ("Learning by Doing") result in higher rates of knowledge retention compared to passive learning.

Participation in the SDC allowed students to act as solar developers by providing open-ended solutions to a real site considering implementation of the team's solar design. The competition's involvement in a wide variety of academic backgrounds fostered interdisciplinary growth for all students through frequent participation with teammates and involvement on complex competition goals such as electrical engineering, mechanical engineering, civil engineering, urban planning & design, and economics. Individuals in the renewable energy sector need baseline understanding of these educational fields in order to holistically flourish in their industry. The use of the SDC as an evaluated course integrated traditional learning practices through research and lectures with the invaluable experience taught to the team through their presentations, modelling, and design of their photovoltaic system.

Course Implementation and Project Scope

The Solar District Cup challenges students to design innovative solar projects for specific project sites, using various design tools and financial models. The teams of students which elected to be assigned a district-use case (or specific project site) received information regarding their project boundaries, design preferences, and electric power distribution. For example, the team at the University of Pittsburgh received information regarding the Penn State Health (PSH) Hershey Medical Campus such as the project boundaries shown in Figure 2, the number of outpatient visits each year, and PSH's mission to foster a culture of environmental responsibility through reducing energy costs and energy consumption. The red boundary as shown in Figure 2 was the limit of development (LOD), the blue pin indicated the main electrical substation, and the yellow and blue perimeters were recommended locations for development by PSH. The campus consisted of 44 university-owned buildings and 40 additional buildings for housing [4]. Additionally, the team was aware of how hospitals require a reliable and resilient source of energy to function effectively and save lives. Therefore, the goal of the team was to design a cutting-edge photovoltaic system that not only satisfies the energy needs of PSH but also recognizes the preferences of the surrounding medical and rural communities.

Figure 2: PSH boundaries and preferred locations [4]

After the team received information regarding their district use case, they had to create a timeline for their capstone project, allowing them to achieve the deliverables of the Solar District Cup in an efficient manner. The timeline was created using the Gantt Chart format, as shown in Figure 3 below.

Solar District Cup Project Schedule

(Instructions: Enter text & values in the Blue cells)

Project Start Date: 1/20/2025 (Monday) **Display Week:** 1

Week 1: 20 Jan 2025 | Week 2: 27 Jan 2025 | Week 3: 3 Feb 2025 | Week 4: 10 Feb 2025 | Week 5: 17 Feb 2025 | Week 6: 24 Feb 2025

