



PANDUAN SISWAZAH

Graduate Prospectus

Institut Sel Fuel Fuel Cell Institute

Mod Penyelidikan Research Mode
Mod Kerja Kursus Coursework Mode



PANDUAN SISWAZAH
INSTITUT SEL FUEL (SELFUEL)

GRADUATE PROSPECTUS
FUEL CELL INSTITUTE (SELFUEL)

Carta Pentadbiran Institut Sel Fuel (SELFUEL)



PANDUAN SISWAZAH
INSTITUT SEL FUEL (SELFUEL)

GRADUATE PROSPECTUS
FUEL CELL INSTITUTE (SELFUEL)

Institut Sel Fuel (SELFUEL)
Universiti Kebangsaan Malaysia
43600 UKM Bangi
Selangor Darul Ehsan, Malaysia
<http://www.ukm.my/selfuel>

Cetakan Kelima/*Fifth Printing*. 2023
Hakcipta/*Copyright* Universiti Kebangsaan Malaysia. 2023

Pihak Pengurusan Universiti sedaya upaya sudah memastikan bahawa bahan Buku Panduan ini adalah tepat pada masa ia diterbitkan. Buku ini bermaksud memberi panduan kepada pelajar untuk memilih program dan kursus pengajian serta kemudahan yang Universiti tawarkan dan bukan pula dimaksudkan sebagai satu ikatan kontrak. Pengurusan Universiti berhak meminda atau menarik tawaran program dan kursus pengajian serta kemudahan tanpa sebarang notis.

Diterbitkan di Malaysia oleh/*Published in Malaysia by* INSTITUT SEL FUEL (SELFUEL) Universiti Kebangsaan Malaysia 43600 UKM Bangi, Selangor Darul Ehsan. MALAYSIA

Dicetak di Malaysia oleh/*Printed in Malaysia by* PUSAT PENERBITAN DAN PERCETAKAN Universiti Kebangsaan Malaysia 43600 UKM Bangi, Selangor Darul Ehsan. MALAYSIA

Semua pertanyaan hendaklah diajukan kepada:
All enquires please contact:

Pengarah/*Director*
INSTITUT SEL FUEL (SELFUEL)
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor Darul Ehsan. MALAYSIA
Telefon: 03-8911 8030
Email: selfuel@ukm.edu.my/ ctie@ukm.edu.my
atau

Penyelaras Program Siswazah/*Graduate Programme Coordinator*
INSTITUT SEL FUEL (SELFUEL)
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor Darul Ehsan. MALAYSIA
Telefon: 603-8911 8522
Emal: mahen@ukm.edu.my (program penyelidikan Doktor Falsafah/*Doctoral research programme*); rozanyunus@ukm.edu.my (program penyelidikan sarjana sains/*Master of Science research programme*);
waiyin.wong@ukm.edu.my (program kerja kursus/*coursework programme*)
atau

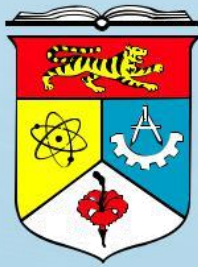
Pegawai Pentadbir/*Administrative Officer*
INSTITUT SEL FUEL (SELFUEL)
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor Darul Ehsan. MALAYSIA
Telefon: 03-8911 8535 Email: syakirsaad@ukm.edu.my



*Universiti Kebangsaan ini merupakan
puncak dari usaha kita ke arah
memenuhi tuntutan dan aspirasi rakyat
yang ingin melihat bahawa bahasa ibunda
mempunyai kedaulatan dan kedudukan
yang sewajarnya di dalam usaha
memenuhi keperibadian nasional*



(Ucapan Tun Abdul Razak di Konvokesyen Pertama UKM, 1973)



Maksud Logo UKM

Logo UKM ialah sebuah perisai yang berpetak empat. Tiap-tiap petak mengandungi gambar dan membawa maksud-maksud tertentu.

Buku

Buku melambangkan ilmu pengetahuan iaitu peranan utama UKM sebagai pusat pengajian tinggi dan penyelidikan.

Perisai

Perisai bererti keteguhan. Keteguhan yang dimaksudkan ialah kemampuan UKM memainkan peranan sebagai pusat pengajian tinggi di negara ini.

Harimau

Harimau melambangkan keberanian dan kegagahan. Harimau mencerminkan masyarakat Malaysia yang berteraskan kebudayaan Melayu. Harimau garang menggambarkan kesediaan dan keupayaan UKM mara memerangi kejahilan, kejahatan dan kepalsuan.

Atom dan Teknologi

Simbol-simbol atom dan teknologi melambangkan konsep pembangunan negara yang berlandaskan sains dan teknologi moden. UKM sebagai pusat ilmu bertanggungjawab mengeluarkan tenaga-tenaga mahir dalam semua bidang untuk memenuhi keperluan pembangunan negara.

Bunga Raya

Bunga raya adalah bunga kebangsaan Malaysia. Lima helai ranggi melambangkan lima prinsip Rukun Negara yang diamalkan dan sentiasa dipelihara oleh rakyat Malaysia.



Falsafah, Wawasan, Misi dan Matlamat Universiti

Falsafah

Paduan antara iman kepada ALLAH dengan ilmu yang bermanfaat serta gabungan antara teori dan amal adalah dasar utama bagi perkembangan ilmu, proses pembinaan masyarakat terpelajar dan pembangunan Universiti

Wawasan

UKM bertekad menjadi Universiti terkehadapan yang mendahului langkah masyarakat dan zamannya bagi membentuk masyarakat dinamis, berilmu dan berakhlak mulia.

Misi

Menjadi university terpilih yang memartabatkan Bahasa Melayu serta mensejatkan ilmu beracuan budaya kebangsaan

Matlamat

Untuk menjadi pusat keilmuan yang terkehadapan, berteknologi dan berdaya saing yang:

Memartabatkan Bahasa Melayu sebagai bahasa ilmu; Membangun masyarakat dinamis dan berakhlak mulia; Mengantarabangsakan citra dan sumbangan UKM bagi masyarakat sejagat; dan

Menjana teknologi yang bermanfaat kepada masyarakat

Kandungan/Content

Carta Pentadbiran Institut Sel Fuel (SELFUEL)	2
Petikan Ucapan Canselor Pertama	5
Maksud Logo UKM	6
Falsafah, Wawasan, Misi dan Matlamat Universiti	7
Latar Belakang – Universiti Kebangsaan Malaysia	10
<i>Background – Universiti Kebangsaan Malaysia</i>	13
Pentadbiran Institut/Administration	16
Latar Belakang – Institut Sel Fuel (SELFUEL)	25
Pengenalan	25
Visi Institut	25
Misi Institut	25
Matlamat Pembelajaran Institut	26
Objektif Institut	26
<i>Background – Fuel Cell Institute (SELFUEL)</i>	27
<i>Introduction</i>	27
<i>Vision of Institute</i>	27
<i>Mission of Institute</i>	27
<i>Educational Objective of Institute</i>	28
<i>Objectives of Institute</i>	28
Program Pengajian Siswazah – Institut Sel Fuel (SELFUEL)	29
<i>Graduate Studies Programmes – Fuel Cell Institute (SELFUEL)</i>	29
Program Pengajian Siswazah (Penyelidikan)	30
Program Sarjana Sains	30
Program Doktor Falsafah	31
Syarat Kemasukan ke Program Sarjana Sains	32
Syarat Kemasukan ke Program Doktor Falsafah	33
Syarat Keperluan Bahasa Inggeris	33
Permohonan Kemasukan	34
Keperluan Kursus	34
Penerbitan Manuskrip Sebagai Syarat Bergraduasi	34
Kursus-kursus yang ditawarkan untuk Program Sarjana Sains	35
Kursus-kursus yang Ditawarkan untuk Program Doktor Falsafah	38
Bidang-Bidang Penyelidikan	41
Penukaran Program Sarjana kepada Program Doktor Falsafah	41
Penulisan Tesis/Disertasi Kompilasi	43
<i>Graduate Studies Programmes (Research)</i>	45
<i>Master of Science</i>	46

<i>Doctor of Philosophy</i>	46
<i>Admission Requirements to the Master of Science Programme</i>	47
<i>Admission Requirements to the Doctoral Programme</i>	48
<i>English Language Requirements</i>	48
<i>Application for Admission</i>	49
<i>Course Requirements</i>	49
<i>Manuscript Publication as a Requirement for Graduation</i>	49
<i>Courses Offered for the Master of Science Programme</i>	49
<i>Courses Offered for the Doctoral Programme</i>	53
<i>Research Areas</i>	56
<i>Conversion from Master Programme to Doctoral Programme</i>	56
<i>Writing Thesis/Dissertation by Compilation</i>	57
Program Pengajian Siswazah (Kerja Kursus)	60
Program Sarjana Sains Teknologi Karbon Rendah dan Hidrogen	60
Syarat Kemasukan	61
Keperluan Bahasa Inggeris	61
Permohonan Kemasukan	61
Struktur Kurikulum	63
Syarat Pengijazahan	64
Kursus-Kursus yang ditawarkan	64
<i>Graduate Studies Programmes (Coursework)</i>	73
<i>Master of Science in Low Carbon and Hydrogen Technology</i>	73
<i>Admission Requirements</i>	74
<i>English Language Requirements</i>	74
<i>Application for Admission</i>	75
<i>Curriculum Structure</i>	75
<i>Graduation Requirement</i>	76
<i>Courses Offered</i>	76
Maklumat Tambahan/ <i>Additional Information</i>	85

Latar Belakang Universiti Kebangsaan Malaysia

Cetusan pertama gagasan perlunya pendidikan tinggi untuk orang Melayu berlaku dalam Mesyuarat Majlis Raja-raja pada 1903. Za'ba, seorang cendekiawan, menulis berkenaan gagasan tersebut dalam akhbar Lembaga Melayu pada 1917. Gerakan pemikiran, perdebatan serta tekad golongan cendekiawan Melayu untuk menubuhkan sebuah universiti dan menggunakan bahasa Melayu, bahasa ibunda sebagai bahasa pengantar di institusi pengajian tinggi bermula pada 1923 apabila Abdul Kadir Adabi, seorang lagi cendekiawan Melayu mengemukakan memorandum gagasan tersebut kepada DYMM Sultan Kelantan. Namun demikian, pemikiran dan tekad tersebut tidak dapat berkembang dan terlaksana kerana wujudnya berbagai-bagai halangan dan rintangan oleh tekanan kolonialisme.

