# Energy Modules for the ChE Curriculum

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# Outline

- Project History and Motivation
- Module Content
- Module Location
- Module Detail
- Future Directions
- Conclusions / Acknowledgments

# Project History and Motivation

- Project began in 2006 with a focus on fuel cell education
- Involved collaboration between 4 institutions
- Website hosted at Michigan Technological University
- Expansion into other energy areas underway
  - Need to educate ChE's in this area
  - Provide modules to quickly bring energy concepts to ChE curriculum

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# Module Content

- Most applicable ChE course
- Reference to related sections of ChE texts
- Problem motivation
- Background
- Example problem statement
- Example problem solution
- Home problem statement
- Home problem solution

# Module Location

- Energy modules are online and available for use by everyone – see the project website:

  http://www.chem.mtu.edu/~jmkeith/energy

  or

  http://tinyurl.com/energymods

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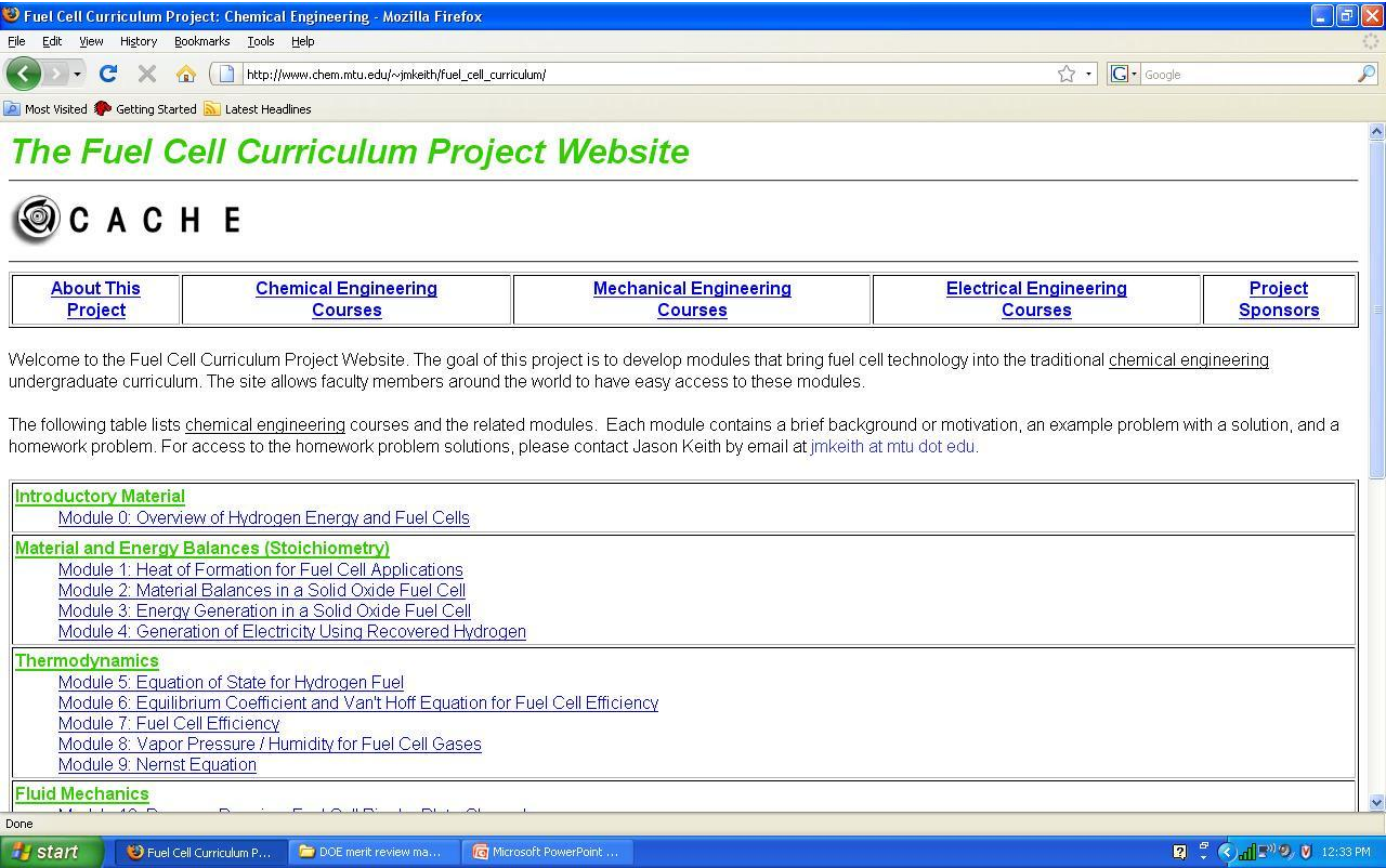
# Module Detail

