A Project-Based Interdisciplinary Program in Sustainable Energy

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Outline of the Talk

ABOUT the Latimer Energy Scholars Program

- PART 1: Fundamental concepts through online learning
- PART 2: Students select practical projects
  - **Fuel cells**
  - **Solar Decathlon / PV panels**
  - **Microscope for use in remote regions**
  - **Dissemination of Solar devices in Uganda**
  - **Cylindrical Solar PV panels**
- Assessment of student learning
- Conclusions and Future Work

ABOUT THE PROGRAM…

- This project-based program is called Latimer Energy Scholars
- Students from any sector of engineering apply for admission and if selected, participate in a two-part program designed to give them a strong background in sustainable science & engineering.
- A "Hybrid" model of on-line learning
  - Web-based content
  - Interactions with instructors and other resources

PART 1:

The students learn fundamental concepts through an online learning approach

- PVCDROM: Students study and interactively carry out tasks following a script written by us.
- Other study media: National Instruments and Texas Instruments webcasts, books in the Latimer Laboratory, industry magazines and materials supplied by industry experts.
- Students can communicate through chat, email and online threaded discussion with faculty and fellow students.
- Students have the opportunity to attend courses and have face-to-face interactions with faculties and industry experts

PART 2:

Students select practical projects, and are paired with a professional in the relevant field, where possible.

- The projects are interdisciplinary and cover all areas of engineering
- The projects are not limited to one area of sustainability [i.e., industry/business, education, frugal engineering, photovoltaics, fuel cells, Current –Voltage (I-V) tracers, etc.]

LOGISTICS…

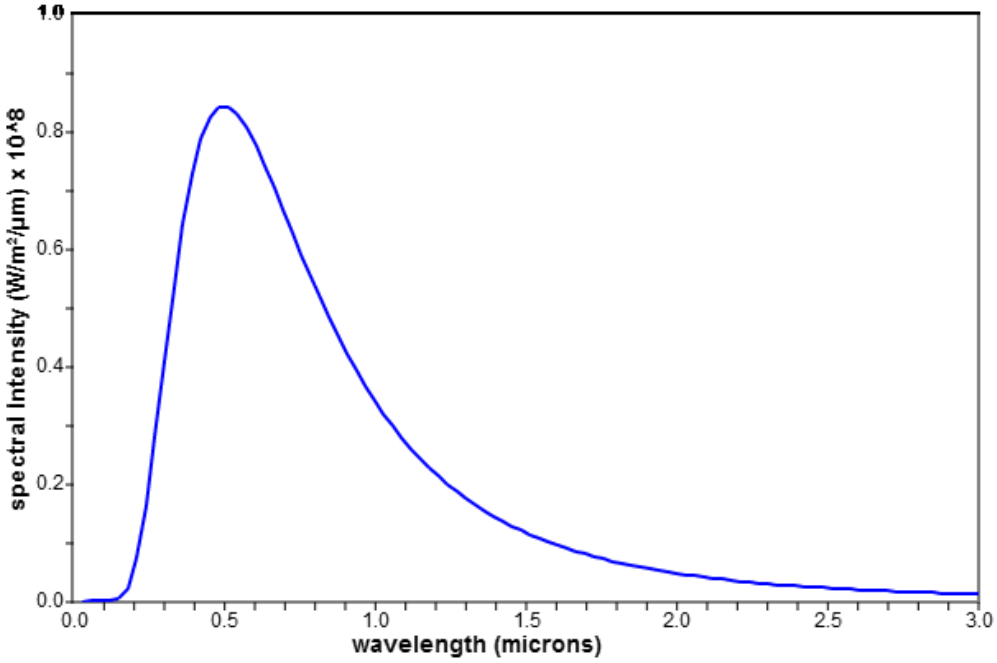
- Typically, students work on the fundamentals during the academic year and work on projects during the summer. Although, there's flexibility on project involvement during the academic year.
- The students are supported through endowment from a $1.3 million grant.

LEARNING THE FUNDAMENTALS…

Let's look at the PVCDROM as an example:

- PVCDROM is essentially an open on-line book which contains animated graphics and simulations to actively engage the students in learning topics in photovoltaics.
- At the lab, we write a series of "sessions/lab handouts" to take them through topics in PVCDROM of interest to the students and their projects and challenge their knowledge.
- Gradually, students are given more autonomy and eventually they carry out their own independent learning.