Mulai 1957 hingga 1967, perjuangan untuk penubuhan universiti kebangsaan menjadi semakin bersemarak sebagai memenuhi tuntutan dan semangat kemerdekaan bangsa dan negara. Sehubungan itu, pada 1968 cendekiawan Melayu telah membentuk sebuah jawatankuasa penaja yang berperanan merancang penubuhan sebuah universiti kebangsaan. Pelbagai forum budaya dan politik diadakan bagi mendapat sokongan kerajaan dan rakyat untuk mewujudkan sebuah institusi pengajian tinggi yang memartabatkan bahasa Melayu sebagai bahasa pengantar dalam semua bidang pangajian dan keilmuan. Perjuangan yang tidak pernah luput itu mencapai kejayaan dengan penubuhan Universiti Kebangsaan Malaysia (UKM) pada 18 Mei 1970 yang memulakan operasi pertamanya di Lembah Pantai Kuala Lumpur. Kumpulan pertama pelajar prasiswazah seramai 190 orang dan seorang pascasiswazah mula mendaftar di tiga buah fakulti iaitu Fakulti Sains, Fakulti Sastera dan Fakulti Pengajian Islam.

Pada 1974, UKM menubuhkan UKM Kampus Sabah di Kebun Kawang, Papar. Nama Kebun Kawang kemudiannya ditukar kepada Limauan oleh Tun Datu Mustapha Datu Harun yang ketika itu sebagai Ketua Menteri Sabah. Kampus yang menempatkan Fakulti Sains dan Sumber Alam ini berpindah ke Bukit Padang, Kota Kinabalu pada 1980. Seterusnya berpindah ke Menggatal, Tuaran pada 1990 bersama Fakulti Sains Pembangunan yang asalnya ditempatkan di Kampus Induk Bangi. Dengan penubuhan Universiti Malaysia Sabah pada 1994, UKM Kampus Sabah ditutup secara rasminya pada 1996 dan kedua-dua fakulti berkenaan dipindahkan ke Kampus Induk Bangi, Selangor.

Universiti ini terus berkembang pesat sebagai sebuah institusi pengajian tinggi awam terkehadapan yang kini mempunyai tiga belas (13) fakulti, sebuah Graduate School of Business (UKM-GSB) dan dua belas (12) institut kecemerlangan penyelidikan. UKM juga mempunyai entiti yang beroperasi secara komersil, iaitu UKM Holdings Sdn. Bhd. dan UKM Technology Sdn Bhd sebagai satu pendekatan

dalam mengkomersilkan dan memasyarakatkan kepakaran yang dimiliki di samping menjana kewangan Universiti.

Kampus induk UKM yang mempunyai keluasan 1,096.29 hektar terletak di Bangi, Selangor Darul Ehsan, kira-kira 35 kilometer dari Bandar raya Kuala Lumpur. Kampus induk terletak di sebuah lembah yang dikelilingi pokok-pokok yang menghidu yang dapat menyediakan suasana nyaman dan tenang untuk para pelajar menimba ilmu. Fakulti dan institut kecemerlangan yang terletak di kampus induk Bangi ialah Fakulti Ekonomi dan

Perniagaan, Fakulti Kejuruteraan dan Alam Bina, Fakulti Pengajian Islam, Fakulti Sains dan Teknologi, Fakulti Sains Sosial dan Kemanusiaan, Fakulti Undang-Undang, Fakulti Pendidikan, Fakulti Teknologi dan Sains Maklumat, Graduate School of Business (UKM-GSB), Institut Alam dan Tamadun Melayu (ATMA), Institut Alam Sekitar dan Pembangunan (LESTARI), Institut Kajian Malaysia dan Antarabangsa (IKMAS), Institut Mikro dan Nanoelektronik (IMEN), Institut Sistem Biologi (INBIOSIS), Institut Penyelidikan Tenaga Suria (SERI), Institut Sel Fuel (SELFUEL), Institut Islam Hadhari (HADHARI), Institut Kajian Etnik (KITA), Institut Infomatik Visual (IVI), Institut Perubahan Iklim (IPI), Pusat Siswazah (PS), Pusat Pengajian Umum (PPU), Pusat

Perkembangan Pelajar dan pusat perkhidmatan lain. Selain itu, UKM juga mempunyai sebuah kampus kesihatan di Jalam Raja Muda Abdul Aziz, Kuala Lumpur yang menempatkan Fakulti Perubatan (Jabatan Praktinikal), Fakulti Sains Kesihatan Bersekutu, Fakulti Pergigian dan Fakulti Farmasi. Manakala Pusat Perubatan UKM (PPUKM) yang mempunyai keluasan 22.3 hektar di Cheras, Kuala Lumpur berupaya memenuhi keperluan semasa dari segi pendidikan, penyelidikan dan perkhidmatan perubatan. PPUKM menempatkan Fakulti Perubatan (Jabatan Klinikal) dan Hospital UKM. Di sini juga ditempatkan Institut Perubatan Molekul (UMBI).

Berasaskan kecemerlangan dalam bidang penyelidikan lebih empat dekad, UKM dipilih sebagai salah sebuah universiti penyelidikan di Malaysia pada 2006. Proses pemantapan bidang penyelidikan disusuli dengan pengwujudan projek tertumpu di bawah lapan (8) nic iaitu Cabaran Membina Negara-bangsa, Pembangunan Lestari Wilayah, Tenaga Keterbaharuan, Teknologi Kesihatan & Perubatan, Perubahan Iklim, Nanoteknologi & Bahan Termaju, Kepelbagaian Biologi dalam Pembangunan Bioteknologi dan ICT: Informatik Isian.

Universiti juga adalah penerima Anugerah Kualiti Perdana Menteri 2006, memperoleh status Swa-Akreditasi pada 2010 dan diberikan status Universiti Autonomi pada Januari 2012. Penganugerahan ini adalah pengiktirafan bagi kecemerlangan UKM dalam bidang akademik dan tadbir urus. UKM melestarikan kecemerlangannya melalui Pelan Strategik UKM 2000-2020 (PS2020) dan Pelan Transformasi ke arah universiti terkemuka dunia menjelang 2018. Kini, UKM

tampil dengan citra baru melalui garis tanda “Mengilham Harapan, Mencipta Masa Depan’. Garis tanda ini memberi keyakinan kepada warganya untuk mengembangkan bakat yang dimiliki, tempat memupuk kebolehan, labuhan untuk berkarya dan berjaya dalam karya tersebut, kerana di sini mereka disediakan dengan prasarana untuk memiliki masa depan yang gemilang.

Background

Universiti Kebangsaan Malaysia

The idea for an institution of higher learning for the Malays was first mooted at the 1903 Rulers' Conference, or Durbar. The Malay intellectual Za'ba, wrote about such a need in the newsletter Lembaga Melayu in 1917. A movement, and subsequent debates, among Malay intellectuals, for the setting up a university using the Malay language as the medium of instruction in the institution of higher learning was formed in 1923 when another Malay thinker Abdul Kadir Adabi, submitted a memorandum on the matter to the HRH the Sultan of Kelantan. However the effort came to nothing due to many obstacles and resistance from the colonial authorities.

Nevertheless, from 1957 until 1967, a resurgence of nationalism revived the idea, and in 1968 Malay scholars formed a steering committee to bring the vision of a national university to reality. A slew of meetings on cultural and political exchanges eventually secured an agreement from the government of the day. The efforts to realise a Malay language-based institution in all subjects bore fruit and resulted in The National University of Malaysia (UKM), in May 18 1970, which opened its doors in Lembah Pantai Kuala Lumpur. The first batch of 190 undergraduates and 1 post-graduates registered at 3 faculties: Science, Arts, and Islamic Studies.

In 1974, UKM set up a campus in Kebun Kawang, Papar. Later, the place was renamed Limauan by the then Sabah Chief Minister Tun Datu Mustapha Datu Harun. The campus housed the Science and Natural Resources faculty, which was moved to Bukit Padang, Kota Kinabalu in 1980. It later relocated to Menggatal, Tuaran in 1990 along with the faculty of Developmental Science which originally was based in the main campus of Bangi. With the formation of University Malaysia Sabah in 1994, UKM's Sabah campus was officially closed in 1996 and the faculties permanently located back to the main campus in Bangi, Selangor.

UKM has since seen tremendous growth in being able to provide an increasing number of places of learning for the people as well undertaking research in various disciplines and fields of study. It now has 13 faculties, a Graduate School of Business (GSB-UKM), as well as 12 research institutes of excellence in education. UKM has also set up UKM Holdings Sdn. Bhd, operating as a commercial entity to benefit from all the expertise it has while also generating income for the University.

The university's main campus in Bangi, Selangor Darul Ehsan spans an area of 1,096.29 hectares approximately 35 kilometres from Kuala Lumpur. The campus is situated in a valley surrounded by hills and greenery, providing a serene and

conducive environment for learning and knowledge exploration. The faculties and institutes housed in the main campus are the Faculty of Economics and Management, Faculty of Engineering and Built Environment, Faculty of Islamic Studies, Faculty of Science and Technology, Faculty of Social Sciences and Humanities, Faculty of Law, Faculty of Education, Faculty of Information Science and Technology, Graduate School of Business (GSB-UKM), Institute of Malay World and Civilisation (ATMA), Institute of Environment and Development

(LESTARI), Institute of Malaysian and International Studies (IKMAS), Institute of Microengineering and Nanoelectronics (IMEN), Institute of System Biology (INBIOSIS), Institute of Solar Energy Research (SERI), Fuel Cell Institute (SELFUEL), Institute of Islam Hadhari (HADHARI), Institute of Ethnic Studies (KITA), UKM Medical Molecular Biology (UMBI), Institute of Climate Change Studies (IPI), Institute of Visual Informatics (IVI), Graduate Centre (PS), Centre of General Studies (PPU), Students Development Centre and other centres of service.

Nevertheless, from 1957 until 1967, a resurgence of nationalism revived the idea, and in 1968 Malay scholars formed a steering committee to bring the vision of a national university to reality. A slew of meetings on cultural and political exchanges eventually secured an agreement from the government of the day. The efforts to realise a Malay language-based institution in all subjects bore fruit and resulted in The National University of Malaysia (UKM), in May 18 1970, which opened its doors in Lembah Pantai Kuala Lumpur. The first batch of 190 undergraduates and 1 post-graduates registered at 3 faculties: Science, Arts, and Islamic Studies.

