An Educational Program on Concentrated Solar Power and Heliostats for Power Generation and Industrial Process

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An educational program will be developed to expand CSP knowledge among college students as well as practicing engineers. It will include:

1. **Possible involvement of freshmen in minor research in CSP.**
2. **Re-establishment of co-op with NREL and Sandia, New Mexico.**
3. **Involvement of under-represented minority students from (LSAMP) group for summer research.**
4. **Involvement of undergraduate students in Capstone Senior Design Projects relevant to Heliostats.**

An educational program will be developed to expand CSP knowledge among college students as well as practicing engineers. It will include:

5. **Possible Involvement of Upper-Class students in CSP Research.**
6. **Development of a four credits senior/first year graduate course.**
7. **Development of five short courses for industry.**
8. **Possible supervising 8 credits MS theses as well as 4 credits graduate project.**
9. **Presentation in ASME and ASEE meeting.**
10. **Publications in ASME Open Journal of Engineering.**

Involvement of under-represented minority students from (LSAMP) group for summer research.

LSAMP is a National Science Foundation program with the purpose of increasing number of under-represented minority in STEM fields. Northeastern University is a member of the Northeast Alliance with University of Connecticut, University of Massachusetts, University of Rhode Island, Worcester Polytechnic Institute and Tufts University.

Currently two female rising seniors from LSAMP group have started doing research in effective and efficient methods for cleaning of heliostat mirrors.

Development of a four credits senior/first year graduate course

APPLICATIONS OF CONCENTRATING SOLAR THERMAL AND POWER TECHNOLOGIES

COURSE EVALUATION: Homework, Exams, Independent Project. Course is open to Engineering and Physics Graduate students or as a senior elective with instructor permission.

Development of short courses for industry. Description

The material from the “APPLICATIONS OF CONCENTRATING SOLAR AND POWER THERMAL TECHNOLOGIES" course described above will be broken into five one day, Web-based/On Ground short courses to be offered to Industry, the public and students.

Course topics are:

1. Provide an overview of Concentrating Solar Power Systems: Performance measurement, general operating conditions, cost performance, high temperature product output.

2. Introduce Optics Fundamentals for Concentrating Solar Power systems

3. Establish Tracking requirements for Performance and Cost-Effective Operation of CSP

4. Optimize Energy Loss from Concentrating Solar Power Systems: Effect of Glazing Enclosures

5. Examine and explain the uses of the High Temperature Energy from CSP

Capstone Project (Senior Design Projects)

Northeastern University is a co-op school and students are split in two divisions (A and B) when they start their second year.

- **Each division spends six months at school and six months at work (co-op) .**
- **Students have to take a sequence of two courses for the Capstone Engineering Design (Senior Design).**
- **The first one is assigned 1 credit and the second course 5 credits.**
- **One division take Capstone 1 in May and June during the summer between 4th and 5th year and then take the second course in Spring of their senior year (January-April).**

Capstone Project (Senior Design Projects)

We already have three CSP projects for students who had their capstone 1 in May.

They are:

1. **Design a solar tracking system for a heliostat mirror**
2. **Design a light-weight Mirrored, deformable surface with a highly effective facet**
3. **Solar pyrolyzer reactor for producing biochar from dry pine needles**

Heliostat actuator project

Design a solar tracking system for a heliostat mirror

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2023 - 2034

Heliostats comprise static and dynamic components (reflective area, a control system, and the mounting and tracking mechanism) operating in a highly controlled manner to provide accurate solar flux pointing. They are primarily used in solar tower applications that provide high energy flux and temperatures (500° – 2000° C) that can lead to more efficient solar collection for electrical power production and energy storage. These components and their control represent numerous opportunities for cost control, both in actual cost and in reliability, maintenance costs, and lifetime. Recent efforts have improved some component designs to lower the costs of customized components such as the drive system, which can account for up to one-third of the total heliostat cost. Drives remain one of the most expensive components in a heliostat system, accounting for approximately half of the $50/m^2 cost target for heliostats. Resilient control of the heliostat is required for adjustment of heliostat structure so it can accurately track sun position to reflect concentrated sunlight toward a receiver target. Wireless and closed-loop controls have become increasingly attractive for new installations as they offer potential cost savings and enhanced performance. In this project you will design, build and test a control system for adjusting a single heliostat structure so it can accurately track sun position to reflect concentrated sunlight toward a receiver target. Testing within the laboratory will also require a visible light source simila

Some collaboration with the **Heliostat Mirror Project** is to be expected.

https://www.energy.gov/eere/solar/articles/no-smoke-all-mirrors-developing-next-generation-heliostats

https://lm.solar/heliostats/

Heliostat Mirror Project

Design a light-weight Mirrored, deformable surface with a highly effective facet

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2023 - 2024

Heliostats comprise static and dynamic components (reflective area, a control system, and the mounting and tracking mechanism) operating in a highly controlled manner to provide accurate solar flux pointing. They are primarily used in solar tower applications that provide high energy flux and temperatures (500° – 2000°C) that can lead to more efficient solar collection for electrical power production and energy storage. These components and their control represent numerous opportunities for cost control, both in actual cost and in reliability, maintenance costs, and lifetime. Drives and mirror facets remain the most expensive components in a heliostat system, each accounting for approximately half of the $50/m^2 cost target for heliostats. Heliostat durability and reliability are not well characterized but are of key importance to ensure high performance and safe operation over the designed lifetime. In this project you will design, build and test mirrors and associated components for a heliostat considering flexible or segmented surfaces that can be deformed using actuators, pneumatic membranes or other configurations you develop that would allow the surface to reflect the incident solar radiation to the target area reducing the dependence on complicated gear mechanisms. It is anticipated that your group would team with the concurrent **Heliostat Actuator Project** in areas that overlap.

https://www.energy.gov/eere/solar/articles/no-smoke-all-mirrors-developing-next-generation-heliostats

Solar pyrolyzer reactor for producing biochar from dry pine needles

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2023 -2024

This project is related to forest fire prevention. Forest organic debris includes leaves, needles, snags, tree limbs and other dead organic material. Such material is highly flammable and contributes to the intensity and spread of forest fires. Removal of organic debris from forest floors can help minimize the spread of forest fires. The removal and collection of the debris can be incentivized by showing that it can be used as a feedstock for value-added products. The general idea proposed herein is to collect such organic debris form the forest floor and eventually pulverize it and utilize it as a bio-fertilizer, (a) in “as is” condition form, (b) as a bio-char, (c) as an activated carbon or (d) as combustion ashes. Bio-chars and activated carbons can be used as bio-fertilizers on various agricultural soils to improve the soil's chemical, physical, and biological properties, and increase crop productivity. The criterion for success will be to demonstrate enhanced growth of plants at the presence of bio-chars, activated carbons or bio-ash.

In this project we will use waste dry pine needles as an example of such organic debris. You are asked to conduct a review of literature on this subject and design a ***continuous flow feeder for pine needles integrated with an existing tracking solar concentrator furnace*** where this material can be pyrolyzed at high temperatures (300-600 °C) in an inert gas to generate bio-char. To achieve such temperatures the current solar tracking control system may need modification. Bio-char can then be activated in steam and generate activated carbon, or it can be burned in air to generate ash. You will then use these materials to investigate their effects in aiding plant growth. You will also need to conduct a techno-economic analysis for these processes.

Thank you

Questions or Feedback