Bring Fuel Cells and Biofuels into Your Course with CACHE Energy Modules

CACHE Fuel Cell Task Force

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For the past few years, a CACHE task force has been developing modules to introduce concepts of hydrogen and hydrogen fuel cells into the chemical engineering undergraduate curriculum. To date, about three dozen modules have been developed for the following ChE courses:

- Introductory Material – 1 module plus links to two Knovel Engineering Cases
- Material and Energy Balances – 5 modules
- Thermodynamics – 5 modules
- Fluid Mechanics – 3 modules plus Comsol module
- Heat and Mass Transport – 3 modules plus Comsol module
- Kinetics and Reaction Engineering – 8 modules plus Comsol module
- Separations – 4 modules
- Process Safety and Process Design – 8 modules including two UniSim modules

Each module contains a background on the technology as it applies to the core course. This is followed by an example problem statement and a solution to the example problems. Finally, a homework problem is provided. Homework solutions are available on a password protected website. Instructors can distrubute the modules "as is" for homework, or give the background information and example problem as an in-class problem.

The modules are available at the following website: http://www.chem.mtu.edu/~jmkeith/fuel_cell_curriculum or the shorter URL http://tinyurl.com/fuelcellcurr

The interactive *"Fuel Cell Power and Voltage Calculator"* has input boxes to enter and/or adjust the number of cells, stack current, and fuel cell cross-sectional area. A screenshot is shown in the image on the next page. As the parameters are adjusted, a point moves along a polarization plot and power density plot. Furthermore, key parameters are to be calculated including voltage, power, and hydrogen consumption rate. This allows a student to learn about the important parameters in fuel cell design and operation. See the image in Figure 1 below.

Furthermore, a comprehensive set of example problems were created by Jason Keith and Michigan Technological University PhD student Daniel Lopez Gaxiola as a supplement

to the text Elementary Principles of Chemical Processes by Richard Felder and Ronald Rousseau. These modules are listed at the following website: http://www.chem.mtu.edu/~jmkeith/fuel_cell_curriculum/index-felder.html or the shorter URL http://tinyurl.com/H2felder
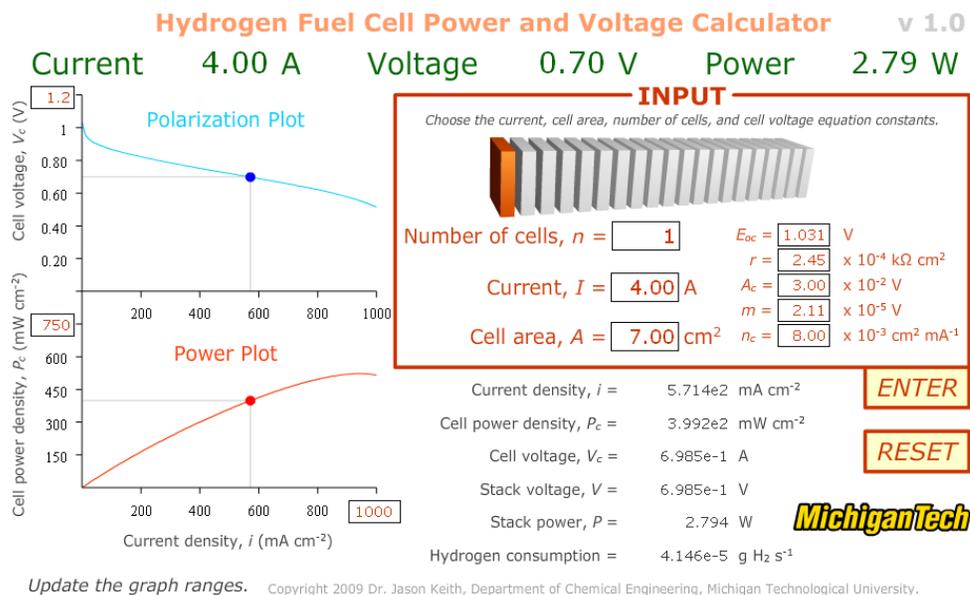
Figure 1. Hydrogen Fuel Cell Power and Voltage Calculator
http://www.chem.mtu.edu/~jmkeith/fuelcellcalculator/H2FuelCellPVCalculator.swf

Also, the fuel cell task force is expanding to an energy modules task force. The goal of the task force is to prepare modules for the ChE core courses for concepts such as wind energy, water energy, coal energy, biomass energy, and solar energy. Task force members include Jason Keith, chair; David Allen; Wayne Bequette; Chau-Chyun Chen; Tom Edgar; Mahmoud El-Halwagi; Scott Fogler; Jeff Siirola; and Gavin Towler. The first 10 modules are listed at:
http://www.chem.mtu.edu/~jmkeith/energy/generalenergy.html

This project includes interaction with the Center for Energy Initiatives at the American Institute of Chemical Engineers. Two universities will be supported to work with the energy task force to develop some of the new energy modules.

The interactive "*Biodiesel Calculator*" has input boxes to enter and/or adjust the volumes of soybean oil and methanol, as well as the density and molecular weights of all reactants and products in the manufacturing of biodiesel. The output is the amount of biodiesel and glycerol reacted as well as the amount of soybean oil and methanol that have not reacted. The user can switch the process between "stoichiometric mode" where the reaction proceeds according to the published stoichiometry and "real world mode" where an excess of one reactant is needed to obtain full conversion. See the image in Figure 2 below.
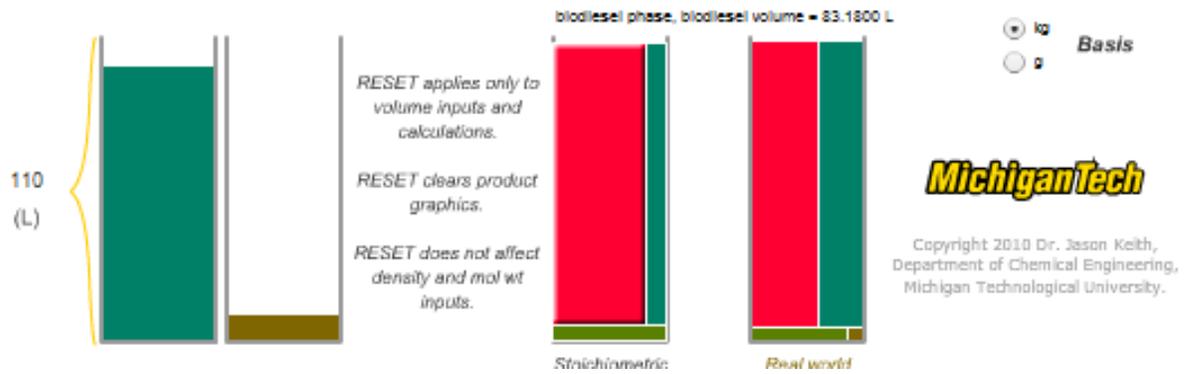
Figure 2. Biodiesel Reaction Calculator
http://www.chem.mtu.edu/~jmkeith/biodieselcalculator/BiodieselReactionCalculator.swf

For any questions, comments, or ideas for new modules, please contact fuel cell task force chair Jason Keith at jmkeith@mtu.edu.