The University of Western Ontario
Faculty of Engineering
DEPARTMENT OF CHEMICAL AND BIOCHEMICAL ENGINEERING

CBE 4432B – Energy and Fuels Production Systems
Course Outline 2025-26

Description

This course introduces students to various technologies for the production of clean and renewable fuels with emphasis on mitigation of harmful emissions and carbon footprint. Pathways for the production of low-carbon hydrogen and its utilization for clean fuels production are discussed. Technologies for biofuels production are presented together with their integration into the existing fossil fuels production facilities.

CEAB Attribute Assessment

Graduate Attribute	Indicator	Assessment tool	Assessment Level
Knowledge Base	KB4: Demonstrate competence in various hydrogen production methods with special emphasis on renewable hydrogen production.	Effectively compare different production routes based on selected set of criteria with emphasis on environmental impact analysis and safety.	A: Applied
Problem Analysis	PA2&3: Demonstrate capability to analyze challenging problems of clean fuels production while meeting growing demand and stricter emissions targets.	Critically analyze a problem and present well argued and verifiable engineering solutions	D: Developed

General Learning Objectives/Outcomes

- Become familiar with and gain knowledge in the following areas and their associated methods:
  - Different sources of energy and their relative merits and limitations
  - Fossil Fuels, their past, present and future
  - Biofuels production processes and their usage as drop-in fuels
  - Utilization of hydrogen for upgrading technologies in petroleum processing
  - Hydrogen extraction from natural gas with CO_2 sequestration
  - Renewable hydrogen production and utilization
- Develop analytical skills to compare different production methods and their sub-systems and propose alternatively configured systems for improved performance.
- Develop understanding of safety and environmental issues in different processes.
- Search the literature for information on the selected topic to present in a formal report, showing both depth of knowledge and analytical skills.

Specific Learning Objectives/Outcomes

Main Sources of Energy

At the end of this section, students should become familiar with:

- Major sources of energy and their relative merits and limitations
- Current contributions of various energy sources and their future trends in different sectors will be elaborated

Unit I. Fossil Fuels: past, present and future

A. Introduction to the Petroleum Industry

At the end of this section, students should be familiar with:

- History and origin and occurrence of crude oil
- Composition and classification of crude oil
- Crude distillation and Specifications of main products

➢ **Catalytic Conversion Processes in Refinery**

At the end of this section, students should become familiar with:

- Unit configurations, chemistry and catalysis of the following processes
  - Catalytic reforming and isomerisation.
  - Hydrotreating and Hydrodesulfurization
  - Catalytic Cracking and Hydrocracking

➢ **Heavy Oil Upgrading Processes**

At the end of this section, students should be able to develop understanding of:

- Process descriptions and review of carbon rejection processes - delayed coking, flexicoking, fluid coking. Process variables, products and yields.

B. Introduction to Natural Gas Industry

At the end of this section, students should be familiar with:

- Composition of raw gas, by-products and pipeline gas.
- Raw gas sweetening and dying processes.
- Recovery of liquids from natural gas

➢ **Hydrogen from Natural Gas Reforming**

At the end of this section, students should be familiar with:

- Composition of raw gas, by-products and pipeline gas.
- Grey hydrogen from natural gas
- Emerging blue hydrogen technologies-with CO_2 sequestration
  - Main emphasis on chemical sequestration

Note: this learning objectives aligns with and are selected for the assessment of following Graduate Attribute:

- **Knowledge Base (KB4 Level: Specialized Engineering Knowledge). Demonstrate competence in engineering knowledge in the area of petroleum and natural gas processing covering both physical and chemical conversion processes.**

- **Problem Analysis (PA2 Level: Demonstrate ability to formulate a strategy to solve an engineering problem): Shows capability to analyze the complex physical and chemical conversion systems and develop a plan to solve their engineering problems.**

Unit II. Renewable Fuels

- ***Liquid Biofuels Production Processes***

At the end of this section, students should be familiar with:

- Biomass feedstock, sources and composition
- Conversion of biomass to transportation fuels
- Different processes for production of bioethanol, biodiesel and green diesel.

