UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

Senior Design Project Description

Company Name	*EPRI*	**Date Submitted**	*04/26/2020*
Project Title	*A Better Approach to Vegetation Management at Utility-scale PV Plants – Phase 5* **(EPRI_MAIN5)**	**Planned Starting Semester**	Fall 2020

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills:

Discipline	Number	Discipline	Number
Mechanical	3	Electrical	2
Computer	3	Systems	
Other ( )			

Company and Project Overview:

The Electric Power Research Institute (EPRI) conducts research, development, and demonstration projects for the benefit of the public in the United States and internationally. As an independent, nonprofit organization for public interest energy and environmental research, we focus on electricity generation, delivery, and use in collaboration with the electricity sector, its stakeholders and others to enhance the quality of life by making electric power safe, reliable, affordable, and environmentally responsible.

One of the larger costs associated with maintenance of utility-scale PV plants is vegetation management. In temperate climates, some weeds can grow 10+ inches per week. If not maintained on a regular basis, the weeds can shade PV modules, which reduces energy production, and can cause hot spots in the module, which is a fire hazard. Plant maintenance providers have tried a litany of conventional and unconventional approaches with inconsistent success over the relatively large footprint of PV plants (a 100 MW plant requires nearly 1 square mile). For instance, regular mowing can launch rocks into modules breaking the front glass (exacerbating O&M costs further) and sheep and goats are picky plant eaters requiring additional oversight by shepherds and donkeys (for protection against prey animals).

Project Requirements:

This project intends to develop a vegetation control technology that overcomes shortcomings of existing

methods. It must:

1) be more cost effective than current techniques;
2) mow all areas of a PV plant, including under the modules and around the racking;
3) be quickly and easily sited at a PV plant (cannot permanently integrate into the plant itself);
4) not damage the PV site and equipment;
5) be reliable, autonomous, and dispatchable; and
6) not modify the environment / native habitat (e.g., cannot introduce foreign plants or scorch the earth).

Scope and Approach

Work will expand upon four previous senior design projects that happened each year starting in 2016. In 2016, an autonomous mowing robot was built and demonstrated. In 2017, a self-sufficient charging station for the robot was built and demonstrated. In 2018, locational and obstacle avoidance sensors were installed, and preliminary control algorithms developed, but not tested in a real-world environment. In 2019, the mowing robot's processor was upgraded to allow improved processing of the numerous sensors, the sensor package was upgraded (LiDAR, GPS, wheel encoders, and digital compass) and the autonomous navigation control algorithms were converted from programming language C to Python to leverage the use of open-source autonomous navigation software in addition. Despite unprecedented events related to a global pandemic, the first real-world tests were conducted on asphalt with some success, while identifying practical navigational improvements needed such as directional error correction and wheel motor speed balancing.

This fifth phase is intended to bring years of work to completion through systems engineering that ensures all aspects of the robot and charging station work harmoniously together as demonstrated by field testing in a real-world PV plant (test host and site to be arranged by project mentor).

Expected Deliverables/Results:

- Self Sufficient Charging station fully operational and verification testing complete
- Autonomous mower fully operational with verification testing complete and all hardware packaged such that operations and maintenance can be easily done by a third party
- Delivery of firmware that provides the full autonomous operation: Navigation of a site to mow grass around obstacles without getting stuck, navigation back to charging station when batteries are low, successful charging and repeated operation, schedule for when to do mowing considering time of year, and weather conditions, successfully manage interaction of firmware modules to avoid conflict between the multiple algorithms.
- Verification testing is a major part of this project as this project is intended to be the final phase to complete this 4 year project. Testing must be done at an actual PV site.

Disposition of Deliverables at the End of the Project:

Delivered to EPRI after the conclusion of the Expo.

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List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

- For CpE students, ECGR 4101or 5101 Advanced Embedded Systems and ECGR 4090 are required (can be completed or started in Fall 2019)
- Students must be able to travel to PV site (to be defined by EPRI) for extensive verification testing which proves all aspects of the operation.