	TASK	LEADER	START	DAYS	END
1	**List of 50 Potential Interviews**				-
1.1	Conduct Research on Current and Developing Infrastructure of Penn State Campus with Regard to Electric Grid Expansion	John Ufer	Mon 1/20/25	8	Mon 1/27/25
1.2	Conduct Research on Student and Faculty interviewers of Penn State and their relation to electric grid expansion and solar development on campus	Siva Surulivel	Mon 1/20/25	8	Mon 1/27/25
1.3	Conduct Research on Solar Photovoltaics experts in the Penn State area	Dalia Chemaitilly	Mon 1/20/25	8	Mon 1/27/25
1.4	Conduct Research on Financial/Social/Environmental Experts in Penn State or Solar Development	Fio Pampena	Mon 1/20/25	8	Mon 1/27/25
1.5	Each Member Drafts Own List of 13 Possible Individuals to Interview with Details and Possible Questions to Ask Them Due to Their Relation with Penn State Health and Solar	All Members	Wed 1/22/25	7	Tue 1/28/25
1.6	Send out all draft emails for contacting possible interviewers	All Members	Sun 1/26/25	3	Tue 1/28/25
1.7	Submission of 50 Names for Interviews	Fio Pampena	Tue 1/28/25	1	Tue 1/28/25
2	**Project Beginnings: Rules**				-
2.1	Attend Webinar: One-Semester Warm Up Workshop (3:30pm)	John Ufer, Fio Pampena	Wed 1/22/25	1	Wed 1/22/25
2.2	Attend Webinar: Development Plan & Distributional Energy Equity (4pm)	Dalia Chemaitilly, John Ufer	Thu 1/30/25	1	Thu 1/30/25
2.3	Take Canvas Quiz from NREL	All members	Tue 1/21/25	1	Tue 1/21/25
2.4	Complete Canvas module 4 (Solar PV Finance)	All members	Tue 1/21/25	7	Mon 1/27/25
2.5	Complete Canvas Module 2 (Development plan & energy equity) & Module 3 (Conceptual design)	All members	Tue 1/21/25	7	Mon 1/27/25
2.6	Complete modules 5 (modeling & analysis software tools) & 6 (deliverable packages and final competition event)	All members	Tue 1/21/25	7	Mon 1/27/25
2.7	Send weekly update about NREL quiz, modules, rules, case to Kerzmann	Dalia Chemaitilly	Thu 1/30/25	1	Thu 1/30/25
3	**Project Proposal**				-
3.1	Compile research and outline project goals	All members	Thu 1/23/25	7	Wed 1/29/25
3.2	Create customer savings analysis visualizations (savings chart + table displaying total system characteristics, etc.)	All members	Thu 1/23/25	7	Wed 1/29/25
3.3	Draft proposal document that encapsulates and summarizes deliverable sections 2-4	All members	Thu 1/23/25	14	Wed 2/05/25
3.4	Create presentation that demonstrates the team's approach to the system design, operation, and innovation	All members	Thu 1/23/25	14	Wed 2/05/25
3.5	Reconvene: is our proposed solution the best choice for the district given its needs, constraints, and goals?	All members	Thu 2/06/25	1	Thu 2/06/25
3.6	Check adherance to proposal/pres. guidelines	All members	Thu 2/06/25	1	Thu 2/06/25
4	**Presentation 1**				-
4.1	Create a presentation that reflects the project proposal & any other work completed	All Members	Sun 1/26/25	8	Sun 2/02/25
4.2	Practice presentation 1	All Members	Sun 2/02/25	3	Wed 2/05/25
4.3	Presentation 1 Group Submission	John Ufer	Tue 2/04/25	1	Tue 2/04/25
4.4	Presentation 1 Individual Peer Reviews submission	All Members	Tue 2/04/25	1	Tue 2/04/25
4.5	Weekly Update: send presentation to stakeholders	Dalia Chemaitilly	Thu 2/06/25	1	Thu 2/06/25
4.6	Presentation 1 CATME Evaluations	All Members	Thu 2/06/25	1	Thu 2/06/25
5	**Conceptual System Design**				-
5.1	Familiarize team with REOpt,SAM and system design of final solution	All Members	Tue 1/21/25	9	Wed 1/29/25
5.2	Select Equipment specifications including Total DC size of each system	Dalia Chemaitilly, Siva Surulivel	Tue 1/28/25	14	Mon 2/10/25
5.3	Diagrams for each systems and wiring between them	All Members	Sun 2/02/25	20	Fri 2/21/25
5.4	Diagram showing location of all proposed PV and electrical system in the district	All Members	Wed 2/12/25	10	Fri 2/21/25
5.5	Shade model image and generate profile for each PV system, provide the details of input and process	All Members	Wed 2/12/25	30	Thu 3/13/25
5.6	Submit Weekly updates 3	Dalia Chemaitilly	Thu 2/13/25	3	Sat 2/15/25
5.7	Send weekly update to stakeholders	Dalia Chemaitilly	Thu 2/13/25	3	Sat 2/15/25
6	**Distribution Impact System**				-
6.1	Design preliminary district solar project with size and hosting capacity roughly sorted out.	Dalia Chemaitilly	Tue 3/11/25	11	Fri 3/21/25
6.2	Familiarize the team with Open DSS for Distribution Impact Calculations	Siva Surulivel, John Ufer	Tue 1/21/25	7	Mon 1/27/25
6.3	Locate interconnection points for solar cell establishment and provide needed additions to comply with pre-existing electric infrastructure	Dalia Chemaitilly, Siva Surulivel	Tue 1/28/25	20	Sun 2/16/25
6.4	Double check hosting heat capacity heat maps for voltage and thermal constraints on system in Open DSS	John Ufer, Fio Pampena	Fri 1/31/25	20	Wed 2/19/25
6.5	Refine and finalize (scale down if needed) solar district system based on any exceeding energy limits	Siva Surulivel, John Ufer	Thu 2/20/25	15	Thu 3/06/25
6.6	Send weekly update to stakeholders	Dalia Chemaitilly	Sun 2/16/25	5	Thu 2/20/25
6.7	Submit Interview Notes and Analysis on Canvas & Teams	All members	Sun 2/16/25	10	Tue 2/25/25
7	**Midterm Report**				-
7.1	Document background Information about project	Fio Pampena	Sat 2/22/25	2	Sun 2/23/25
7.2	Document the team's vision and goals	John Ufer	Sat 2/22/25	2	Sun 2/23/25
7.3	Collect and analyze data from research & interviews	All Team Members	Sat 2/22/25	3	Mon 2/24/25
7.4	Come up with the solution Ideas	All Team Members	Sun 2/23/25	4	Wed 2/26/25
7.5	Prepare Plan of Action	All Team Members	Wed 2/26/25	1	Wed 2/26/25
7.6	Send the Report to Stakeholders	Dalia Chemaitilly	Thu 2/27/25	1	Thu 2/27/25
7.7	Submit Mid-Term Report	John Ufer	Thu 2/27/25	1	Thu 2/27/25
8	**Financial Analysis**				-
8.1	Familiarize the team with SDC Financial Model Spreadsheet	All Team Members	Tue 1/21/25	14	Mon 2/03/25
8.2	Complete Solar PV Finance Modules and Webinars	Siva Surulivel, John Ufer	Tue 1/21/25	14	Mon 2/03/25
8.3	Utilize solar plan for given District and apply financial model	Dalia Chemaitilly	Sat 3/22/25	10	Mon 3/31/25
8.4	Ensure ROI is positive after 20 years	John Ufer	Wed 2/12/25	5	Sun 2/16/25
8.5	Adjust financial model with other edits in distribution impact and development plan	Fio Pampena, Siva Surivel	Wed 2/12/25	30	Thu 3/13/25
8.6	CATME Evaluations	All Members	Sun 3/09/25	3	Tue 3/11/25
8.7	Send weekly update to stakeholders	Dalia Chemaitilly	Mon 3/10/25	3	Wed 3/12/25

8	**Financial Analysis**				-
8.1	Familiarize the team with SDC Financial Model Spreadsheet	All Team Members	Tue 1/21/25	14	Mon 2/03/25
8.2	Complete Solar PV Finance Modules and Webinars	Siva Surulivel, John Ufer	Tue 1/21/25	14	Mon 2/03/25
8.3	Utilize solar plan for given District and apply financial model	Dalia Chemaitilly	Sat 3/22/25	10	Mon 3/31/25
8.4	Ensure ROI is positive after 20 years	John Ufer	Wed 2/12/25	5	Sun 2/16/25
8.5	Adjust financial model with other edits in distribution impact and development plan	Fio Pampena, Siva Surivel	Wed 2/12/25	30	Thu 3/13/25
8.6	CATME Evaluations	All Members	Sun 3/09/25	3	Tue 3/11/25
8.7	Send weekly update to stakeholders	Dalia Chemaitilly	Mon 3/10/25	3	Wed 3/12/25
9	**Development Plan**				-
9.1	Familiarize the team with Development Plan & Energy Equity Modules	Fio Pampena	Tue 1/21/25	14	Mon 2/03/25
9.2	Begin and completei nterviewing process with Penn State students, faculty, and PV experts	All Members	Thu 1/30/25	30	Fri 2/28/25
9.3	Review zoning ordinances of Penn State Health to adhere to project guidelines	Fio Pampena, Siva Surulivel	Thu 1/30/25	7	Wed 2/05/25
9.4	Integrate interviewee feedback with development plan	All members	Sun 2/02/25	28	Sat 3/01/25
9.5	Integrate design plan with PV finance and distribution system impact modules	Fio Pampena, Dalia Chemaitilly, Jo	Tue 4/01/25	7	Mon 4/07/25
9.6	Weekly update to stakeholders	Dalia Chemaitilly	Sun 3/23/25	5	Thu 3/27/25
9.7	Weekly update to stakeholders	Dalia Chemaitilly	Wed 3/26/25	5	Sun 3/30/25
10	**Presentation 2**				-
10.1	Create presentation showing close to finished conceptual system design, distribution system impact, & financial analysis, development plan	All Members	Sun 3/09/25	6	Fri 3/14/25
10.2	Practice presentation 2	All Members	Sun 3/16/25	4	Wed 3/19/25
10.3	Submit & give presentation 2 to class	All Members	Thu 3/20/25	1	Thu 3/20/25
10.4	Individual peer reviews	All Members	Thu 3/20/25	6	Tue 3/25/25
10.5	Give presentation 2 to stakeholders	Dalia Chemaitilly	Tue 3/25/25	1	Tue 3/25/25
11	**Final Report**				-
11.1	Deadline for receipt of Final Deliverable Packages from all Finalist Teams (NREL)	Dalia Chemaitilly	Wed 4/09/25	1	Wed 4/09/25
11.2	2 minute video	All Members	Thu 4/10/25	8	Thu 4/17/25
11.3	Final Presentation	All Members	Thu 4/10/25	8	Thu 4/17/25
11.4	Deadline for receipt of presentation file from all finalist teams (NREL)	Dalia Chemaitilly	Wed 4/16/25	1	Wed 4/16/25
11.5	First-place winners of each division present in the project pitch event (NREL)	Dalia Chemaitilly	Mon 4/21/25	1	Mon 4/21/25
11.6	Surveys	All Members	Mon 4/21/25	2	Tue 4/22/25