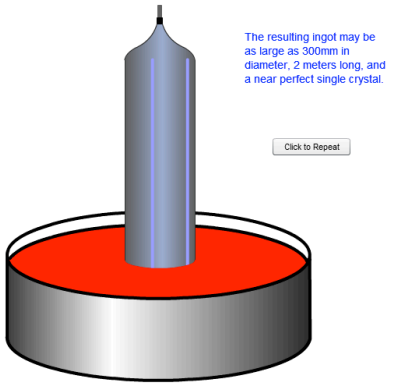
- Below is an example of a controllable graphic from PVCDROM.
- www.pveducation.org/pvcdrom/
- Interactive



The most attractive feature of this program is its interdisciplinary character.

- Students study the physics of the sun and of semiconductors, the **electrical engineering** of cell characteristics and electrical optimization, the **mechanical engineering** of heat transfer and device and panel design, and the **manufacturing engineering** of putting it all together to produce a practical device.

The figure below is a still shot of a dynamic animation of the manufacturing of a single-crystal ingot of silicon, using the Czochralski process.



PROJECTS:

- The second part of the program is a project that the students choose.
- We make no effort to match the student's project to their academic department.
- In fact, most students do not pick a project that matches their chosen major.
- Students earn an additional academic unit for completing a successful project and submitting an appropriate report.

EXAMPLES OF PROJECTS…

- Fuel cells
- Solar Decathlon / PV panels
- Microscope for use in remote regions
- Dissemination of Solar devices in Uganda (Solar Sisters)
- Cylindrical Solar Modules (Solyndra)

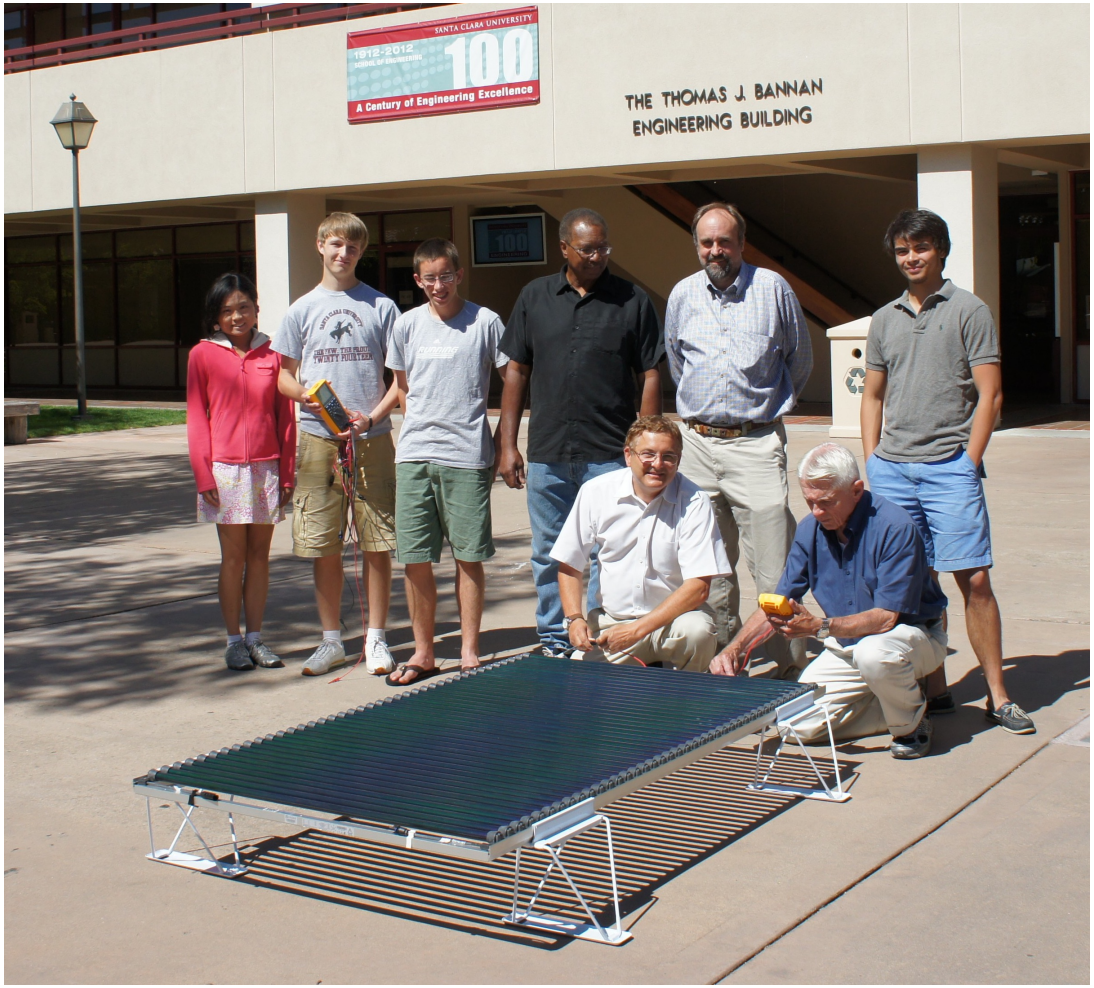
SOLAR SISTER (www.solarsister.org/)