- ***Green Hydrogen from Biomass***

At the end of this section, students should be familiar with different process routes to produce hydrogen from biomass:

- Biomass gasification reactions, catalysts, process conditions and products.
- Various gasification processes and their comparison based on hydrogen yields.
- Hydrogen from bio-oil reforming

Unit III. Renewable Hydrogen Production

At the end of this section, students should become familiar with current trends and future directions in this renewable energy-based industry:

- Working principle of different types of electrolyzers, their design aspects and applications
  - Polymer Electrolyte Membrane Electrolyzers (PEM)
  - Alkaline Electrolyzer
  - Solid Oxide Electrolyzers

Hydrogen production via electrolysis offer opportunities for synergy with dynamic and intermittent power generation, which is characteristic of renewable energy technologies such as solar and wind energy. In times of excess electricity production from these sources it is possible to use this excess electricity to produce hydrogen through electrolysis.

- ***Photocatalytic Hydrogen Production***

- This emerging technology is based on photocatalytic water splitting system for hydrogen generation. The photocatalyst should exhibit appropriate band gap to harvest light, suitable band-edge positions that overlap the water splitting potential.

The current state of the art will be presented and challenges for larger scale application of the technologies will be discussed.

- ***Carbon-free Hydrogen from Nuclear Energy***

  - Although not a renewable source of hydrogen, excess power from nuclear power plants can contribute to carbon-free hydrogen produced via electrolysis and help reduce carbon footprint of conventional fuels.

- ***Safety, Loss Prevention and Environmental Analysis***

At the end of this section, students should be able to:

- Become familiar with fire an explosion hazards in the industry.
- Develop understanding of storage safety, loss prevention, handling of products.

Note: the above learning objectives align with and are selected for the assessment of two Graduate Attributes:

- **Knowledge Base (KB4 level: Specialized Engineering Knowledge). Demonstrate acquired competence in characteristics of alternative processes and their relative contributions to produce renewable and clean fuels.**
- **Problem Analysis (PA3 level: Demonstrate ability to reach substantiated conclusions). Show acquired ability to critically analyze a problem and present well argued and validated conclusions.**

Prerequisites

CBE 2206A/B and 2207A/B or the former CBE 2216 or Chemistry 2213A/B and 2223B or GPE 2213A/B and 2214A/B, CBE 2224A/B or GPE 2218A/B, CBE 3315A/B or GPE 3315A/B.

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Corequisites

None

Antirequisites

None

Delivery Mode

In person as per posted time table

Instructor

Prof. A. Prakash (TEB 441) Telephone: 519-661-2111 ext: 88528 email: aprakas2@uwo.ca

Undergraduate Assistant

(TEB 477) Telephone: 519-661-2111 ext: 82131 email: cbeundergraduate@uwo.ca

Required Text

None

Reference Texts

M.A. Fahim, T.A. Al-Sahhaf, and A.S. Elkilani," Fundamentals of Petroleum Refining", Elsevier, 2010. (https://shop.elsevier.com/books/fundamentals-of-petroleum-refining/fahim/978-0-444-52785-1)

J.H. Gary and G. E. Handwerk and M.J. Kaiser, "Petroleum Refining Technology and Economics", 5th Ed. CRC Press, 2007.

X. Wang and M. Economides, "Advanced Natural Gas Engineering", Gulf Pub. Co., Houston, Tex., 2009.

S. Mokhatab, W. A. Poe, and J.Y. Mak,"Handbook of Natural Gas Transmission and Processing: Principles and Practices", 3rd Ed., Gulf Professional Publishing, Amsterdam, 2015.

J.G. Speight, "The Biofuels Handbook", RSC Publishing, Cambridge, 2011.

S. Lee and Y.T. Shah, "Biofuels and Bioenergy: Processes and Technologies", CRC Press, 2013.
A. Labouret and M. Villoz, "Solar Photovoltaic Energy", 4th Ed., Dunod, Paris, 2009.
B. Everett, G. Boyle, S. Peake, and J. Ramage, "Energy Systems and Sustainability", 2nd Ed., Oxford University Press, 2012.
Assabumrungrat, S., Wongsakulphasatch, S., Assabumrungrat, S., Wongsakulphasatch, S., Kim-Lohsoontorn, P., & Rodrigues, A. E. " *Hydrogen Production Technologies*." Basel, Switzerland: MDPI - Multidisciplinary Digital Publishing Institute, 2021.
Puga, A. "Photocatalytic hydrogen production for sustainable energy." Hoboken, NJ: John Wiley & Sons, Inc., 2023.
Naterer, G. F., Dincer, Ibrahim., & Zamfirescu, Calin. "Hydrogen Production from Nuclear Energy" [electronic resource] (1st ed. 2013.). London: Springer London. https://doi.org/10.1007/978-1-4471-4938-5, 2013.