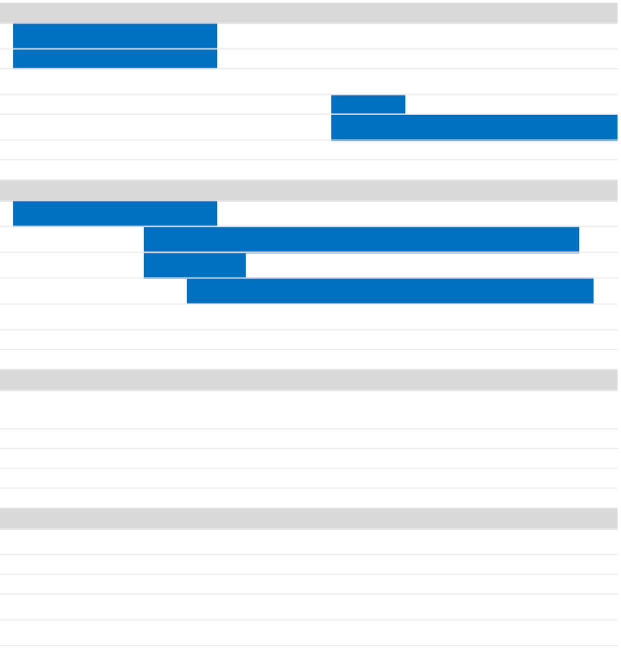

Figure 3: Gannt Chart Timeline created for SDC Project Goals for First 6 Weeks out of 15 Week Semester

Each Solar District Cup deliverable was labeled as an overall goal. The students then planned smaller tasks within each deliverable that matched the rubric from the Solar District Rule Book [5]. The team leader helped to delegate tasks to all the members of the team, making sure every student completed an equitable share of the work. The students also had to make sure that the deadlines recorded in their Gantt chart matched the deadlines of the official competition. Since the sustainability capstone course at the University of Pittsburgh is one semester long, students had four months to complete their project submission and, therefore, had to manage their time efficiently to complete the variety of tasks included in the SDC competition.

The team's first goal was to conduct interviews with industry professionals, researchers, and medical staff, allowing them to gain a better understanding of solar development and community perception. As off-site developers of the solar project, the team wanted to make sure that their visualizations would adequately function in the real world. To account for this gap in primary observations, the team asked the interviewees questions related to a number of different topics: optimization of solar racking (ground-mount, rooftop, etc.), agrivoltaics and plant specialization, financial aspects (solar tax credits, zoning clauses), as well as the site's impact on hydrology and stormwater management. Interview candidates that explicitly guided the team through the solar development process include Seth Berry, who gave the team invaluable information about renewable subsidies and project-based financial analysis [6]. Jason Grottini of Envinity discussed community impacts of behind-the-meter development, where users can supply their energy needs through individualized production and storage systems [7]. Kevin Graves of Oriden provided reasons for the implementation of agrivoltaics and how it can benefit the community by addressing the land use conflict solar may pose to agriculture [8]. Although these considerations assuredly broadened the scope and research timeline for the team's model, the team views the interview process as an essential step to covering all project bases.

Using the knowledge from interviews and training modules provided by NREL [9], the students felt ready to create conceptual design. Each student on the team developed their design independently using Helioscope. Then, they took turns presenting their ideas to the rest of the team and discussed the strengths and weaknesses of each design. For example, one team member prioritized implementing agrivoltaics while another prioritized rooftop solar, so the final design included both types of technology. The type of equipment used in each design also varied as some students used more powerful panels than others. After the discussion, the team compiled a list of the strongest aspects of each design and synthesized them into one final proposed photovoltaic plan.

The final proposed photovoltaic plan of the campus is shown in Figure 4. The team proposed a photovoltaic system comprised of 6 individual photovoltaic systems. Systems 1 and 2 spanned the entirety of the agricultural field highlighted by the Solar District Cup to be a region of specific consideration for solar development. System 1 acted as an agrivoltaics system providing additional benefits to Penn State Health through the provision of produce to the surrounding communities of the area and promoting native pollination through rearing of native plants to central Pennsylvania [10]. System 2 acted as a ground mount photovoltaic system. Systems 3 and 4 were solar parking canopies covering a total of 4 pre-existing parking lots throughout Penn State Health's campus, providing ample electricity to the campus and shading benefits to both cars and people utilizing the parking spaces [11]. System 5 was a culmination of three different rooftop PV systems. System 6 utilized the second space highlighted by the Solar District Cup to be a region of specific consideration for solar development due to its close proximity to a substation. System 6 was a new solar parking canopy for the campus. Multiple sites were also utilized for solar park benches that do not connect to the electric grid but directly engage the campus community with solar by charging personal devices in outdoor settings.