In 1974, UKM set up a campus in Kebun Kawang, Papar. Later, the place was renamed Limauan by the then Sabah Chief Minister Tun Datu Mustapha Datu Harun. The campus housed the Science and Natural Resources faculty, which was moved to Bukit Padang, Kota Kinabalu in 1980. It later relocated to Menggatal, Tuaran in 1990 along with the faculty of Developmental Science which originally was based in the main campus of Bangi. With the formation of University Malaysia Sabah in 1994, UKM's Sabah campus was officially closed in 1996 and the faculties permanently located back to the main campus in Bangi, Selangor.

UKM has since seen tremendous growth in being able to provide an increasing number of places of learning for the people as well undertaking research in various disciplines and fields of study. It now has 13 faculties, a Graduate School of Business (GSB-UKM), as well as 12 research institutes of excellence in education. UKM has also set up UKM Holdings Sdn. Bhd, operating as a commercial entity to benefit from all the expertise it has while also generating income for the University.

The university's main campus in Bangi, Selangor Darul Ehsan spans an area of 1,096.29 hectares approximately 35 kilometres from Kuala Lumpur. The campus is situated in a valley surrounded by hills and greenery, providing a serene and conducive environment for learning and knowledge exploration. The faculties and institutes housed in the main campus are the Faculty of Economics and Management, Faculty of Engineering and Built Environment, Faculty of Islamic Studies, Faculty of Science and Technology, Faculty of Social Sciences and Humanities, Faculty of Law, Faculty of Education, Faculty of Information Science and Technology, Graduate School of Business (GSB-UKM), Institute of Malay World and Civilisation (ATMA), Institute of Environment and Development (LESTARI), Institute of Malaysian and International Studies (IKMAS), Institute of Microengineering and Nanoelectronics (IMEN), Institute of System Biology (INBIOSIS), Institute of Solar Energy Research (SERI), Fuel Cell Institute (SELFUEL), Institute of Islam Hadhari (HADHARI), Institute of Ethnic Studies (KITA), UKM Medical Molecular Biology (UMBI), Institute of Climate Change Studies (IPI), Institute of Visual Informatics (IVI), Graduate Centre (PS), Centre of General Studies (PPU), Students Development Centre and other centres of service.

UKM was appointed as one of the four research universities of Malaysia in 2006 based on its excellent record in research for 40 years. That recognition has gained further ground when the Malaysia Genome Institute (MGI) and the International Institute of Global Health, United Nations University were set up at the university. Its areas of research were further consolidated and enhanced with the identification of eight niche areas; Challenges to Nation Building, Sustainable Territorial Development, Renewable Energy, Health and Medical Technology, Climate Change, Nanotechnology and Advanced Materials, Biological Diversity in Biotechnology Development, and ICT: Content Informatics.

UKM is also the recipient of the Prime Minister's Quality Award 2006, a recognition of its excellent achievements in the academic and management fields. It has also been conferred the status of an Autonomous University in January 2012, while it looks ahead to a Transformation Pelan by 2018. With these strong foundations, UKM aims at not just sustaining but also enhancing its level of excellence via its 2000-2020 (PS2020) Strategic Plan in line with its slogan, 'Inspiring Futures, Nurturing Possibilities'. All these developments have brought about greater confidence among its staff to continue upgrading their capabilities while enhancing their talents in a conducive, healthy, and supportive environment as provided by the university.

Pentadbiran Institut/*Administration*

Pengarah/*Director*

Prof. Ir. Dr. Siti Kartom Kamarudin
BEng (Hons), MSc., Ph.D (UKMalaysia), PEng
Tel: 603-8911 8030
Emel: ctie@ukm.edu.my

Timbalan Pengarah/*Deputy Director*

Assoc Prof. Dr. Mohd. Shahbudin Mastar @ Masdar
BEng (Hons), MSc (UKMalaysia), Ph.D (Gunma)
Tel: 603-8911 8536
Email: shahbud@ukm.my

Ketua Jaminan Kualiti/*Head of Quality Assurance*

Ts. Dr. Lim Kean Long
BEng (Hons) MEng (UKMalaysia), Ph.D (UNSW), PTech (MT), AMIChemE,
Grad IEM, Grad Eng
Tel: 603-8911 8494
Emel: kllim@ukm.edu.my

Penyelaras Program Siswazah (Penyelidikan)/*Graduate Programme Coordinator (Research)*

Assoc. Prof. Dr. Mahendra Rao Somalu
BEng (Hons), MEng (UKMalaysia), Ph.D (Imperial College London),
AMIChemE.
Tel: 603-8911 8522
Emel: mahen@ukm.edu.my

Penyelaras Program Siswazah (Kerja Kursus)/*Graduate Programme Coordinator (Coursework)*

Dr. Wong Wai Yin
BEng (Hons), Ph.D (UKMalaysia) AMIChemE.
Tel: 603-8911 8588
Emel: waiyin.wong@ukm.edu.my

Penyelaras Penyelidikan & Inovasi/*Research & Innovation Coordinator*

Dr. Umi Azmah Hasran

BEng (Hons) (Loughborough), MSc, Ph.D (UKMalaysia), AMIChemE
Tel: 603-8911 8525
Emel: umi.h@ukm.edu.my

**Penyelaras Hal Ehwal Jaringan Industri, Alumni dan Masyarakat (HEJIM)/
*Coordinator of Industry, Alumni & Community Partnerships***

Assoc Prof. Dr. Lorna Jeffery Minggu
BSc (UMIST), MSc., Ph.D (UKMalaysia)
Tel: 603-8911 8520
Emel: lorna_jm@ukm.edu.my

Webmaster

Dr. Lim Swee Su
BEng (Hons), MEng (UKMalaysia), Ph.D (Newcastle), AMIChemE, GradIEM
Tel: 603-8911 8522
Emel: limss@ukm.edu.my

**Felo Penyelidik Utama Lantikan Bersama/*Joint Appointment Principal
Research Fellows***

Prof. Ir. Dr. Siti Kartom Kamarudin (Pengarah)
BEng, MSc, Ph.D (UKMalaysia), PEng
Tel: 603-8911 8536
Emel: ctie@ukm.edu.my

Felo Penyelidik Kanan Lantikan Bersama/*Joint Senior Research Fellow*

Assoc. Prof. Dr. Mohd. Shahbudin Mastar @ Masdar
BEng (Hons), MSc (UKMalaysia), Ph.D (Gunma)
Tel: 603-8911 8536
Email: shahbud@ukm.edu.my

Felo Penyelidik Kanan/*Senior Research Fellows*

Assoc. Prof. Ts. Dr. Loh Kee Shyuan
BSc (Hons), Ph.D (UKMalaysia), MMIC, PTech(GT)
Tel: 603-8911 8523
Emel: ksloh@ukm.edu.my

Assoc. Prof. Dr. Edy Herianto Abdul Majlan
BEng (USU-Indonesia), MSc, Ph.D (UKMalaysia), AMIChemE
Tel: 603-8911 8521
Emel: edy@ukm.edu.my

Assoc. Prof. Dr. Lorna Jeffery Minggu
BSc (UMIST), MSc, Ph.D (UKMalaysia)
Tel: 603-8911 8520
Emel: lorna_jm@ukm.edu.my

Assoc. Prof. Dr. Mahendra Rao Somalu
BEng (Hons), MEng (UKMalaysia), Ph.D (Imperial College London),
AMIChemE.
Tel: 603-8911 8522
Emel: mahen@ukm.edu.my

Felo Penyelidik/*Research Fellows*

Dr. Umi Azmah Hasran
BEng (Hons) (Loughborough), MSc, Ph.D (UKMalaysia), AMIChemE
Tel: 603-8911 8525
Emel: umi.h@ukm.edu.my

Ts. Dr. Lim Kean Long
BEng (Hons), MEng (UKMalaysia), Ph.D (UNSW), PTech (MT), AMIChemE,
GradIEM, Grad Eng
Tel: 603-8911 8494
Emel: kllim@ukm.edu.my

Dr. Khuzaimah Arifin
BEng (UNRI-Indonesia), MSc, Ph.D (UKMalaysia)
Tel: 603-8911 8528
Email: khuzaim@ukm.edu.my

Dr. Sharifah Najiha Timmiati
BSc (Hons), Ph.D (UTMalaysia)
Tel: 603-8911 8526
Email: najiha@ukm.edu.my

Dr. Mimi Hani Abu Bakar
BEng (Hons), MSc (UKMalaysia), Ph.D (Lincoln)
Tel: 603-8911 8518
Emel: mimihani@ukm.edu.my

Dr. Sahriah Basri
BEng (UiTM), MSc, Ph.D (UKMalaysia)
Tel: 603-8911 8539
Emel: sahriah@ukm.edu.my

Dr. Rozan Mohamad Yunus

BSc (Hons), MSc. (UKMalaysia), Ph.D (Kyushu)

Tel: 603-8911 8527

Emel: rozanyunus@ukm.edu.my

Dr. Wong Wai Yin

BEng (Hons), Ph.D (UKMalaysia)

Tel: 603-8911 8588

Emel: waiyin.wong@ukm.edu.my

Dr. Nabila A. Karim

BEng (UiTM), Ph.D (UKMalaysia)

Tel: 603-8911 8518

Emel: nabila.akarim@ukm.edu.my

Dr. Azran Mohd Zainoodin

BEng (UniMAP), Ph.D (UKMalaysia)

Tel: 603-8911 8524

Emel: azrans@ukm.edu.my

Dr. Lim Swee Su

BEng (Hons), MEng (UKMalaysia), Ph.D (Newcastle), AMIChemE, GradIEM

Tel: 603-8911 8522

Emel: limss@ukm.edu.my

Dr. Nurul Akidah Baharuddin

BEng (Hons), MSc, Ph.D (UKMalaysia)

Tel: 603-8911 8538

Emel: akidah@ukm.edu.my

Dr. Norazuwana Shaari

BEng, MSc (USM), Ph.D (UKMalaysia)

Tel: 603-89118534

Emel: norazuwanashaari@ukm.edu.my

Dr. Lim Bee Huah

BEng (UNITEN), PhD (UKMalaysia), CEng, MIMechE

Tel: 603-89118534

Email: beehuah@ukm.edu.my

Dr. Muhammed Ali Shaikh Abdul Kader Abdul Hameed

B. Tech (Crescent Engineering College) MSc, PhD (UKMalaysia)

Tel: 603-89118496

Email: mas@ukm.edu.my

Felo Utama Bersekutu/Associate Principal Fellows

Prof. Dr. Mohammad Kassim
BSc (Hons) (Lakehead), MSc (UKMalaysia), Ph.D (Bristol)
Tel: 603-8921 5419
Email: mb_kassim@ukm.edu.my