- One of the Latimer Scholars spent the summer of 2012 in Uganda, working with the social enterprise Solar Sister. This organization has the mission of enabling the last-mile distribution of solar lighting devices in developing countries while promoting women empowerment.
- The experience included the presentation of a technical training component for Solar Sister's training sessions and learning techniques for effective cost and energy analyses for solar products versus inefficient fuel sources including kerosene.
- Included in-country collaborations with Barefoot Power, Ultratec, and the Rural Electrification Agency of Uganda.

"As a Latimer Energy Scholar I entered this internship with prior experience demonstrating and explaining solar technologies to those new to the subject. Additionally, I was already familiar with solar portable devices in the Latimer Energy Lab including products by d.Light, Angaza Design and Light Up the World."

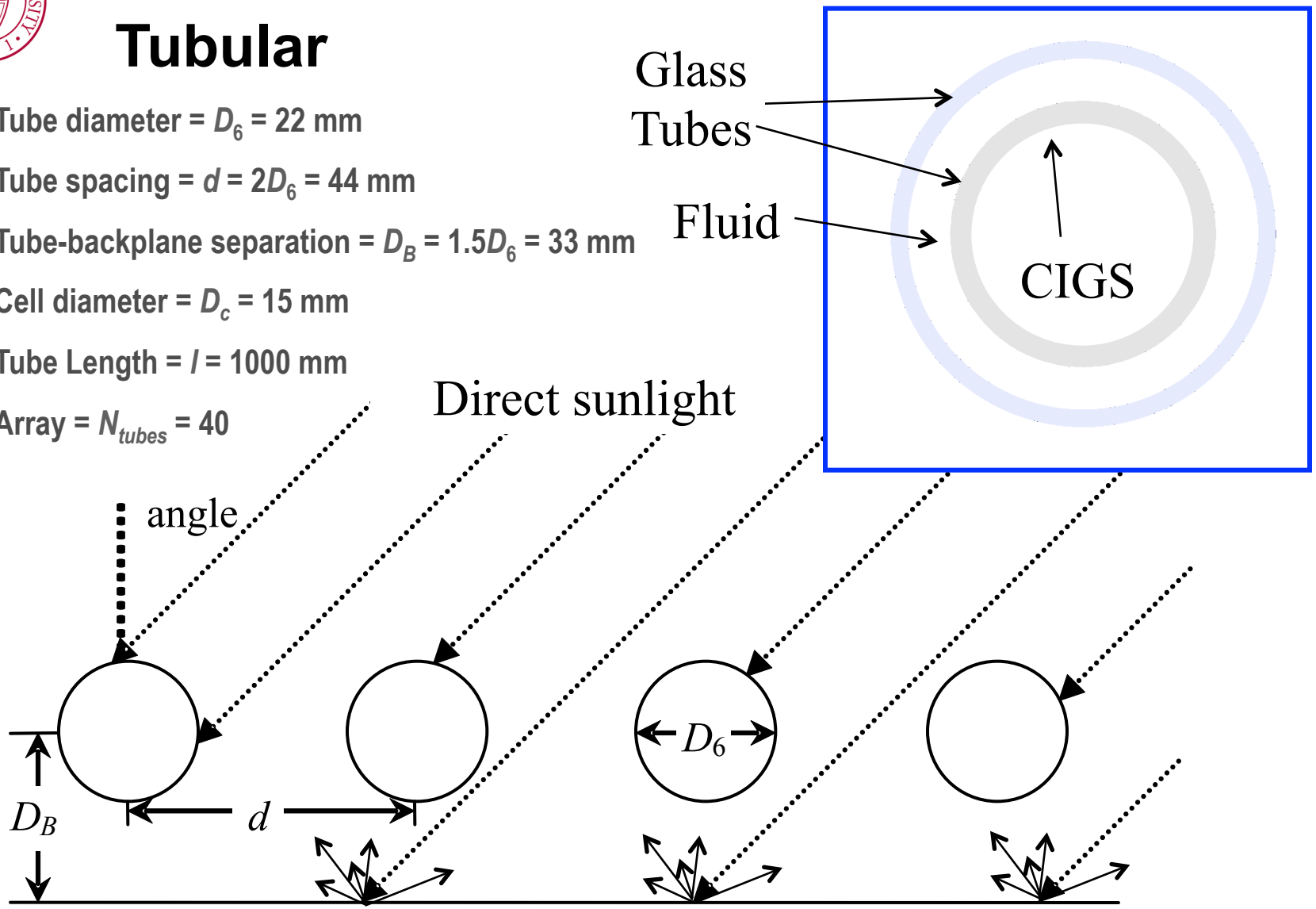
Kirsten

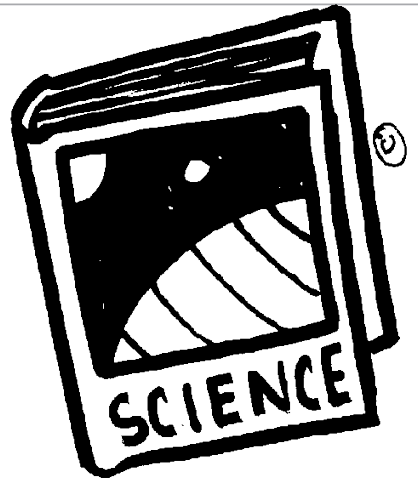
CYLINDRICAL PHOTOVOLTAIC SOLAR MODULES



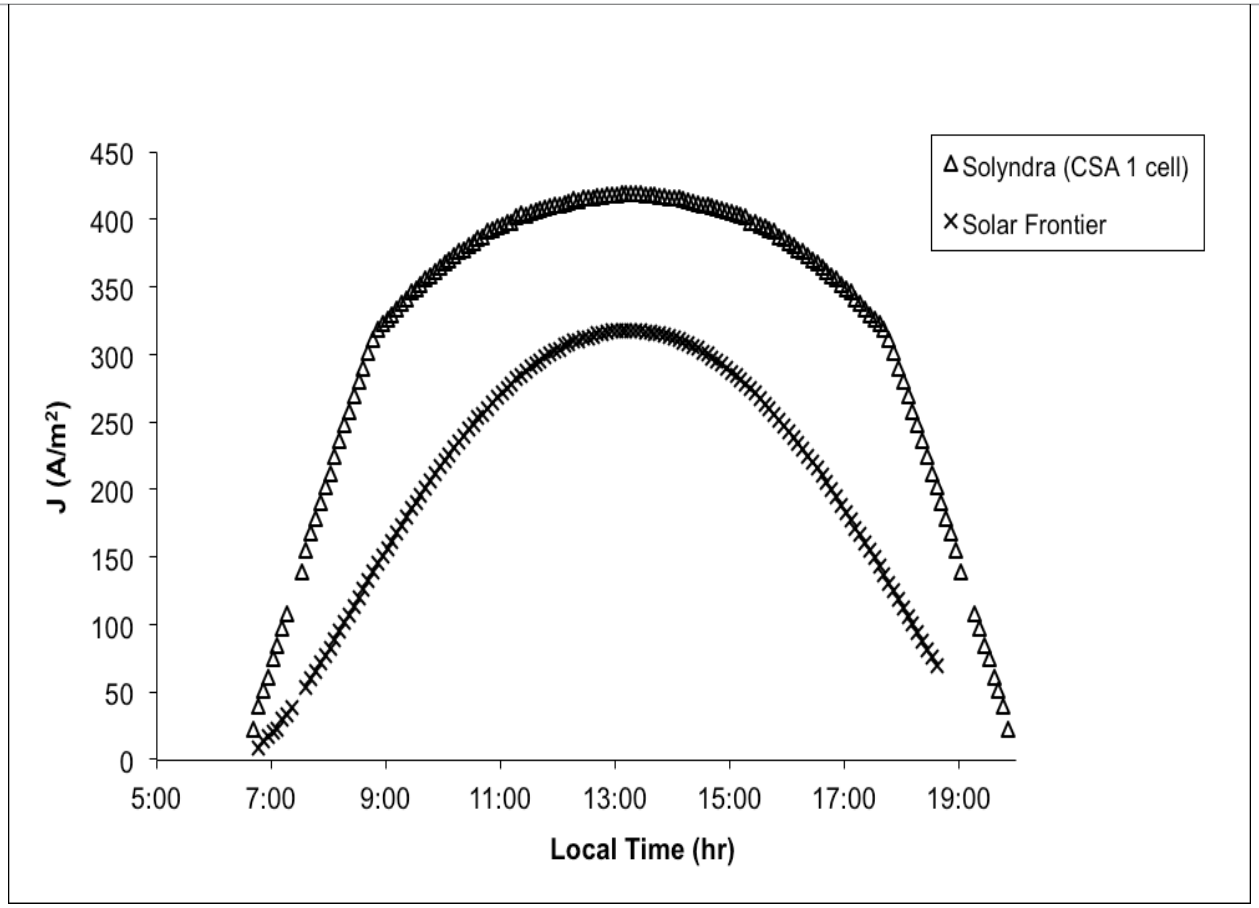
Tubular

- Tube diameter = D_6 = 22 mm
- Tube spacing = $d = 2D_6$ = 44 mm
- Tube-backplane separation = $D_B = 1.5D_6$ = 33 mm
- Cell diameter = D_c = 15 mm
- Tube Length = l = 1000 mm
- Array = N_{tubes} = 40