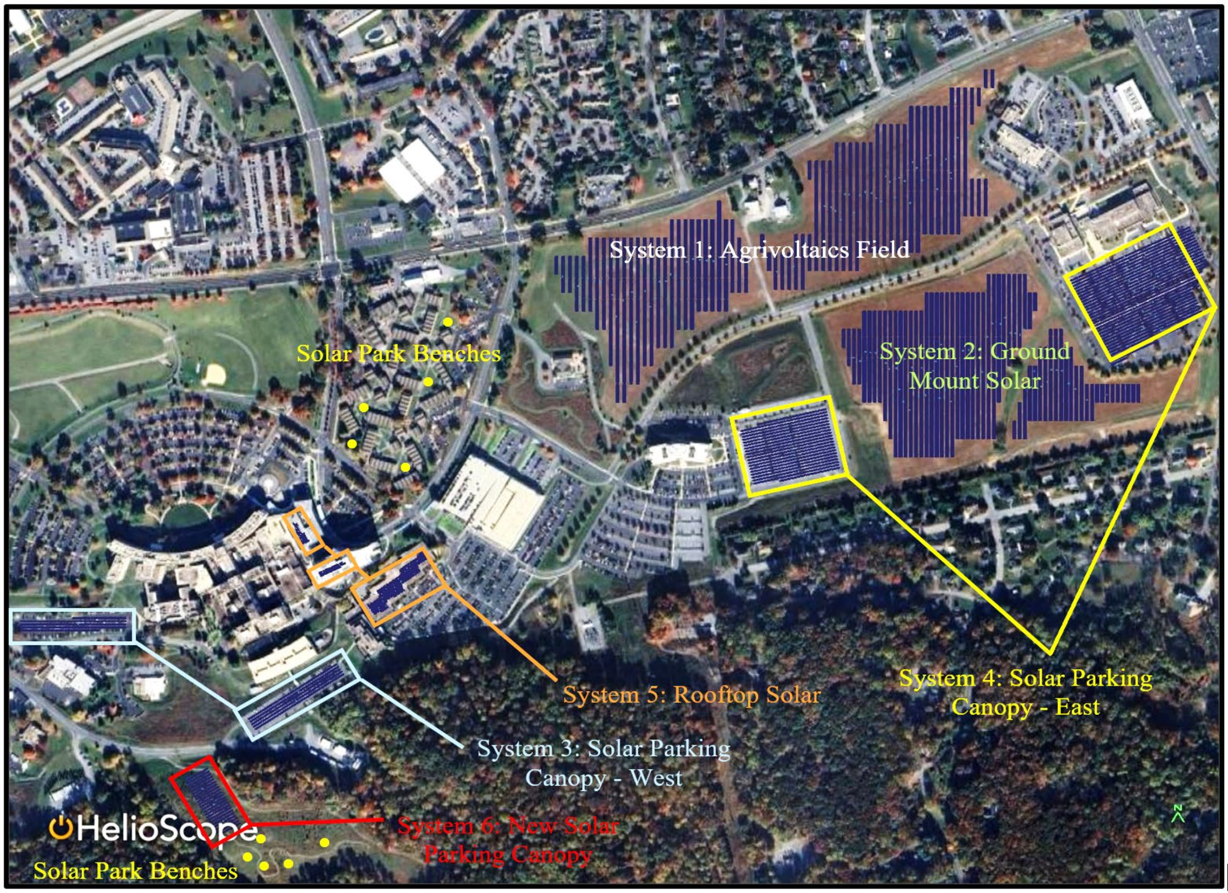

Figure 4: Overall photovoltaic plan for PSH

Helioscope was the primary software used for conceptual design because it quickly models the arrangement of solar panels and inverters. Additionally, the Solar District Cup provided students with free Helioscope accounts and tutorials. Helioscope streamlines the process from site assessment to energy generation, making it an important tool for industry professionals. The team performed component selection analysis, ultimately selecting Sunny Tripower inverters rated at 110 kW and AWG size 12-gauge copper wire for the conceptual system design. Canadian Solar panels rated at 575W and 1000V were the chosen modules for single axis tracking and fixed ground mount paneling primarily due to their high efficiency, their ubiquity in American markets, and their high maximum voltage rating. For the rooftop and canopy arrays, the team selected American-manufactured 410W Hanwha Qcells modules to maximize domestic content for overall system design. The smaller physical footprint of these modules offered the geometric flexibility needed for constrained space. Additionally, this module choice facilitated more precise string sizing, minimizing the risk of clipping losses and inverter mismatches. The ground mount arrays feature a panel height of 5ft with 11.7ft row spacing while the agrivoltaic arrays have panels elevated to a height of 8ft with 20ft row spacing to allow for optimized crop and energy production, ideally transforming the underutilized swathes into beneficial community assets. Overall, the ground-coverage ratio was between 0.4-0.55 to reflect industry standards.

The team also reviewed Single Line Diagrams and Shading Heatmaps produced through Helioscope to evaluate the efficiency of their design. The team used Open DSS to reveal the project site's heat map and determine the ideal points of interconnection based on PV hosting capacity. The team used the USDA Web Soil Survey to evaluate whether shallow bedrock was present which could increase the financial risk of their project [12]. Additionally, the team reviewed their project boundaries with a topographic map to determine whether high sloping areas were present as single-axis-tracker solar panels may have a limited tolerance. Lastly, the team reviewed the FEMA NRI Hail Risk map to determine whether their project could be damaged by hail, increasing the cost of project insurance. This hail risk was as well as the team's assumed degradation rate of panels and proposed decommissioning year were integrated into the financial analysis, blending financial and engineering constraints together to give the team a more holistic and realistic experience in solar design.

Additionally, preferences to local communities in the proposed location of development were also taken into account by the team. This gave students insight into how public opinion influences project development. Aesthetic appearance of the site in comparison to what it was previously was established to emphasize the minimal degradation from previous use and appearance that this project would bring to the area. The team also had to follow Penn State Health guidelines on preferred locations for development, making the students aware of realistic constraints put on photovoltaic projects. Preferred types of solar infrastructure indicated by the university were rooftop and ground mount, but after evaluation, rooftop infrastructure was deemed insufficient to produce significant electricity needs, creating a conflict of interest between the students as solar developers and the competition guidelines, allowing for students to seek out realistic means of compromise to produce viable results pleasing both entities.