Prof. Dr. Andanastuti Muchtar
BEng (Hons) (Leeds), Ph.D (NUSingapore)
Tel: 603-8911 8379/603-8921 3895
Email: muchtar@ukm.edu.my

Prof. Ir. Dr. Abu Bakar Sulong
BEng (Hons) (Gifu), Ph.D (Sejong), MIEM, PEng
Tel: 603-8921 6678
Email: abubakar@ukm.edu.my

Prof. Ir. Dr. Zahira Yaakob
BSc (Toledo), MSc, Ph.D (UMIST)
Tel: 603-8921 6420
Email: zahira@ukm.edu.my

Prof. Dr. Che Hassan Che Haron
BSc (Bridgeport), MSc (Pittsburgh), Ph.D (Coventry)
Tel: 603-8921 3184 / 8911 8416
Email: chase@ukm.edu.my

Prof. Dr. Norhamidi Muhamad
BSc (Bridgeport), MSc, Ph.D (Wales)
Tel: 603-8921 4073
Email: norhamidi@ukm.edu.my

Prof. Dr. Azizah Ahmad
BSc (Hons) (UKMalaysia), MSc (UPMalaysia), Ph.D (UKMalaysia)
Tel: 603-8921 5439
Email: azizan@ukm.edu.my

Prof. Dr. Kamisah Osman
BSc (Hons) (UKMalaysia), M.Ed, Ph.D (Manchester)
Tel: 603-8921 6284
Email: kamisah@ukm.edu.my

Prof. Dr. Mariyam Jameelah Ghazali
BEng (Hons), MSc (USMalaysia), Ph.D (Sheffield)
Tel: 603-89216418
Email: mariyam@ukm.edu.my

Professor Ir. Dr. Mohd. Sobri Takriff
BSc (Cum Laude), MSc, Ph.D (Arkansas), PEng, CEng, FICHEME
Tel: 603-89216417/6102
Email: sobritakriff@ukm.edu.my

Prof. Ts. Dr. Chia Chin Hua
BSc (Hons), MSc, Ph.D (UKMalaysia)
Tel: 603-89215473
Email: chia@ukm.edu.my

Felo Kanan Bersekutu/Associate Senior Fellows

Assoc. Prof. Dr. Mohammad Hafizuddin Jumali
BSc (Hons) (UKMalaysia), Ph.D (Warwick)
Tel: 603-8921 8595
Email: hafizhj@ukm.edu.my

Assoc. Prof. Dr. Rasyikah Md Khalid
LL.B (Sheffield), LL.M (Malaya), Ph.D (UKMalaysia), Certified Mediator
(MMC)
Tel: 603-8921 6335
Emel: rasyikah@ukm.edu.my

Assoc. Prof. Dr. Masli Irwan Rosli
BEng (Hons), MSc (UKMalaysia), Ph.D (Leeds)
Tel: 603-8921 6403
Email: masli@ukm.edu.my

Assoc Prof Dr. Norasikin Ahmad Ludin
BSc (Hons) (UPMalaysia), MSc (UKMalaysia), PhD (Wales)
Tel: 603-89118586
Email: sheekeen@ukm.edu.my

Assoc. Prof. Ts. Dr. Wan Nor Roslam Wan Isahak
BSc (Hons), MSc, Ph.D (UKMalaysia), MMIC, PTech
Tel: 603-8921 6424
Emel: wannorroslam@ukm.edu.my

Assoc. Prof. Dr. Fathin Faizah Said
BEc (Hons), MSc (UKMalaysia), Ph.D (Essex)
Tel: 603-89214205
Emel: fatin@ukm.edu.my

Felo Bersekutu/Associate Fellows

Dr. Manal Ismail

BEng (hons) (Bradford), PhD DIC (Imperial College London) Senior
AMIChemE, BEM IEM Grad members

Tel: 603-8921 6404

Email: manal@ukm.edu.my

Dr. Nur Hidayatul Nazirah Kamarudin

BEng (Hons), MSc, Ph.D (UTMalaysia)

Tel: 603-8911 7138

Emel: nhnazirah@ukm.edu.my

Dr. Darman Nordin

BEng (Hons) (UKMalaysia), Ph.D (Newcastle)

Tel: 603-8921 6968

Emel: darman@ukm.edu.my

Dr. Nabilah Afiqah Mohd Radzuan

BEng (Hons), MSc, Ph.D (UKMalaysia)

Tel: 603- 8921 7190

Emel: afiqah@ukm.edu.my

Dr. Teh Lee Peng

BSc (Hons) (UTMalaysia), Ph.D (UKMalaysia)

Tel: 603- 8921 3880

Emel: lpteh@ukm.edu.my

Dr. Mohamad Azuwa Mohamed

BSc (Hons), MSc, Ph.D (UKMalaysia)

Tel: 603- 8921 5441

Emel: mazuwa@ukm.edu.my

Dr. Peer Mohamed

BEng (Hons) (IIUM), Ph.D (UKMalaysia)

Tel: 603- 8921 6405

Emel: peer@ukm.edu.my

Dr. Ang Wei Lun

BEng (Hons), Ph.D (UKMalaysia)

Tel: 603- 8921 6501

Emel: wl_ang@ukm.edu.my

Pegawai Tadbir/ *Administrative Officer*

En. Ahmad Syakir Saad

Tel: Tel: 603-8921 8535

Emel: syakirsaad@ukm.edu.my

Pegawai Sains Kanan/ Senior Science Officers

En. Azman Mohd Nor

Tel: 603-8921 7085

Emel: azmannor@ukm.edu.my

En. Zul Fauzi Azlan Mohd

Tel: 603-8921 7083

Emel: zulfauzi@ukm.edu.my

Pegawai Penyelidik/*Research Officers*

En. Mohd Faizal Md. Nasir

Tel: 603-8921 7080

Emel: mfaizal@ukm.edu.my

Pn. Nabilah Mohd Sopian

Tel: 603-8921 7084

Emel: nabilah@ukm.edu.my

Penolong Jurutera/*Assistant Engineers*

En. Ariff Fadzillah Haron

Tel: 603-8921 6019

Emel: ariyul@ukm.edu.my

En. Mohd Asri Yussof

Tel: 603-8921 6019

Emel: asriyusof@ukm.edu.my

En. Mohamad Fareeq Ahmad Fudzi

Tel: 603-8921 6046

Emel: fareeq@ukm.edu.my

Penolong Pegawai Sains/ *Assistant Science Officers*

Pn. Nik Samila Yussof

Tel: 603-8921 7084

Emel: niksamila@ukm.my

En. Muhammad Taufik Mohd Hafzi

Tel: 603-8921 6046

Email: taufikhafzi@ukm.edu.my

Pembantu Setiausaha Pejabat/ *Secretary*

Pn. Sakinah Din
Tel: 603-8911 8531
Emel: sakin@ukm.edu.my

Pembantu Tadbir/*Administrative Assistants*

Pn. Nora Azlina Asikin Harun
Tel: 603-8911 8532
Emel: noraz@ukm.edu.my

Pn. Hafizatul Izzati Badrul Zaman
Tel: 603-8911 8533
Emel: izzati@ukm.edu.my

Pembantu Operasi/*Operations Assistant*

En. Mohd Azahar Azahari
Tel: 603-8911 8531
Email: azahar@ukm.edu.my

Latar Belakang Institut Sel Fuel (SELFUEL)

Pengenalan

Institut Sel Fuel telah diluluskan penubuhannya di Universiti Kebangsaan Malaysia oleh Jabatan Pengajian Tinggi, Kementerian Pengajian Tinggi Malaysia pada bulan Julai 2006 sebagai sebuah institut penyelidikan yang pertama di Malaysia melakukan penyelidikan dalam bidang sel fuel. Institut ini mula beroperasi secara rasmi setelah Prof. Dato' Ir. Dr. Hj. Wan Ramli Wan Daud sebagai Pengarah yang telah dilantik oleh Naib Canselor Universiti Kebangsaan Malaysia, YBhg. Prof. Tan Sri Dato' Dr. Sharifah Hapsah binti Syed Hasan Shahabudin pada 1 Januari 2007.

Penubuhan institut ini mencerminkan kekuatan penyelidikan sel fuel dan tenaga hidrogen di Universiti Kebangsaan Malaysia selama 12 tahun yang telah berjaya menarik dana penyelidikan IRPA besar dari Kementerian Sains, Teknologi dan Inovasi (MOSTI); menerbitkan banyak kertas di dalam jurnal antarabangsa berindeks dan berimpak tinggi, dan di dalam pascasidang dan prasidang persidangan antarabangsa dan kebangsaan; dijemput membenteng banyak kertas ucapan utama antarabangsa dan kebangsaan dan menghasilkan banyak harta intelek sel fuel dan tenaga hidrogen. Penubuhan Institut Sel Fuel di Universiti Kebangsaan Malaysia juga mencerminkan kekuatan penyelidikan tenaga keterbaharuan dalam bidang tenaga hidrogen dan teknologi sel fuel di universiti yang sudah berusia kira-kira 51 tahun.

Visi Institut

Menjadi pusat rujukan teknologi sel fuel dan tenaga hidrogen, serta dasar dan pengurusan tenaga bertaraf dunia.

Misi Institut

1. Meneroka sains, kejuruteraan, pengurusan dan ekonomi bagi membangunkan teknologi sel fuel dan tenaga hidrogen pribumi, dan dasar dan pengurusan tenaga.
2. Membina modal insan dalam bidang-bidang tersebut

Matlamat Pembelajaran Institut

Melahirkan graduan peringkat sarjana dan doktor falsafah yang mempunyai pengetahuan yang luas, berkemahiran tinggi dan berkaliber dalam bidang kejuruteraan sel fuel dan tenaga hidrogen, serta pengurusan dan dasar tenaga.