Course Notes

Summery notes and power point slides will be posted on course website.

Units

SI units will be used in reports with British Engineering units between brackets.

Evaluation

The final course mark will be determined as follows:

Assignments and Quizzes	20%
Literature Review Report	30%
Midterm Examination	20%
Final Examination	30%

Notes

1) **The final Examination will allow use of 2-page crib sheet (single side)/one page (double side). Non-programmable calculators allowed.**
2) **Non-programmable calculators are allowed during exams.**
3) The deadline for submitting the Literature Review Report will be announced**.**

Reports will be submitted electronically on the course OWL site. The penalty for late submission of an assignment or report is 2 percentage points per day.

"In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, all remaining course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any remaining assessments will also be conducted online at the discretion of the course instructor"

Conduct

Students are expected to conduct themselves during them in a professional and respectful manner that is not disruptive to others.

Cell phone use

Use of cellphones is not allowed during lectures, laboratory, or examinations.

Use of English

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Policy Framework: Missed Classes, Late Work, and Academic Integrity

Absence/Late Accommodation Policy

1. Students must familiarize themselves with the University Policy on Academic Consideration –

   Undergraduate Students in First Entry Programs posted on the Academic Calendar: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/academic_consideration_Sep24.pdf

   This policy does not apply to requests for Academic Consideration submitted for attempted or completed work, whether online or in person. The policy also does not apply to students experiencing longer-term impacts on their academic responsibilities. These students should consult Accessible Education.

2. Students missing a test/assignment/lab or examination will report the absence by submitting Academic Consideration Request form through STUDENT ABSENCE PORTAL.

3. **All requests for Academic Considerations must be made within 48 hours after the assessment date or submission deadline. All Academic Consideration requests must include supporting documentation. However, recognizing that formal documentation may not be available in some extenuating circumstances, the policy allows students to make one Academic Consideration request without supporting documentation in this course. However, the following assessments are excluded from this, and therefore always require formal supporting documentation:**

   - **Examinations scheduled during official examination periods.**
   - **Midterm Tests and other designated assessments as noted on the course outline.**
   - **Any assessment already covered by a flexible deadline.**
   - **If a student mistakenly submits their one allowed Academic Consideration request without supporting documentation for the assessments listed above that do not require academic consideration, the request cannot be recalled and reapplied. This privilege is forfeited.**

4. **Requests without supporting documentation are limited to one per term per course.**

5. **An undocumented absence is only valid for a 24-hour period, from midnight on the day specified to midnight of the following day.** An appropriate use of an undocumented absence would be for an in-class assessment that takes place that day. Where the time given to complete the assessment is longer than 24 hours, an undocumented absence will not cover a student for the full time given to complete the assessment, and flexibility considerations in submitting the assessment will override the undocumented absence.

7. NOTE: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence.

8. It is the student's responsibility to check the date, time and location of the Special Examination.

II. Religious Accommodation

When scheduling unavoidably conflicts with religious holidays, which (a) require an absence from the University or (b) prohibit or require certain activities (i.e., activities that would make it impossible for the student to satisfy the academic requirements scheduled on the day(s) involved), no student will be penalized for absence because of religious reasons, and alternative means will be sought for satisfying the academic requirements involved. If a suitable arrangement cannot be worked out between the student and instructor involved, they should consult the appropriate Department Chair and, if necessary, the student's Dean.

It is the responsibility of such students to inform themselves concerning the work done in classes from which they are absent and to take appropriate action.

III. Academic Integrity

In the Faculty of Engineering, we encourage students to create a culture of honesty, trust, fairness, respect, responsibility, and courage, befitting the professional degree you are pursuing.
Please visit Academic Integrity Western Engineering for more information

IV. Academic Offences

Plagiarism means using another's work without giving credit. The university has rules against plagiarism and other scholastic offences. Western Engineering has a zero-tolerance policy on plagiarism. The minimum penalty is zero on the course work and a repeat offence will earn you zero on the course. A third offence may lead to expulsion from the university.

Scholastic Discipline for Undergraduate Students & Cheating, Plagiarism and Unauthorized Collaboration: What Students Need to Know

Students must write their reports, essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is

attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (http://www.turnitin.com). Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

V. Faculty of Engineering AI Policy

The use of generative Artificial intelligence (GenAI) tools won't be discouraged in the Faculty of Engineering. As we pride ourselves on building the future we can't hide from the use of GenAI tools to contribute to the understanding of the course materials. You are able to use GenAI tools as follows:

- For any written assignment, except take-home exams and personal reflections, you may use a GenAI tool to help you brainstorm or frame your initial ideas and grammar. However, your final submission must be entirely in your own words and demonstrate your individual experience and insight.
- For any written or practical project AI tools may be used across your workflow. Use them responsibly and reflect in your final presentation on how these tools supported or challenged your creative thinking.
- All GenAI tools used at any point of the course with the intent of helping with homework, assignments or any other assessment content must be disclosed and referenced appropriately.