Through the financial modelling of the 6 photovoltaic systems in the team's proposed solar design, an aggregate cost of $45 million was needed for design, construction, implementation, and management of the systems. With the Solar District Cup Financial Model 2024 Spreadsheet, a great deal of research had to be conducted for Pennsylvania and Hershey solar ordinances about the various costs, taxes, and financial benefits given to new solar projects. The average annual production in the form of a P50 metric was also found through Helioscope modeling, as well as all other energy metrics relevant to the financial calculations. Despite the large cost of fixed capital investment, overall, the 6 segments of the team's proposed PV system break-even in year 9 of operation. This leaves approximately 16 years of operation for the customers of the proposed PV system to make profit over the installation of solar energy on campus.

The team developed their proposed solar design to be sent to Penn State Health through a Power Purchase Agreement (PPA). PPA prices between types of solar arrays differed due to additional construction costs associated with agrivoltaics and solar parking canopies in comparison to reduced construction costs of ground mount and rooftop arrays. These prices range from $0.136 to $0.084 per kWh of energy distributed to the campus. Comparison to leasing or complete purchase of the solar design by the campus was also considered by the team, but overall savings to the university were most lucrative when utilizing PPA for distribution to the campus. Total expected savings over the 25-year time period that the solar arrays are expected to generate electricity for the campus is expected to generate approximately $18.5 million in savings for electricity generation from solar instead from baseline electric utilities utilized at a base rate of

$0.085 per kWh, not including distribution fees. Adjusted for the net present value of savings over the next 25 years of savings, the team's proposed solar design will save $5.82 million in aggregate electricity cost over a span of 25 years, or on average $233,000 in electricity savings annually.

In total, the 6 combined photovoltaic systems have a capacity to generate 26.23 MW of DC electricity for transmission to Penn State Health's grid. Modelled annual energy generation of the team's proposed solar site is 34,624 MWh of energy which pairs well with the entirety of Penn State Health wide estimated energy consumption of 51,579 MWh annually. The team's proposed solar design satisfies approximately 67% of the energy needs of the campus. Penn State College of Medicine's goal of promoting environmental responsibility when utilizing energy is satisfied greatly through the provision of over two-thirds of their electric supply from the team's proposed PV design. The unique secondary benefits achieved through the implementation of agrivoltaics, parking canopy solar, and solar park benches allow for a thoroughly integrated form of clean energy generation enhancing the current uses of all areas proposed for PV development. With access to solar park benches, the PSH community can continue to work outdoors and charge their devices. Additionally, solar park benches promote the use of renewable energy as they provide people with positive experiences related to solar energy. Increased access to fresh produce for food insecure members of the surrounding community, reduced heat stress on the automotive infrastructure throughout campus, and increased exposure to outdoor studying environments with ample electricity all improve campus functions through alternative methods outside of solely energy production.

Educational Research Experience Learning Outcomes

For participation in the SDC in 2025 at the University of Pittsburgh, the team consisted of four individuals. Their skill sets varied widely, with disciplines in mechanical engineering & economics, chemical engineering & biology, civil engineering, and urban design & planning. This wide array of educational experience promoted ease when deciding on specific roles each member would take for the completion of the SDC. Since there were 5 overarching objectives of the SDC, the 4 students focused on objectives based on their specific interests and preexisting skill sets.

All members made equal contributions in the conceptual design phase of the project where each student developed their own photovoltaic design, conceptual layout, conducted preliminary expense calculations for their project, and electricity generation for the hospital and university complex of Penn State Health. Each designer had to defend their suggestions with research on their panels and inverters of choice, arrangement, efficiency, cost expenditure, and interaction with the preexisting environment. The team's lead designer was responsible for evaluating all cases for each aspect of the design, then redesigning an overall system playing on the strengths of each individuals' designs. The lead designer was responsible for determining the finalized panel and inverter types used in the project, how many panels were connected to one inverter, the directionality of the panels, and their secondary uses throughout the Penn State Health site. One-line electrical diagrams detailing specific arrangement of panels in each of the 6 subsystems were also developed by the lead designer. These diagrams detailed safe operating voltage and amperage, length of wire needed for the system, total power output, module specifications, inverter specifications and electrical connections to overall interconnection points and service panels. The lead designer additionally conducted shading analyses detailing the efficiency of the photovoltaic systems.

Two members formed the distribution approach team responsible for interconnecting the finalized conceptual design into preexisting electrical infrastructure. They operated as joint leads to the distribution approach. The distribution approach joint leads analyzed how the proposed 26.3 MW system could be integrated into preexisting electrical infrastructure without overriding the electric grid thermally or electrically [13]. To do this, the pair analyzed an interconnection heat map that was given to the group from Penn State Health listing electrical limits of existing power lines and substations in the Derry Township area where the Penn State Health campus is located. The two members were responsible for ensuring each subsystem in the team's design avoided overloading any one section of the electric grid throughout campus. This was achieved through smart inverter use and division of photovoltaic systems into separate interconnection points to avoid electrical failure.

All 4 members engaged in the development plan together to contribute to research aligning with the correct legislation guiding the solar development project. Applicable zoning ordinances in Derry Township, Dauphin County, and Penn State Health special zoning regulations were utilized to operate the theoretical photovoltaic system under the legality of overseeing zoning authorities [14,15]. Authorities having jurisdiction over fire, electrical, health and safety were also identified and their laws observed to operate the theoretical construction of the proposed photovoltaic system under safe conditions for the university, the public, and operators of the plant. Additionally, the developers of the project took into account the aesthetic appearance of the proposed photovoltaic system and attempted to gauge public opinion on the panels and their effect on the daily life of locals near the proposed project. A soil analysis, topography analysis, hail risk analysis, construction timeline, and permit acquisition process for the photovoltaic project were also undergone by the developers.