Objektif Institut

1. Menjalankan program penyelidikan, pengembangan dan projek demonstrasi (PP&P) untuk menghasilkan teknologi sel fuel pribumi.
2. Menggalakkan dan menyokong pembangunan industri sel fuel di Malaysia dengan menyediakan sumber teknologi yang diperolehi daripada program penyelidikan, pengembangan dan projek demonstrasi (PP&P).
3. Merancang strategi pembangunan industri sel fuel negara melalui penyediaan instrument governans, termasuk dasar negara, undang-undang dan pengurusan sumber.
4. Menjadi pusat tumpuan negara bagi memajukan teknologi sel fuel pribumi.
5. Menjadi pusat pegeram teknologi untuk industri sel fuel negara.
6. Menghasilkan sumber manusia yang mahir dalam bidang sel fuel bagi menyokong industri sel fuel negara

Background

Fuel Cell Institute (SELFUEL)

Introduction

Fuel Cell Institute was approved at the National University of Malaysia by the Department of Higher Education, Ministry of Higher Education Malaysia in July 2006 as the first research institute in Malaysia which carries out research in the field of fuel cells. The institute began operation officially with the appointment of Prof. Dato' Ir. Dr. Hj. Wan Ramli Wan Daud as the founding Director by the Vice-Chancellor of the National University of Malaysia, YBhg. Prof. Tan Sri Dato' Dr. Sharifah Hapsah binti Syed Hasan Shahabudin on January 1, 2007.

The establishment of this institute reflects the strength of fuel cell and hydrogen energy research at the National University of Malaysia for 12 years which has attracted large IRPA research funds from the Ministry of Science, Technology, and Innovation (MOSTI). Moreover, this institute has published a large number of papers in many indexed and high-impact international journals, in international and national precedings and conferences. Fuel Cell Institute was also invited to present many international and national keynote papers. In addition, this institute has produced many intellectual properties realted to fuel cells and hydrogen energy. The establishment of Fuel Cell Institute at the National University of Malaysia also reflects the strength of renewable energy research in the field of hydrogen energy and fuel cell technology at the university which has aged 51 years.

Vision of Institute

To be a world class reference centre for fuel cell and hydrogen technology; and for energy management and policy.

Mission of Institute

1. To explore the frontiers of knowledge in science, engineering, management, and economy for the development of world class indigenous fuel cell and hydrogen technology and sustainable energy management and policy.
2. To develop excellent world class human capital in these areas.

Educational Objective of Institute

To produce excellent postgraduates at Masters and PhD levels who are well equipped with very wide knowledge and skills in fuel cell, hydrogen energy, energy management and policy.

Objectives of Institute

1. To be the national focal centre for advancing indigenous fuel cell and hydrogen energy technology and formulating energy management and policy.
2. To conduct research, development, and project demonstration programs for the production of indigenous fuel cell and hydrogen energy technology and the formulation of energy management and policy.
3. To promote and support the development of the fuel cell and hydrogen energy industry in Malaysia by providing indigenous technology.
4. To plan the national fuel cell industry development strategies through the provision of the instrument of governance including national policy, law, and resources management.
5. To be the technology incubator centre for the national fuel cell industry.
6. To produce skilled human resources in the fields of fuel cell, hydrogen energy and energy management and policy to support the national fuel cell industry.

Program Pengajian Siswazah Institut Sel Fuel (SELFUEL)

Institut Sel Fuel (SELFUEL) menawarkan dua (2) mod program pengajian siswazah seperti berikut:

PENYELIDIKAN

Program pengajian siswazah mod penyelidikan ditawarkan sejak Sesi 2009/2010 sehingga sekarang seperti berikut:

1. Program Sarjana Sains
2. Program Doktor Falsafah

KERJA KURSUS

Program Sarjana Sains Teknologi Karbon Rendah dan Hidrogen ditawarkan bermula pada Sesi 2022/2023.

Graduate Studies Programmes Fuel Cell Institute (SELFUEL)

Fuel cell Institute (SELFUEL) offers two (2) modes of graduate studies programmes as follows:

RESEARCH

The graduate studies programmes in research mode are offered since the session of 2009/2010 till present as follow:

1. Master of Science
2. Doctor of Philosophy

COURSEWORK

The Master of Science in Low Carbon and Hydrogen Technology is offered starting from the session of 2022/2023.

Program Pengajian Siswazah (Penyelidikan)

Program Sarjana Sains (Penyelidikan)

Pengenalan

Program Sarjana Sains ini bertujuan membekalkan pelajar dengan ilmu lanjutan tentang teknologi sel fuel. Program ini dapat melahirkan graduan dengan pemahaman tentang konsep dan teori asas mengenai sel fuel, aplikasi sel fuel, pencirian/analisis prestasi sel fuel dan berupaya menjalankan penyelidikan dengan baik. Di samping itu, program ini bertujuan melahirkan graduan yang berkaliber dan sesuai untuk memegang jawatan sebagai penyelidik, ahli akademik, jurutera yang menyumbang kepada perkembangan dan pembangunan saintifik di dalam bidang teknologi sel fuel.

Tempoh Pengajian

Sepenuh masa adalah empat (4) hingga enam (6) semester
Separuh masa adalah enam (6) hingga lapan (8) semester

Hasil Pembelajaran Program (HPP)

- 1) **Ilmu Pengetahuan dan Pemahaman** - Berkebolehan untuk menguasai ilmu baharu melalui penyelidikan dalam bidang kejuruteraan sel fuel, tenaga hidrogen dan/atau pengurusan dan dasar tenaga.
- 2) **Kemahiran Kognitif** - Berkebolehan untuk menggunakan pemikiran kritis dan kemahiran saintifik untuk menyelesaikan masalah dalam bidang kejuruteraan sel fuel, tenaga hidrogen dan/atau pengurusan dan dasar tenaga.
- 3) **Kemahiran Praktikal** - Berkebolehan untuk mengadaptasi kemahiran praktikal dalam penyelidikan yang berdaya saing dalam bidang kejuruteraan sel fuel, tenaga hidrogen dan/atau pengurusan dan dasar tenaga.
- 4) **Kemahiran Interpersonal dan Komunikasi** - Berkebolehan untuk menghubungkan idea-idea dan isu-isu berkaitan kemasyarakatan dan persekitaran dalam bidang kejuruteraan sel fuel, tenaga hidrogen dan/atau pengurusan dan dasar tenaga serta menyampaikan maklumat/idea/laporan secara profesional dan berkeyakinan.
- 5) **Kemahiran Digital dan Berangka** - Berkebolehan untuk mengadaptasi teknologi maklumat atau teknologi digital dalam menganalisis data berangka dan grafik bagi menyokong pembelajaran dan penyelidikan.

- 6) **Kepimpinan, Autonomi dan Tanggungjawab** - Berkebolehan memimpin dan mengurus projek dengan berkesan serta bertanggungjawab dalam menjalankan penyelidikan yang signifikan.
- 7) **Kemahiran Diri dan Keusahawanan** - Berkebolehan menguasai kemahiran personal dan pembangunan karier serta ciri-ciri keusahawanan melalui pembelajaran dan pembangunan sendiri.
- 8) **Etika dan Profesionalisme** - Berkebolehan untuk melaksanakan penyelidikan dengan bertanggungjawab dan berpegang teguh pada kod amalan yang sah dengan berintegriti, beretika dan profesional.

Program Doktor Falsafah (Penyelidikan)

Pengenalan

Program Doktor Falsafah ini bertujuan membimbing pelajar menjadi seorang graduan yang menunjukkan kefahaman sistematik dan mendalam tentang teknologi sel fuel. Program ini dapat melahirkan graduan yang berkemampuan tinggi dan berkebolehan dalam menjana dan menyampaikan ilmu dalam bidang teknologi sel fuel. Penganugerahan ijazah doktor falsafah mengambil kira pengetahuan pelajar yang luas serta keupayaannya menjalankan penyelidikan secara sendiri dalam bidang penyelidikannya.

Tempoh Pengajian

Sepenuh masa adalah enam (6) hingga dua belas (12) semester
Separuh masa adalah lapan (8) hingga empat belas (14) semester

Hasil Pembelajaran Program (HPP)

- 1) **Ilmu Pengetahuan dan Pemahaman** - Berkebolehan untuk menjana ilmu baharu melalui penyelidikan dalam bidang kejuruteraan sel fuel, tenaga hidrogen dan/atau pengurusan dan dasar tenaga.
- 2) **Kemahiran Kognitif** - Berkebolehan untuk menggunakan pemikiran kritis dan membangunkan kemahiran saintifik untuk memformulasi dan menyelesaikan masalah dalam bidang kejuruteraan sel fuel, tenaga hidrogen dan/atau pengurusan dan dasar tenaga.
- 3) **Kemahiran Praktikal** - Berkebolehan untuk merancang dan mengadaptasi kemahiran praktikal dalam penyelidikan yang berdaya saing dalam bidang kejuruteraan sel fuel, tenaga hidrogen dan/atau pengurusan dan dasar tenaga.
- 4) **Kemahiran Interpersonal dan Komunikasi** - Berkebolehan untuk memberi khidmat nasihat kepada orang terhadap isu-isu berkaitan kemasyarakatan dan

- persekitaran dalam bidang kejuruteraan sel fuel, tenaga hidrogen dan/atau pengurusan dan dasar tenaga serta menyampaikan maklumat/idea/laporan secara profesional dan berkeyakinan.
- 5) **Kemahiran Digital dan Berangka** - Berkebolehan untuk mengadaptasi teknologi maklumat atau teknologi digital dalam pemprosesan data dan penilaian kritikal terhadap data berangka dan grafik bagi menyokong pembelajaran dan penyelidikan.
 - 6) **Kepimpinan, Autonomi dan Tanggungjawab** - Berkebolehan memimpin dan mengurus projek dengan berkesan serta bertanggungjawab dalam menjalankan penyelidikan yang signifikan dengan kerjasama rakan sekerja dan pihak berkepentingan.
 - 7) **Kemahiran Diri dan Keusahawanan** - Berkebolehan menguasai kemahiran personal dan pembangunan karier serta ciri-ciri keusahawanan melalui pembelajaran dan pembangunan sendiri.
 - 8) **Etika dan Profesionalisme** - Berkebolehan untuk melaksanakan penyelidikan secara bertanggungjawab dengan seliaan yang minimum dan berpegang teguh pada kod amalan yang sah dengan berintegriti, beretika dan profesional.