- Module subject areas:
  - Hydrogen and Fuel Cells
  - General Energy Analysis
  - Wind Energy
  - Water Energy
  - Solar Energy
  - Biomass Energy
  - Coal Energy

# Module Detail

- http://www.chem.mtu.edu/~jmkeith/fuel_cell_curriculum

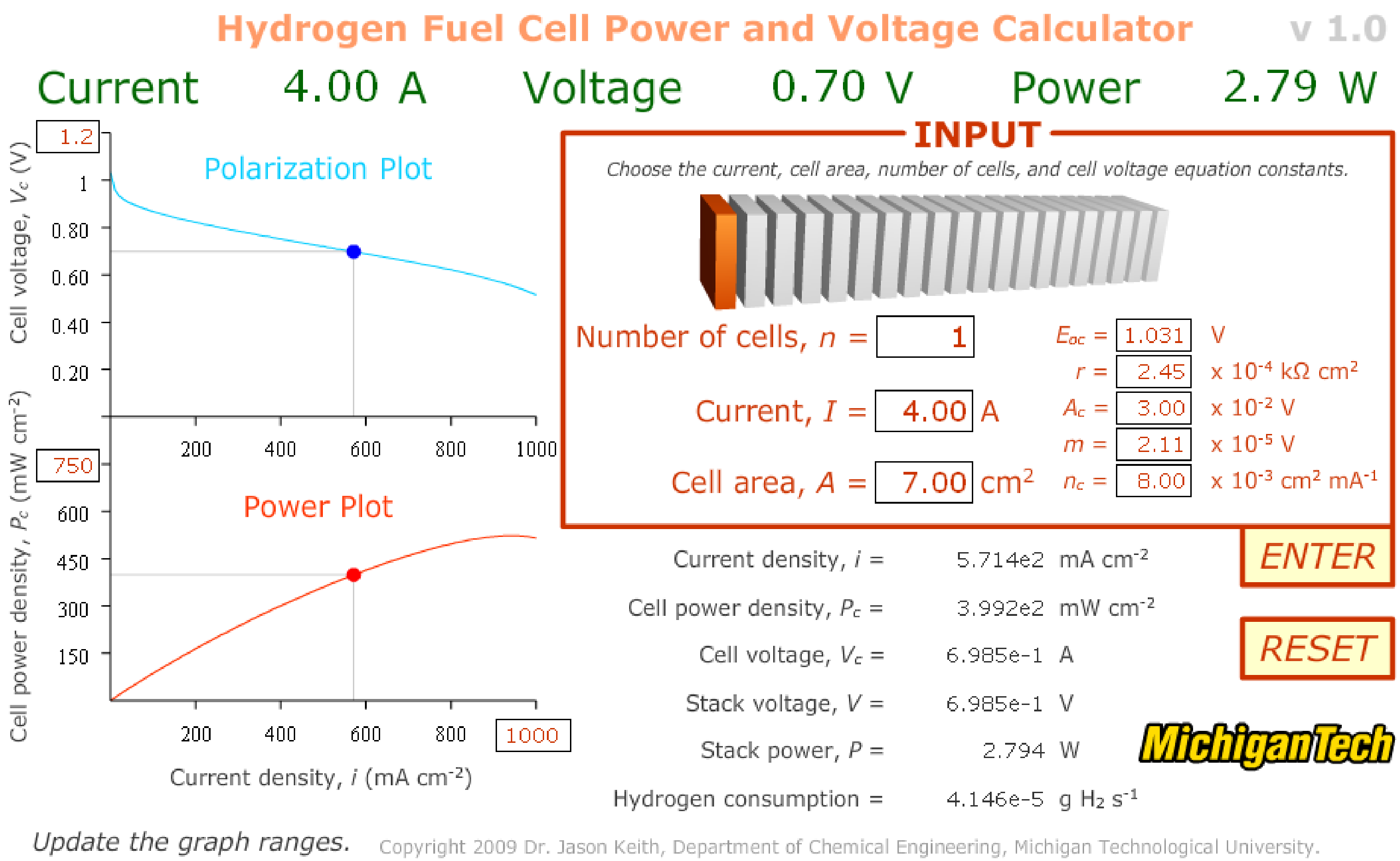


# Module Detail

- Hydrogen and Fuel Cells
  - Chemical Engineering is “complete” with 38 modules but new content is still being added under DOE project
    - Also includes fuel processing by steam reforming
  - Mechanical Engineering has 17 modules with additional modules under development
  - Electrical Engineering has 6 modules with additional modules under development

# Fuel Cell Calculator

*http://tinyurl.com/FCabacus*