Additionally, one member acted as financial analyst for the entirety of the project determining the financial viability of the project's entirety but also all 6 constituent photovoltaic sites within the overall project. The team was aided by the SDC in the financial analysis with the provision of an Excel based Solar PV Model capable of calculating customer annual savings, net present value of system earnings, the rate of return on investment, and the breakeven analysis of the project. In order to complete these financial assessments, the lead financial analyst had to research the applicable state and federal tax incentives facing the team's proposed photovoltaic system such as Solar Renewable Energy Credits (SRECs), Domestic Content, Energy Community, and Low-Income Allocation interim tax credits, and preferred depreciation rates for the photovoltaic infrastructure and production rate [16]. The result of this in-depth financial analysis was a breakeven analysis which factored in incentives, depreciation and tax implication to determine an overall customer annual savings of the project, shown in Figure 5.

Figure 5: Breakeven Analysis for the Proposed Solar Array

The students competing in the University of Pittsburgh's SDC capstone project gained an array of valuable skills throughout the duration of the competition. The project proposal and conceptual design gave students the opportunity to familiarize themselves with industry grade software like System Advisor Model, Helioscope, and Aurora Solar, useful tools specifically in photovoltaics, but also in many other realms of renewable energy industries. The conceptual design challenge also allowed students to familiarize themselves with many electrical engineering concepts such as calculations involving distribution losses, energy scale up, voltage and amperage regulation, and panel efficiency metrics. Electrical distribution movement, array design, material selection, shading considerations, and electrical safety considerations were also important topics stressed to the team that have valuable applications in the energy industry. Through completion of the financial analysis, students bridged the engineering concepts taught to them at the University of Pittsburgh with the necessary understanding of economic viability of projects to further ensure they make well informed decisions in their engineering careers in efficiency, safety, human health and wellbeing, but also to ensure their decisions are economically sound. Topics like net present value, rate of return on investment, depreciation, and tax breaks were extremely important to the project, but also will continue to be useful skills for the students to apply in their careers as engineers. Lastly, the development plan taught students about the legal side of engineering, an aspect that does not get emphasized much in traditional modes of education. By understanding the regulations, codes, standards, and legislation in place to create infrastructure without compromising the health and safety of the environment, the team learned to better understand what institutions oversee their actions and therefore they will be more likely to act within the relevant regulations throughout their future careers.

The SDC additionally strengthened many soft skills applicable to all academic and professional fields. The competition involved presenting the team's project proposal to a board of solar industry experts specifically judging each of the specific objectives as well as an additional representative from the SDC use case, in this instance Penn State Health. Oral presentation skills were utilized for first round proposals, a final presentation pitch, and the national finals to determine the team with the best design, where the University of Pittsburgh was able to secure the award of regional winner and national runners-up. Literature reviews, interdisciplinary communication and collaboration, and conducting interviews were also frequent parts of the SDC, all relating to interpersonal communication which can be utilized in any setting. The SDC helped participants greatly in formulating their own thoughts on advanced topics like energy production and conveying them to a wide array of audiences, an important skill when working with others in different fields or having different viewpoints as them. Students developed critical problem-solving skills by navigating project impasses and technical uncertainty. When facing complex strategic decisions or design trade-offs, the team leaned on industry mentorship to assist in decision making and validate designs. Additionally, internal challenges regarding group dynamics and workload distribution were resolved through structured, transparent communication. This dual approach allowed students to practice both technical decision-making and professional conflict resolution.

Academically aligned competitive challenges are not new to college curricula. Competitions like the NASA rover challenge have challenged and augmented student learning through physical experience in mechanical engineering, electrical engineering, design, and construction aspects to achieve impressive rover designs and pique student interest in adjacent curricula [17]. Similar aspects of design are seen in the Solar District Cup competition; most notably interdisciplinary teamwork, open ended project goals, and intercollegiate competition on subjects not directly taught in the university setting. These unique course attributes that competition brings to this type of curricula help students excel in and gain interest in the fields they compete in, essential in preparing students well for careers in the challenges they are participating in. The Solar District Cup acts as a potential vessel for competition oriented academic curricula promoting high involvement of students in renewable energy technologies and engineering practices. Through the success of the University of Pittsburgh SDC team in competing in and winning their regional challenge, students on the team found interest and involvement in clean energy systems, leading to early careers in sustainable and clean energy technologies directly and indirectly related to the solar design competition.

Participation in the SDC has had a profound effect on the members of the University of Pittsburgh team. Prior to the competition, one team member had some direct experience in photovoltaic systems through her co-op experience. Her work as a solar engineering intern was integral to the project and further developed her skills as a solar engineer. Through working on the SDC, her interest in solar energy was further strengthened and participation in the SDC helped her promote her solar experience to obtain a full-time position with a solar developer after graduating. An additional member with work experience in energy, but not renewables also took a great interest in clean energy industries from participation in the SDC. His work in financial analysis and solar efficiency software for the SDC developed strong analytical and economic skills, helping him obtain a career in nuclear energy generation after college. The SDC has had a profound impact on enticing young professionals interested in sustainability to pursue careers in clean energy generation.

From a pedagogical perspective, the integration of the SDC yielded exceptional student outcomes. Quantitative assessment reveals that the SDC cohort achieved the highest cumulative score among all 13 capstone teams, securing near-perfect marks on all summative assessments, presentations, and reports. Instructor observations suggest that the external incentives associated with a national competition shifted student motivation from highly grade focused to a more professional and standards-oriented approach to problem solutions. This added emphasis resulted in final course deliverables that exceeded typical instructor expectations when evaluated against the final report rubric (Figure 6).