Syarat Kemasukan ke Program Sarjana Sains

Syarat kemasukan minimum ke program Sarjana Sains mod penyelidikan yang ditawarkan di Institut Sel Fuel adalah dipertimbangkan berdasarkan kriteria-kriteria berikut:

- i) Ijazah Sarjana Muda dengan Kepujian dan mempunyai PNGK 2.75 dan ke atas dari Universiti Kebangsaan Malaysia atau yang setara dari mana-mana institusi pengajian tinggi yang diiktiraf oleh Senat; ATAU
- ii) Ijazah Sarjana Muda dengan Kepujian dan mempunyai PNGK di antara 2.50 – 2.74 dari Universiti Kebangsaan Malaysia atau yang setara dari mana-mana institusi pengajian tinggi yang diiktiraf oleh Senat serta mempunyai pengalaman kerja sekurang-kurangnya satu (1) tahun dalam bidang berkaitan. Sekiranya tiada pengalaman kerja, calon perlu menjadi Pembantu Penyelidik (RA) bagi tempoh minimum enam (6) bulan dan menunjukkan prestasi yang baik serta disahkan oleh penyelia. Institut juga akan melakukan penilaian dalaman untuk tujuan kelulusan sebelum diberikan tawaran pengajian di Institut Sel Fuel; ATAU
- iii) Ijazah Sarjana Muda dengan Kepujian dan mempunyai PNGK di antara 2.00 – 2.49 dari Universiti Kebangsaan Malaysia atau yang setara dari mana-mana institusi pengajian tinggi yang diiktiraf oleh Senat serta mempunyai pengalaman kerja sekurang-kurangnya lima (5) tahun dalam bidang

berkaitan. Sekiranya tiada pengalaman kerja, calon perlu menjadi Pembantu Penyelidik (RA) bagi tempoh minimum satu (1) tahun dan menunjukkan prestasi yang baik serta disahkan oleh penyelia. Institut juga akan melakukan penilaian dalaman untuk tujuan kelulusan sebelum diberikan tawaran pengajian di Institut Sel Fuel.

Syarat Kemasukan ke Program Doktor Falsafah

Syarat kemasukan minimum ke program Doktor Falsafah mod penyelidikan yang ditawarkan di Institut Sel Fuel adalah dipertimbangkan berdasarkan kriteria-kriteria berikut:

- i) Ijazah Sarjana Muda dengan Kepujian dan mempunyai PNGK 3.67 dan ke atas dari Universiti Kebangsaan Malaysia atau yang setara dari mana-mana institusi pengajian tinggi yang diiktiraf oleh Senat; ATAU
- ii) Ijazah Sarjana dari Universiti Kebangsaan Malaysia atau yang setara dari mana-mana institusi pengajian tinggi yang diiktiraf oleh Senat

Syarat Keperluan Bahasa Inggeris

1. Calon luar negara mesti memenuhi syarat bahasa Inggeris seperti berikut:
 - i) Mendapat keputusan TOEFL pBT dengan skor minimum 453; ATAU
 - ii) Mendapat keputusan TOEFL iBT dengan skor minimum 46; ATAU
 - iii) Mendapat keputusan TOEFL ITP dengan skor minimum 585; ATAU
 - iv) Mendapat keputusan IELTS dengan skor minimum 5.5; ATAU
 - v) Mendapat keputusan MUET dengan skor minimum Band 3.5; ATAU
 - vi) Mendapat keputusan Pearson Test of English dengan skor minimum 51; ATAU
 - vii) Mendapat keputusan Cambridge English Qualifications and Test dengan skor minimum 160
2. Calon antarabangsa yang tidak memenuhi syarat kecekapan berbahasa Inggeris boleh diberikan tawaran bersyarat berikut:
 - i) Pelajar dibenarkan mengikuti Kursus Persediaan Bahasa Inggeris dalaman (*Progressive English Programme*, PEP) di UKM dengan had tempoh selama dua (2) tahun maksimum, namun pelajar masih tertakluk kepada peraturan Jabatan Imigresen Malaysia yang sedang berkuat kuasa.
3. Calon antarabangsa yang berasal dari negara yang menggunakan Bahasa Inggeris sebagai bahasa rasmi atau yang memiliki kelayakan akademik yang

diperoleh dari mana-mana institusi pengajian tinggi yang menggunakan Bahasa Inggeris sebagai bahasa pengantar sepenuhnya boleh dikecualikan daripada syarat (a) di atas.

Permohonan Kemasukan

Permohonan kemasukan ke Institut Sel Fuel boleh dilakukan secara dalam talian menerusi tapak web: <https://join.ukm.my/>. *Semua dokumen sokongan perlu dimuatnaik melalui sistem tersebut. Sila baca panduan permohonan yang dikemaskini dengan teliti.*

Keperluan Kursus

1. Pelajar program Sarjana Sains hendaklah mendaftar dan lulus 6 kredit kursus terdiri daripada:
 - 4 kredit kursus RARA6014 Kaedah Penyelidikan (Sains dan Teknologi); DAN
 - 2 kredit kursus (1 daripada kursus di bawah)
 - RARA6022 Tenaga Hidrogen; ATAU
 - RARA6032 Pengurusan dan Dasar Tenaga; ATAU
 - RARA6042 Elektrokimia Sel Fuel; ATAU
 - RARA6052 Sistem dan Aplikasi Sel Fuel

2. Pelajar program Doktor Falsafah hendaklah mendaftar dan lulus 8 kredit kursus terdiri daripada:
 - 4 kredit kursus RARA8014 Kaedah Penyelidikan (Sains dan Teknologi); DAN
 - 4 kredit kursus (2 daripada kursus di bawah)
 - RARA8022 Tenaga Hidrogen Lanjutan; ATAU
 - RARA8032 Pengurusan dan Dasar Tenaga Lanjutan; ATAU
 - RARA8042 Elektrokimia Sel Fuel Lanjutan; ATAU
 - RARA8052 Sistem dan Aplikasi Sel Fuel Lanjutan

Penerbitan Manuskrip Sebagai Syarat Bergraduat

Syarat penerbitan manuskrip sebagai syarat bergraduat bagi program pengajian siswazah mod penyelidikan di Institut Sel Fuel adalah seperti dalam jadual di bawah:

Syarat Penerbitan Manuskrip	
Ijazah Sarjana Sains (MSc)	Ijazah Doktor Falsafah (PhD)

Sekurang-kurangnya 1 artikel telah diterima untuk penerbitan dalam jurnal berindeks WoS .	Sekurang-kurangnya 2 artikel telah diterima untuk penerbitan dalam jurnal berindeks WoS .
---	---

Kursus-Kursus yang Ditawarkan untuk Program Sarjana Sains

RARA6014 Kaedah Penyelidikan (Sains dan Teknologi)

Kursus ini bertujuan memberikan latar belakang dan kaedah menjalankan sesebuah penyelidikan saintifik. Etika penyelidikan yang dibincangkan ialah prinsip-prinsip penyelidikan, peranan penyelidik, salah laku seperti kegiatan plagiat dan lain-lain supaya pelajar mampu mempamerkan etika yang baik semasa menjalankan penyelidikan. Kursus ini menekankan asas teknik pencarian maklumat secara manual dan atas talian, reka bentuk eksperimen, pemprosesan dan analisis data, penyediaan usulan penyelidikan, teknik persembahan hasil penyelidikan secara lisan dan bertulis, dan pengenalan kepada kegiatan penyelidikan di Institut Sel Fuel, UKM. Kaedah pengurusan data juga diajarkan supaya dapat dimanfaatkan oleh pelajar dalam penyelidikan masing-masing. Aspek perundangan berkaitan harta intelek, aspek keselamatan di ruang bekerja, dan format menulis tesis mengikut gaya UKM juga dibincangkan. Penilaian kursus ini adalah berdasarkan kepada mutu kertas cadangan penyelidikan yang disediakan oleh pelajar dan pembentangan cadangan tersebut di dalam seminar.

Bacaan Asas

1. Kornuta, H.M., Germaine R.W. 2019. *A Concise Guide to Writing a Thesis or Dissertation: Educational Research and Beyond*. Second Ed. Routledge.
2. Miles, M.B., Huberman, A.M., Saldana, J.M. 2019. *Qualitative Data Analysis: A Methods Sourcebook*. SAGE Publications Ltd.
3. Efron, S.E., Ravid R. 2018. *Writing the Literature Review: A Practical Guide*. First Ed. The Guilford Press.
4. Ramakrishna, B., Anil Kumar, H.S. 2017. *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers*. First Ed. Notion Press.
5. Talib, O. 2017. *Aplikasi Penulisan Artikel Jurnal*. MPWS.

RARA6022 Tenaga Hidrogen

Matlamat kursus ini adalah untuk memberi pengenalan asas kepada para pelajar tentang tenaga hidrogen. Pelajar-pelajar akan diperkenalkan dengan prinsip asas

penggunaan tenaga hidrogen pada peringkat awal. Seterusnya, pelajar-pelajar akan didedahkan dengan pelbagai kaedah dalam pemprosesan fuel, penyimpanan hidrogen dan penggunaan hidrogen sebagai tenaga. Isu-isu sosial dan keselamatan yang berkaitan dengan penggunaan tenaga hidrogen akan dibincangkan.

Bacaan Asas:

1. Basile, A., Dalena, F., Tong, J., Veziroğlu, T.N. 2017. *Hydrogen Production, Separation and Purification for Energy*. London: The Institution of Engineering & Technology.
2. Dagdougui, H., Sacile, R., Bersani, C., Ouammi, A. 2018. *Hydrogen Infrastructure for Energy Applications: Production, Storage, Distribution and Safety*. London: Academic Press-Elsevier.
3. Sankir, M., Sankir, N.D. 2017. *Hydrogen Production Technologies*. New Jersey: Scrivener Publishing-Wiley.
4. Mirandam, P.E. 2019. *Science and Engineering of Hydrogen-Based Energy Technologies: Hydrogen Production and Practical Applications in Energy Generation*. Oxford: Academic Press-Elsevier.
5. Lanzini, A. Calise, F., Ferrero, D., Santarelli, M., D'Accadia, M.D. 2019. *Solar Hydrogen Production: Processes, Systems and Technologies*. Oxford: Academic Press-Elsevier.

RARA6032 Pengurusan dan Dasar Tenaga

Kursus ini membincangkan isu-isu utama bagi pembuatan polisi dan pengurusan tenaga dalam konteks global. Pelbagai faktor seperti politik, teknologi, dan sosial yang mempengaruhi pembuatan polisi dan pengurusan tenaga juga diteliti. Topik yang saling kait-mengait antara satu sama lain seperti undang-undang dan ekonomi tenaga berkenaan dengan polisi, pengurusan, dan kelestarian tenaga dilihat melalui lensa landskap global yang cepat berubah. Pelajar akan dapat menilai, membuat kesimpulan, dan mengkritik mengenai hubungan yang terdapat dalam pengurusan dan pembuatan polisi tenaga global.