Input boxes: number of cells, stack current, and fuel cell cross-sectional area
Adjust parameters to move a point along a polarization plot and power density plot
Calculated parameters include voltage, power, and hydrogen consumption rate

# Module Detail

- General Energy Analysis (J. Keith, D. Crowl)
  - Stoichiometric Analysis of Fuel Combustion
  - Energy Value of Fuels
  - Hydrogen Production Cost
  - Fuel Energy Cost and Energy Density
  - Hydrogen Flammability
  - Theoretical Fuel Consumption and Power

# Module Detail

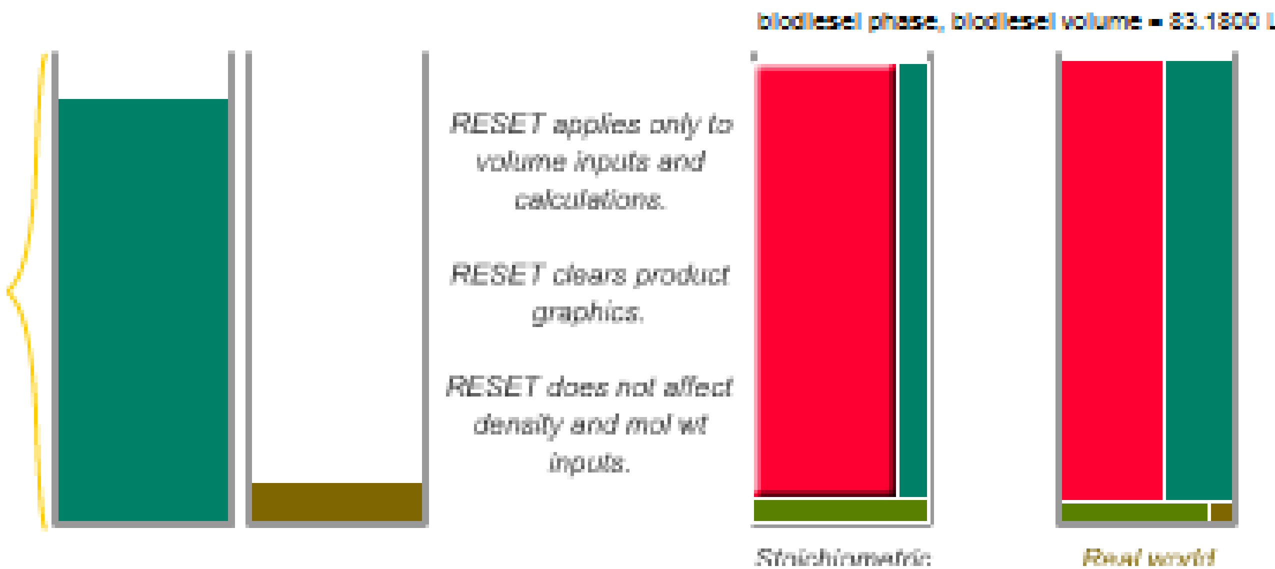
- General Energy Analysis (J. Keith, D. Crowl)
  - Energy Consumption Analysis
  - Energy Efficiency Analysis
  - Energy Emissions Analysis
  - Battery Energy Analysis
  - Battery / Fuel Cell Vehicle Range