ENGR1907 - Final Report Rubric

Criteria	Ratings						Pts
Resolves a Sustainability Problem - Sustainability Problem: thorough and relevant - Goals and Benefits: clear and easy to identify - Project Objectives: all important objectives identified - Evidence: relevant information used to support deliverables	**30 pts** **Exceptional**	**26 pts** **Very Good**	**22 pts** **Average**	**18 pts** **Below Average**	**14 pts** **Unsuccesful**	**0 pts** **Missing**	30 pts
Approach - Problem Approach: strong and considers all aspects - Alternatives Considered: 3 or more considerations - Analysis: decision making is explained thoroughly - Innovativeness: solutions are creative and well thought out	**30 pts** **Exceptional**	**26 pts** **Very Good**	**22 pts** **Average**	**18 pts** **Below Average**	**14 pts** **Unsuccessful**	**0 pts** **Missing**	30 pts
Report Layout & Organization - Organization: report clearly organized, succint and relevant - Written Communication: exceptional writing - Grammar and Spelling: little to no errors - References: references complete and well-organized	**30 pts** **Exceptional**	**26 pts** **Very Good**	**22 pts** **Average**	**18 pts** **Below Average**	**14 pts** **Unsuccessful**	**0 pts** **Missing**	30 pts
Deliverables & Future Work - Accomplishments: clear and thorough explanation - Impact: all benefits to society/stakeholder included - Future Work: Detailed discussion of next steps	**30 pts** **Exceptional**	**26 pts** **Very Good**	**22 pts** **Average**	**18 pts** **Below Average**	**14 pts** **Unsuccessful**	**0 pts** **Missing**	30 pts
Images, Tables & Charts - Formatting: professional w/ thorough descriptions - Explanation: thoroughly discussed in the text - Relevance: important to the project	**30 pts** **Exceptional**	**26 pts** **Very Good**	**22 pts** **Average**	**18 pts** **Below Average**	**14 pts** **Unsuccessful**	**0 pts** **Missing**	30 pts
							Total Points: 150

Figure 6: Final Report Rubric for the Sustainability Capstone Course

The project team's success securing 1st place in the regional division gained institutional recognition, leading to a feature in The Swanson School of Engineering Pitt News Program. The interview process provided a platform for student team members to provide some insight into the pedagogical benefits of the competition compared to traditional coursework. One student noted, “Most students don’t get these experiences in class,” while discussing the challenge of developing a financial model without prior background. “I had to do a lot of research about tax credits and depreciation,” a team member explained, highlighting the importance of self-directed learning in areas like energy policy, net present value and break-even analysis. Students also discussed how the interdisciplinary nature of the project positively impacted their career trajectories. 'We learned how to focus on our individual strengths and interests,' one student said, attributing their competitive success and improved career readiness to this collaborative approach of the SDC competition [18]

Peer feedback for the team was also exemplary. The team's Final Presentation was assessed by their classmates on 22 different metrics ranging from problem solving approach to evidence of supporting research. The team received an overall peer grade of 95%, the highest in the class. Here are some relevant quotes from peers that support… technical understanding by the end of the project, "It is clear that this group has extensive knowledge on solar panel design and implementation and the research they have done is evident. Your solutions and the evidence you bring up to support it make for a strong argument, and I am intrigued on what this project will amount to." … And integration of real-world standards that goes beyond the typical classroom expectation, "I think it was interesting how you brought up how zoning ordinances impacted your final solution, because that's not something I would've thought about. Your analysis of your potential solutions was very thorough."… And detailed understanding of subject to be able to simply some very complex systems, "The presentation was able to break down a lot of more complex solar information into a digestible manner." …. One student specifically mentioned how the competition added to the consideration and creativity of the course, " The competition adds unique restrictions to the project and prompts more creativity."

Peer feedback for the team was also exemplary. The team's Final Presentation was assessed by their 54 classmates on 22 different metrics ranging from problem solving approach to evidence of supporting research. The team received an overall peer grade of 95%, top in the class. Comments from peer reviews supported the notion that the team was able to present complex engineering topics in a clear and digestible manner. One peer review comment said, "The presentation team was able to break down a lot of complex solar information into a digestible manner." Other comments focused on the team's attention to real-world standards, with one student stating, "I think it was interesting how you brought up how zoning ordinances impacted your final solution.: Furthermore, the added competitive and industry focused aspects of the SDC competition enhanced the project's engineering rigor, as a peer said, "The unique restrictions to the project prompted more creativity." Compared to traditional capstone project teams, the SDC team gained enhanced experiential learning driven by the external demands of the competition.

Conclusion

Through the application of the Self Determination Theory, students grew their interest and furthered their understanding of photovoltaic energy. The shared interest of sustainable development between students with diverse academic paths provided a unique opportunity for students to simultaneously provide their own expertise in their field of study and learn from each other's skill sets without a traditional lecture style. For example, the team member with a background in urban studies was more motivated to develop an equity plan that involves teaching children at PSH about solar power while the team member with a background in civil engineering was more motivated to assess civil grading for the site. Both tasks were important for the success of the project.

We observed that the competitive element of the SDC encouraged students to iteratively approach design and apply core engineering concepts repeatedly, suggesting a reinforcement of knowledge retention consistent with active learning educational frameworks such as Edgar Dale's Cone of Experience [3]. Passive methods of education like lecture often incorporate learning stimuli that are poorly retained from students. The SDC's in-depth use of photovoltaic modelling software like

Aspen and Helioscope, financial planning documents, and conversations with experts in relevant fields provided opportunities for strong knowledge retention in the renewable energy sector.

The integration of the Solar District Cup into the Sustainability Capstone at the University of Pittsburgh challenged students to learn new technical knowledge about the solar energy industry, collaborate across different disciplines, and present their findings to a panel of judges. STEM education thrives when students develop projects because project-based learning encourages students to think critically, solve problems, and make meaningful academic memories. Students who participated in the Solar District Cup believe that they have achieved a higher level of learning because they have engaged with highly technical content, resembling professional work experience such as reviewing the National Electrical Code and other national regulations. The competition helped transition students from academic coursework and lectures to professional-level project development, building skills in real-world permitting, financial analysis, design, professionalism, and stakeholder engagement.

The SDC team at the University of Pittsburgh won first place in their district. Their success validates the integration of national competitions into capstone curricula and provides a clear example of how a competition provides extra motivation and pushes students beyond their comfort zone. For many of the students, they had minimal knowledge of solar energy systems. Integrating competitions into capstone courses engages self-learning at the highest levels of Bloom's taxonomy as shown in Figure 7 [19] while working within the guidance of mentorship and competition constraints.