Bacaan Asas:

1. Ozawa, M., Chaplin, J., Pollitt, M., Reiner, D., Warde, P. 2019. *In Search of Good Energy Policy. Series: Cambridge Studies on Environment, Energy and Natural Resources Governance*. Cambridge University Press. 388 p.
2. Webber, M.E. 2019. *Power Trip: The Story of Energy (Hardcover)*. 2019. Basic Books. 304 p.
3. J.Rifkin, J. *The Green New Deal: Why the Fossil Fuel Civilization Will Collapse by 2028, and the Bold Economic Plan to Save Life on Earth*. 2019. St. Martin's Press. 292 p.
4. Rosenbaum, W.A. 2019. *Environmental Politics and Policy (11 Ed.)*. CQ Press. 352 p.

5. IRENA. 2019. *Global Energy Transformation: A Roadmap to 2050*.

RARA6042 Elektrokimia Sel Fuel

Kursus ini memperkenalkan teori umum elektrokimia, instrumentasi dan kaedah pencirian elektrokimia dalam sel fuel. Di peringkat awal, pelajar akan didedahkan kepada topik pengenalan kepada sel fuel, bahan mangkin/membran sel fuel dan jenis-jenis sel fuel. Turut dibincangkan dalam kursus ini adalah topik elektrokimia asas, elektromangkin, termodinamik sel fuel dan tindak balas redoks sel fuel. Kaedah pencirian elektrokimia seperti siklik voltametri, spektroskopi impedans elektrokimia dalam mengukur prestasi mangkin/bio-mangkin serta membran sel fuel juga akan dibincangkan dengan lanjut dalam kursus ini. Akhir sekali, pelajar dikehendaki melakukan projek berkaitan bidang sel fuel dan dinilai berdasarkan pembentangan dan laporan bertulis.

Bacaan Asas:

1. Sorensen, B. & Spazzafumo, G. 2019. *Hydrogen and Fuel Cells*. 3rd Edition. Elsevier/Academic Press.
2. O'Hayre, R., Cha, S-W., Colella, W. & Prinz, F. B. 2016. *Fuel Cell Fundamentals*. John Wiley & Sons.
3. Jiang, S. P., Li, Q. 2021. *Introduction to Fuel Cells: Electrochemistry and Materials*. Springer Singapore.
4. Breitkopf C., Swider-Lyons K. 2016. *Handbook of Electrochemical Energy*. New York: Springer.
5. Koper, M. & Wieckowski, A. 2019. *Fuel Cell Catalysis: A Surface Science Approach*. Wiley.

RARA6052 Sistem Sel Fuel dan Aplikasi

Tujuan kursus ini adalah untuk membincangkan topik-topik penting berkaitan sistem sel fuel bersuhu tinggi dan rendah dan aplikasinya dalam pelbagai bidang. Konsep, proses elektrokimia dan teori-teori sel fuel akan dibincangkan dan dihubungkan dengan sistem sel fuel untuk pemahaman pelajar. Reka bentuk stak, analisis prestasi, pengurusan air dan haba, kawalan dan pemantauan serta keadaan operasi sel fuel juga dibincangkan secara meluas untuk pemahaman pelajar dalam pelbagai aspek kejuruteraan sistem proses sel fuel. Masalah-masalah dan isu-isu semasa dalam sistem sel fuel diuraikan dengan menggabungkan pelbagai disiplin ilmu untuk membantu pelajar membuat penilaian dan penerangan secara kritis terhadap sesuatu sistem sel fuel. Pelajar juga akan didedahkan dengan sistem sel fuel melalui lawatan makmal. Akhir sekali, pelajar dikehendaki melakukan projek berkaitan bidang sel fuel dan dinilai berdasarkan laporan bertulis dan pembentangan.

Bacaan Asas:

1. Albarbar, A., Alrweq, M. 2018. *Proton Exchange Membrane Fuel Cells: Design, Modelling and Performance Assessment Techniques*. Springer International Publishing.
2. Su, H., Gomez, J.C.C., Reddy, H., Sita, C., Pasupathi, S., Bujlo, P. 2016. *Recent Advances in High-Temperature PEM Fuel Cells*. Academic Press.
3. Hacker, V., Mitsushima, S. 2018. *Fuel Cells and Hydrogen: From Fundamentals to Applied Research*. Elsevier.
4. Fergus, J., Hui, R., Li, X., Wilkinson, D.P. & Zhang, J. 2016. *Solid Oxide Fuel Cells: Materials Properties and Performance*. First Ed. Boca Raton: CRC Press.
5. Kaur, G. 2020. *Intermediate-temperature Solid Oxide Fuel Cells: Electrolyte, Electrodes and Interconnects*. Oxford: Elsevier.

Kursus-Kursus yang Ditawarkan untuk Program Doktor Falsafah

RARA8014 Kaedah Penyelidikan Lanjutan

Kursus ini bertujuan menghuraikan kaedah menjalankan sesuatu penyelidikan saintifik secara terperinci. Etika penyelidikan yang merangkumi prinsip-prinsip penyelidikan, peranan penyelidik, salah laku seperti kegiatan plagiat dan lain-lain dibahaskan secara mendalam supaya pelajar mampu mempamerkan etika penyelidikan yang terbaik dan profesional. Tajuk-tajuk berkaitan pengurusan penyelidikan yang meliputi teknik pencarian maklumat secara manual dan atas talian, reka bentuk eksperimen, memproses, menganalisis dan merumuskan data, penyediaan usulan penyelidikan, teknik persembahan hasil penyelidikan secara lisan dan bertulis, dan pengenalan kepada kegiatan penyelidikan di Institut Sel Fuel, UKM juga ditekankan. Kaedah pengurusan data dan statistik juga diajarkan supaya dapat dimanfaatkan oleh pelajar dalam penyelidikan masing-masing. Aspek perundangan berkaitan harta intelek, aspek keselamatan di ruang bekerja, dan format menulis tesis mengikut gaya UKM juga dibahaskan. Penilaian kursus ini adalah berdasarkan kepada mutu kertas cadangan penyelidikan yang disediakan oleh pelajar dan pembentangan cadangan tersebut di dalam seminar.

Bacaan Asas:

1. Kornuta, H.M., Germaine R.W. 2019. *A Concise Guide to Writing a Thesis or Dissertation: Educational Research and Beyond*. Second Ed. Routledge.
2. Miles, M.B., Huberman, A.M., Saldana, J.M. 2019. *Qualitative Data Analysis: A Methods Sourcebook*. SAGE Publications Ltd.

3. Efron S.E., Ravid, R. 2018. *Writing the Literature Review: A Practical Guide*. First Ed. The Guilford Press.
4. Ramakrishna, B., Anil Kumar, H.S. 2017. *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers*. First Ed. Notion Press.
5. Talib, O. 2017. *Aplikasi Penulisan Artikel Jurnal*. MPWS.

RARA8022 Tenaga Hidrogen Lanjutan

Matlamat kursus ini adalah untuk memberi pengenalan lanjut kepada para pelajar tentang tenaga hidrogen. Pelajar-pelajar akan diperkenalkan dengan prinsip asas penggunaan tenaga hidrogen pada peringkat awal. Seterusnya, pelajar-pelajar akan didedahkan dengan pelbagai kaedah dalam pemprosesan fuel, penyimpanan hidrogen dan penggunaan hidrogen sebagai tenaga. Hubungan kait di antara proses penghasilan sehingga ke penggunaan hidrogen akan dibincangkan. Isu-isu sosial dan keselamatan yang berkaitan dengan penggunaan tenaga hidrogen akan dibincangkan.

Bacaan Asas:

1. Basile, A., Dalena, F., Tong, J., Veziroğlu, T.N. 2017. *Hydrogen Production, Separation and Purification for Energy*. London: The Institution of Engineering & Technology.
2. Dagdougui, H., Sacile, R., Bersani, C., Ouammi, A. 2018. *Hydrogen Infrastructure for Energy Applications: Production, Storage, Distribution and Safety*. London: Academic Press-Elsevier.
3. Sankir, M., Sankir, N.D. 2017. *Hydrogen Production Technologies*. New Jersey: Scrivener Publishing-Wiley.
4. Mirandam, P.E. 2019. *Science and Engineering of Hydrogen-Based Energy Technologies: Hydrogen Production and Practical Applications in Energy Generation*. Oxford: Academic Press-Elsevier.
5. Lanzini, A. Calise, F., Ferrero, D., Santarelli, M., D'Accadia, M.D. 2019. *Solar Hydrogen Production: Processes, Systems and Technologies*. Oxford: Academic Press-Elsevier.

RARA8032 Pengurusan dan Dasar Tenaga Lanjutan

Kursus ini membincangkan dan menghuraikan secara mendalam isu-isu utama bagi pembuatan polisi dan pengurusan tenaga dalam konteks global yang lebih luas. Pelbagai faktor seperti politik, teknologi, dan sosial yang mempengaruhi pembuatan polisi dan pengurusan tenaga juga diteliti dan dikaitkan dengan pelbagai senario ekonomi dan pengurusan tenaga. Topik yang saling kait-mengait antara satu sama lain seperti undang-undang dan ekonomi tenaga berkenaan dengan polisi, pengurusan, dan kelestarian tenaga dilihat melalui lensa landskap global yang cepat berubah. Pelajar dapat menghurai, membuat kesimpulan, dan mengkritik hubungan yang terdapat dalam pengurusan dan pembuatan polisi tenaga global.

Bacaan Asas:

1. Ozawa, M., Chaplin, J., Pollitt, M., Reiner, D., Warde, P. 2019. *In Search of Good Energy Policy. Series: Cambridge Studies on Environment, Energy and Natural Resources Governance*. Cambridge University Press. 388 p.
2. Webber, M.E. 2019. *Power Trip: The Story of Energy (Hardcover)*. 2019. Basic Books. 304 p.
3. J.Rifkin, J. *The Green New Deal: Why the Fossil Fuel Civilization Will Collapse by 2028, and the Bold Economic Plan to Save Life on Earth*. 2019. St. Martin's Press. 292 p.
4. Rosenbaum, W.A. 2019. *Environmental Politics and Policy (11 Ed.)*. CQ Press. 352 p.
5. IRENA. 2019. *Global Energy Transformation: A Roadmap to 2050*.

RARA8052 Elektrokimia Sel Fuel Lanjutan

Kursus ini bertujuan untuk membincangkan topik-topik berkaitan elektrokimia lanjutan dalam pelbagai sistem sel fuel. Pada peringkat awal, kursus ini akan mendedahkan pelajar kepada konsep-konsep dan teori-teori secara mendalam yang berkaitan tindak balas termodinamik dan elektrokimia sel fuel, jenis-jenis sel fuel, sel, komponen sel fuel, dan prestasi sel fuel. Bahan termaju elektromangkin dan elektrolit untuk sel fuel serta kaedah pemilihan bahan bagi sistem elektrokimia tertentu juga dibincangkan secara terperinci dalam kursus ini. Teknik-teknik berkaitan dengan pencirian elektrokimia untuk sistem-sistem ini juga akan dibahaskan untuk membantu pelajar mentafsir dan membuat penilaian dan penerangan secara kritis terhadap topik tersebut.