# Module Detail

- Testing of modules by J. Keith in CM3977 Fundamentals of Hydrogen as an Energy Carrier
- Energy Knowledge Survey
  - IRB approval
  - Pre-test / Post-test
  - Also used by T. Edgar at UT

# Biodiesel Reaction Calculator v 1.0

| | RAW MATERIALS | | | PRODUCTS | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Soybean Oil** *Triolein* | **Methanol** | *NaOH* → | **Biodiesel** *Methyl Oleate* | **Glycerol** | **Soybean Oil** *Triolein* | **Methanol** | **Ratio** *Main Product/Byproducts* |
| **Volume** (L) | 100 *Hit ENTER* | 10 *Hit ENTER* | REACT | 83.1800 | 6.01513 | 19.0378 | 0 | 3.32 |
| | | | RESET | 62.3850 | 4.51135 | 39.2784 | 2.50000 | 1.35 |
| **Density** (g/cm³) | 0.90 | 0.79 | | 0.88 | 1.26 | 0.90 | 0.79 | *Stoichiometric values are shown.* |
| **Mol Wt** (g/mol) | 885.46 | 32 | | 296.50 | 92.10 | 885.46 | 32 | ☑ *Display real world values.* |
| **Mass** (kg) | 90 | 7.90000 | | 73.1984 | 7.57906 | 17.1340 | 0 | 2.96 |
| | | | | 54.8988 | 5.68430 | 35.3505 | 1.97500 | 1.28 |
| **Moles** (kg mol) | 0.10164 | 0.24688 | | 0.24688 | 0.08229 | 0.01935 | 0 | 2.43 |
| | | | | 0.18516 | 0.06172 | 0.03992 | 0.06172 | 1.13 |




◉ kg ○ g **Basis**

MichiganTech



Available online at *http://tinyurl.com/BiodieselCalc*

# Path Forward

- Development of additional energy modules for CM3977
  – Modeling of coal gasification
  – Modeling of biomass gasification
  – Producing electricity / hydrogen from wind

- Collaboration with other CACHE Trustees
  – Energy Integration (JMK w/ Mahmoud El-Halwagi)
    - Plant design courses
  – Carbon Capture (JMK w/ Chau-Chyun Chen, Aspen)
    - Several modules planned spanning ChE curriculum

# Path Forward

- Interaction underway with AIChE on energy modules in traditional and renewable sources, through collaboration with Darlene Schuster of Institute for Sustainability
  - Relationship between conventional and biofuels and thermodynamic efficiency in internal combustion engines , including life cycle assessment
    - Jeff Seay and David Silverstein, University of Kentucky
  - High temperature water splitting for hydrogen production using a sulfur-iodine thermochemical cycle
    - John O'Connell, University of Virginia

# Conclusions / Acknowledgments

- Energy Modules are for your use!
- Contact one of the authors to participate
- Acknowledgments of Partial Support:
  - CACHE Corporation
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http://tinyurl.com/mtuh2ed

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