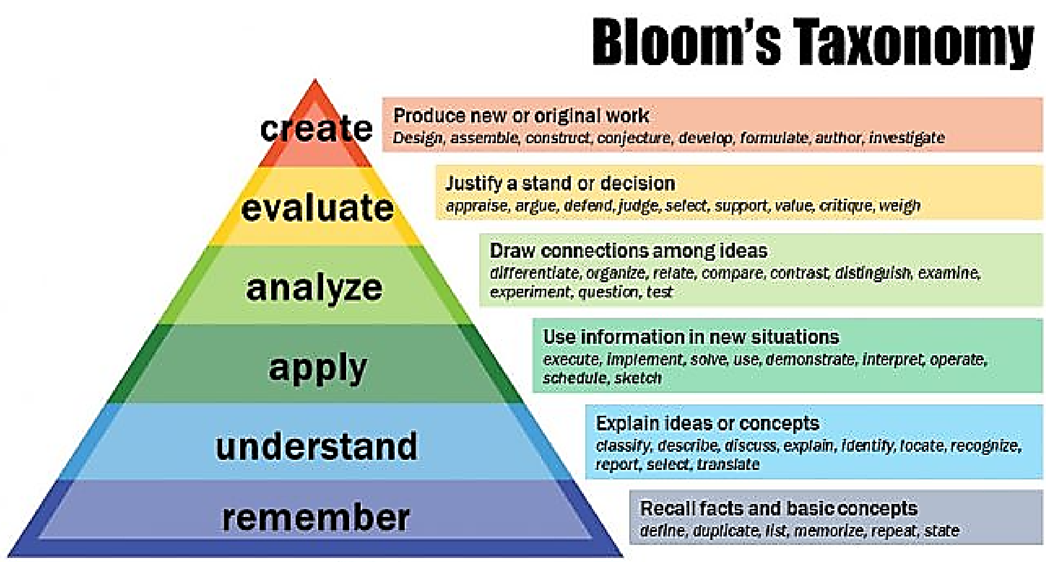

Figure 7: Bloom's Taxonomy [19]

We recommend that engineering educators make use of similar competition-based experiences when possible. The competition provides real-world experiences within the constraints of the competition rules, enhances soft skills and professional skills, improves technical adaptability, provides additional motivation, and introduces a need for self-learning.

References

[1] N.R.E.L. "Class of 2024-2025 Rules." United States Department of Energy. https://nrel.instructure.com/courses/245/files/1909/download?download_frd=1 [Accessed Jan 08, 2025].

[2] Ryan, R.M., Deci, E.L., "Intrinsic and Extrinsic Motivation from a Self-Determination Theory Perspective: Definitions, Theory, Practices, and Future Directions," *Contemporary Educational Psychology*, https://www.sciencedirect.com/science/article/pii/S0361476X20300254 [Accessed Jan 08, 2025].

[3] Lee, S.J., Reeves, T.C., "Edgar Dale - A Significant Contributor to the Field of Educational Technology," *Educational Technology*, https://www.jstor.org/stable/44429532?seq=1 [Accessed Jan 09, 2025].

[4] G. Maps, "Solar District Cup Penn State Health Profile Progress Deliverable," S. D. C. Competition, Ed., ed: National Renewable Energy Laboratories, 2025.

[5] N.R.E.L., "Class of 2024-2025 Rules," United States Department of Energy, https://nrel.instructure.com/courses/245/files/1909/download?download_frd=1 [Accessed Jan 27, 2025].

[6] S. Berry, "COO at Solar Renewable Energy," in Financial and Construction Timeline for PV Development, D. Chemaitilly, Ed., ed. SRE, 2025.

[7] J. Grottini, "Vice President of Envinity Solar Construction and Recommissioning Project," in Metering Techniques and Financial Implications of Various Solar Development, D. Chemaitilly, Ed., ed. State College, Pennsylvania: Envinity, 2025.

[8] K. Graves, "Senior Director of Engineering and Procurement," in Solar Consulting and Software Usage, D. Chemaitilly, Ed., ed. Oriden Solar, 2025.

[9] A. Walker, "Solar District Cup Conceptual Design Slides 8/25/2023," *Solar District Cup*, https://nrel.instructure.com/courses/245/modules/items/1338 [Accessed Feb 27, 2025].

[10] D. Ripp, "Education and Operations Manager," in Agrivoltaics, J. Ufer, Ed., ed, 2025.

[11] "Solar Parking Canopies: Harnessing Clean Energy in Everyday Spaces," *Crete United*, https://creteunited.com/blog/solar-parking-canopies-harnessing-clean-energy-in-everyday-spaces [Accessed Apr 06, 2025].

[12] "Web Soil Survey," *United States Department of Agriculture*, https://websoilsurvey.nrcs.usda.gov/app/ [Accessed Jan 09, 2025].

[13] *Penn State Health District Use Case Electric Line Distribution Heatmap*. (2024). Accessed: 04/01/2025.

[14] “Zoning Ordinance for Township of Derry, Dauphin County, PA,” https://www.derrytownship.org/wp-content/uploads/2024/07/Zoning-Ord-2019-last-revised-5.28.24-per-Ord.-2024-02.pdf [Accessed Mar 12, 2025].

[15] "Township of Derry, PA Mifflin County Codes and New Laws," *Township of Derry*, https://ecode360.com/13950815#13951065 [Accessed Apr 05, 2025].

[16] "Energy Community Tax Credit Bonus," U.S. Department of Energy, https://arcgis.netl.doe.gov/portal/apps/experiencebuilder/experience/?id=a2ce47d4721a477a8701bd0e08495e1d [Accessed Apr 05, 2025].

[17] “Human Exploration Rover Challenge,” National Aeronautics and Space Administration, https://www.nasa.gov/learning-resources/nasa-human-exploration-rover-challenge/ [Accessed Apr 21, 2026].

[18] Pitt, “Pitt Students Shine Bright in NREL Solar District Cup,” *Pitt Students Shine Bright in NREL Solar District Cup* , May 27, 2025. https://news.engineering.pitt.edu/pitt-students-shine-bright-in-nrel-solar-district-cup/ [accessed Jan. 10, 2026].

[19] Armstrong, P., “Bloom’s Taxonomy,” *Vanderbilt University Center for Teaching*, https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/ [Accessed Jan. 10, 2025].