- **The students worked on characterizing the performance of the panel, both theoretically and through measurements.**
- **3 reasons why this project was important:**
  - Studies and analyses done by Solyndra are generally not available as they are their intellectual property.
  - Much of the study has relevance to solar thermal, **which is widespread in the global solar energy industry**
  - It makes a wonderful teaching tool, stretching across many fields, including: mechanical engineering, chemistry, glass making, optics, reflectivity (albedo), and electrical engineering.



Short circuit current per m^2 for Solyndra (top curve) and Standard CIGS PV module from Solar Frontier.

ASSESMENT OF STUDENT LEARNING

Student learning is accessed in two ways:

- After each PVCDROM-based section, the students are asked to report on their learning experience, engagement and knowledge acquired.
  - The instructor expands on student's comments and knowledge by asking the student additional questions, presenting additional examples, showing real-life measurements and mentioning related areas that where not mentioned in the PVCDROM
  - After each PVCDROM-based section, the students are asked to report on their learning experience, engagement and knowledge acquired.
- We also sought to assess what students learned from projects.

CONCLUSIONS

- It is our belief that this combination of on-line learning, supplemented by laboratory work, with applications to real-life projects offers an excellent approach to interdisciplinary engineering education.
- This approach warrants further testing.
- Future work will expand the use of the Camino platform so that participating students can share session reports from the PVCDROM as well as information, insights and data from their projects.

QUESTIONS?

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Selected References

•K. Mangan, “Open Education’s Wide World of Possibilities”, The Chronicle of Higher Education, April 29, 2012- http://chronicle.com/article/Open-Educations-Wide-World-of/131672/

•M. Martin, “The Hybrid Online Model: Good Practice”, Educause Quarterly, Number 1, 2003 http://net.educause.edu/ir/library/pdf/eqm0313.pdf

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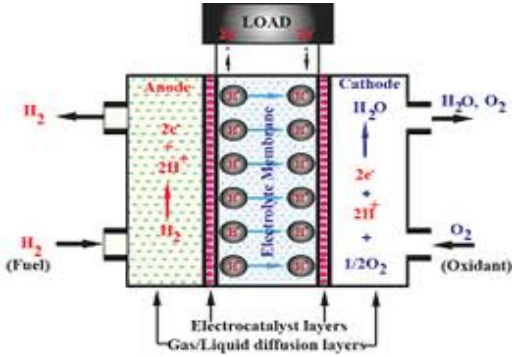
Hydrogen Proton Exchange Membrane (PEM) Fuel Cell



- **What is a hydrogen PEM fuel cell?**
  - Storage device converts fuel (hydrogen) and oxygen from air into electricity
  - Commonly used in portable applications, satellites and transportation, such as airplanes and automobiles
- **Experiments include:**
  - Avogadro's Number and Faraday Efficiency Measurements
  - Electrolyzer Performance and Decomposition Voltage
  - System Efficiency and Characteristic Curves