GenAI tools use won't be permitted in any type of examination or other assessments where the faculty have prohibited their use. If use of GenAI tools is detected by the instructor in these instances, academic offences penalties might be imposed against the student.

VI. Accessibility

Western is committed to achieving barrier free accessibility for persons with disabilities studying, visiting and working at Western. As part of this commitment, there are a variety of services, groups and committees on campus devoted to promoting accessibility and to ensuring that individuals have equitable access to services and facilities. To help provide the best experience to all members of the campus community, please visit the Accessibility Western University for information on accessibility-related resources available at Western.

Students with disabilities may arrange for academic accommodation at Western. For a more detailed explanation, please visit Academic Support & Engagement -Academic Accommodation.

VII. Inclusivity, Diversity, and Respect

The Faculty of Engineering at Western University is committed to creating equitable and inclusive learning environments that value diverse perspectives and experiences. We recognize that university courses often marginalize students based on social identity characteristics such as, but not limited to, Indigeneity, race, ethnicity, nationality, ability, gender identity, gender expression, sexuality, age, language, religion, and socioeconomic status. Understanding this, we strive to facilitate equitable experiences and inclusion within the classroom by respecting and integrating multiple ways of knowing, being, and doing. Please visit the Office of Equity, Diversity and Inclusion.

VIII. Health and Well-Being

- Health & Wellness Services – Students - Offers appointment-based medical clinic for all registered part-time and full-time students.
- Mental Health Support - Provides professional and confidential services, free of charge, to students needing assistance to meet their personal, social and academic goals. Services include consultation, referral, groups and workshops, as well as brief, change-oriented psychotherapy.
- Crisis Support - For immediate assistant, please visit Thames Hall Room 2170 or call 519-661-3030. The crisis clinic operates between 11:00 am - 4:30 pm. For after-hours crisis support, click here.
- Gender-Based Violence and Survivor Support - "Western is committed to reducing incidents of gender-based and sexual violence (GBSV) and providing compassionate support to anyone who is going through or has gone through these traumatic events. If you are experiencing or have experienced GBSV (either recently or in the past), you will find information about support services for survivors, including emergency contacts at the following website: https://www.uwo.ca/health/student_support/survivor_support/gethelp.html To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Important Contacts

Engineering Undergraduate Services	SEB 2097	519-661-2130	engugrad@uwo.ca
Office of the Registrar/Student Central	WSSB 1120	519-661-2100	

Important Links

- WESTERN ACADEMIC CALENDAR

- ACADEMIC RIGHTS AND RESPONSIBILITIES
- ENGINEERING PROGRESSION REQUIREMENTS AND ACADEMIC REGULATIONS
- UNIVERSITY STUDENTS' COUNCIL (USC) - SERVICES
- IMPORTANT DATES AND DEADLINES
- ACADEMIC CONSIDERATION FOR MEDICAL ILLNESS - UNDERGRADUATE STUDENTS
- ACCOMMODATIONS FOR RELIGIOUS HOLIDAYS
- SCHEDULING OF ASSIGNMENTS, TESTS, AND EXAMINATIONS
- STUDENT FORMS
- OFFICE OF THE REGISTRAR
- RETENTION OF ELECTRONIC VERSION OF COURSE OUTLINES (SYLLABI)
- ACADEMIC APPEALS
- STUDENT ABSENCE PORTAL

Attendance

Attendance at all lectures, tutorials and laboratories is mandatory. Any student who, in the opinion of the instructor, is absent too frequently from class, or workshop/tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from making final oral presentation and submission of final design report.

Conduct

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others.

Notices

Students are responsible for regularly checking their Western email and notices posted in front of chief instructor's offices.

Consultation

Students are encouraged to discuss problems with their teaching assistant and/or instructor in tutorial sessions. Office hours will be arranged for the students to see the instructor and teaching assistants. Other individual consultation can be arranged by appointment with the appropriate instructor.

Accreditation (AU) Breakdown

Engineering Science = 70%
Engineering Design = 30%