Bacaan Asas:

1. Sorensen, B., Spazzafumo, G. 2019. *Hydrogen and Fuel Cells*. 3rd Edition. Elsevier/Academic Press.
2. O'Hayre, R., Cha, S-W., Colella, W., Prinz, F. B. 2016. *Fuel Cell Fundamentals*. John Wiley & Sons.
3. Jiang, S. P., Li, Q. 2021. *Introduction to Fuel Cells: Electrochemistry and Materials*. Springer Singapore.
4. Breitkopf, C., Swider-Lyons K. 2016. *Handbook of Electrochemical Energy*. New York: Springer.
5. Koper, M., Wieckowski, A. 2019. *Fuel Cell Catalysis: A Surface Science Approach*. Wiley.

RARA8052 Sistem Sel Fuel dan Aplikasi Lanjutan

Kursus ini bertujuan ini untuk membincangkan dengan lebih lanjut berkenaan reka bentuk sistem sel fuel untuk pelbagai aplikasi. Konsep-konsep sel fuel akan dikaitkan dengan sistem sel fuel secara mendalam untuk membolehkan pelajar berfikir secara kritis. Reka bentuk stak, analisis prestasi, pengurusan air dan haba, kawalan dan pemantauan serta keadaan operasi sel fuel juga diuraikan dan digabungkan dengan pelbagai masalah untuk membolehkan pelajar menilai dan mentafsir pelbagai aspek kejuruteraan sistem proses sel fuel. Masalah-masalah dan isu-isu semasa dalam sistem sel fuel juga dibahasakan dengan menggabungkan pelbagai disiplin ilmu untuk membantu pelajar membuat penilaian dan penerangan secara kritis terhadap sesuatu sistem sel fuel. Pelajar juga akan didedahkan dengan sistem sel fuel melalui lawatan makmal. Akhir sekali, pelajar dikehendaki melakukan projek berkaitan bidang sel fuel dan dinilai berdasarkan laporan bertulis dan pembentangan.

Bacaan Asas:

1. Albarbar, A., Alrweq, M. 2018. *Proton Exchange Membrane Fuel Cells: Design, Modelling and Performance Assessment Techniques*. Springer International Publishing.
2. Su, H., Gomez, J.C.C., Reddy, H., Sita, C., Pasupathi, S., Bujlo, P. 2016. *Recent Advances in High-Temperature PEM Fuel Cells*. Academic Press.
3. Hacker, V., Mitsushima, S. 2018. *Fuel Cells and Hydrogen: From Fundamentals to Applied Research*. Elsevier.
4. Fergus, J., Hui, R., Li, X., Wilkinson, D.P. & Zhang, J. 2016. *Solid Oxide Fuel Cells: Materials Properties and Performance*. First Ed. Boca Raton: CRC Press.
5. Kaur, G. 2020. *Intermediate-temperature Solid Oxide Fuel Cells: Electrolyte, Electrodes and Interconnects*. Oxford: Elsevier.

Bidang-Bidang Penyelidikan

1. Kejuruteraan Sistem Proses
2. Bahan dan Pembuatan Plat Sel Fuel
3. Proses Elektrokimia Sel Fuel
4. Sel Fuel Cecair Langsung
5. Sel Fuel Oksida Pepejal
6. Biohidrogen dan Biosel Fuel
7. Pemprosesan Fuel
8. Hidrogen Suria
9. Pengurusan dan dasar tenaga
10. Penyimpanan Tenaga

Penukaran Program Sarjana kepada Program Doktor Falsafah

1. Syarat permohonan adalah seperti berikut:
 - a) Pelajar Sarjana (secara disertasi) yang mendaftar secara sepenuh masa sahaja adalah layak memohon menukar bentuk pengajian.
 - b) Pelajar perlu membuat permohonan sebelum semester ke-3 pengajian, agar pertimbangan dapat dilakukan dalam semester ke-3 dan keputusan dapat dikeluarkan sebelum semester ke-4 pengajian bermula.
 - c) Pelajar yang telah mencapai objektif kajian Sarjana (biasanya akhir semester 3) tidak layak dipertimbangkan dan harus menyelesaikan pengajian Sarjananya.
 - d) Mempunyai laporan kemajuan yang memuaskan dan mendapat sokongan penyelia.

2. Cara permohonan adalah seperti berikut:
 - a) Calon menyediakan usulan baru untuk Doktor Falsafah yang merangkumi:
 - Tambahan skop penyelidikan
 - Signifikan penyelidikan
 - Tambahan objektif penyelidikan
 - Tambahan masa penyelidikan
 - Idea baru dalam penyelidikan tersebut
 - Penemuan baru yang mungkin akan diperolehi
 - b) Permohonan hendaklah dibuat secara bertulis kepada Pengarah, dengan perakuan Penyelia Utama/Pengerusi Jawatankuasa Penyeliaan.
 - c) Jawatankuasa Pertukaran Status Pengajian Pascasiswazah (JPSPP) akan dibentuk untuk meneliti dan menilai proposal calon.
 - d) Calon akan membentangkan proposal penyelidikan Doktor Falsafah tersebut dengan kehadiran ahli JPSPP dan pensyarah lain.
 - e) JPSPP akan menyatakan pandangan dan komen terhadap proposal tersebut.
 - f) Calon akan membuat pembetulan proposal mengikut cadangan JPSPP.
 - g) Calon menyerahkan proposal baru kepada Ketua Pentadbiran Institut untuk perakuan Jawatankuasa Akademik dan Siswazah Institut dan kelulusan Pengarah Institut.

- h) Sebarang keputusan akan dimaklumkan kepada calon.

Penulisan Tesis/Disertasi Kompilasi

1. Syarat-syarat bagi penulisan tesis/disertasi format kompilasi:

- i. Penyelia bersetuju bahawa tesis/disertasi penyelidikan yang telah dijalankan ditulis dalam bentuk tesis/disertasi kompilasi
- ii. Pelajar perlu membuat permohonan secara bertulis kepada Pengarah untuk menulis tesis/disertasi dalam bentuk kompilasi
- iii. Pelajar telah menerbitkan makalah atau makalah telah diterima untuk penerbitan dalam jurnal tersohor yang diiktiraf oleh Fakulti/Institut. Namun demikian, setiap disiplin memerlukan tahap impak yang berbeza bagi memastikan kualiti yang setaraf dengan pengajian di peringkat Doktor Falsafah atau Sarjana.
- iv. Makalah perlu memenuhi skop dan objektif penyelidikan yang dijalankan oleh pelajar. Kertas yang dibentangkan dalam persidangan atau seminar, dan kertas yang diterbitkan dalam prosiding persidangan atau seminar hanya boleh diterima sebagai bahan penerbitan sokongan sahaja.
- v. Syarat dan bilangan penerbitan makalah adalah seperti berikut:
 - Program Doktor Falsafah:
 - i. Sekurang-kurangnya **EMPAT (4)** artikel telah diterbitkan atau diterima untuk penerbitan dalam makalah berindeks **WoS** dan berkuartil **Q1/Q2**.
 - ii. **DUA (2)** daripada artikel-artikel yang diterbitkan atau diterima untuk penerbitan seperti dalam Perkara (i) di atas **WAJIB** berindeks **WoS** dan berkuartil **Q1**.
 - Program Sarjana:
 - i. Sekurang-kurangnya **DUA (2)** artikel telah diterbitkan atau diterima untuk penerbitan dalam makalah berindeks **WoS** dan berkuartil **Q1/Q2**.
 - ii. **SATU (1)** daripada artikel-artikel yang diterbitkan atau diterima untuk penerbitan seperti dalam Perkara (i) di atas **WAJIB** berindeks **WoS** dan berkuartil **Q1**.

- vi. Pelajar perlu mendapatkan kebenaran hak cipta daripada penerbit makalah yang diterbitkan sekiranya tesis/disertasi hendak dibukukan.
 - vii. Pelajar merupakan **pengarang utama** atau **pengarang yang dirujuk** bagi setiap makalah yang dinyatakan dalam Perkara (e) di atas dan ditulis **bersama penyelia**.
 - viii. Pelajar yang mempunyai lebih dari satu afiliasi perlu meletakkan Universiti Kebangsaan Malaysia sebagai afiliasi pertama.
 - ix. Bagi pelajar berstatus warganegara, di mana tesis mesti ditulis dalam Bahasa Melayu kecuali dengan kebenaran Institut, makalah boleh ditulis dalam bahasa ia diterbitkan. Namun, calon perlu menyertakan ringkasan makalah dan maklumat makalah penerbitan di dalam Bahasa Melayu mengikut format seperti dalam Perkara 2 di bawah.
2. Format serta kandungan tesis/disertasi adalah seperti berikut:
1. Pernyataan bahawa tesis/disertasi ditulis mengikut format kompilasi.
 2. Senarai penerbitan yang dimasukkan sebagai bab dalam tesis/disertasi.
 3. Keseluruhan tesis/disertasi perlu disediakan mengikut format penulisan tesis/disertasi Gaya UKM.
 4. Bab Pengenalan – Bab ini memberi pengenalan kepada isu yang dikaji dan menerangkan perkaitan di antara makalah yang telah diterbitkan bagi memastikan tesis/disertasi dipersembahkan dalam bentuk yang bersepadu.
 5. Bab Bahan Penerbitan – Setiap makalah yang telah diterbitkan perlu dipersembahkan sebagai bab berasingan di dalam tesis/disertasi. Abstrak makalah dan maklumat jurnal penerbitan perlu disertakan bagi tesis/disertasi yang ditulis dalam bahasa yang selain dari bahasa penulisan tesis/disertasi.
 6. Bab Kesimpulan – Bab ini mensintesis dapatan kajian dan memberi kesimpulan menyeluruh tentang penyelidikan yang telah dijalankan.
 7. Rujukan – Senarai rujukan merangkumi rujukan bagi bab Pengenalan dan Kesimpulan.

GRADUATE STUDIES PROGRAMMES (RESEARCH)

Master of Science (Research)

Introduction

Master of Science program is intended to equip student with extended knowledge on fuel cell technology. This program is designed to produce graduates with understanding on concept and theoretical basis of fuel cell, fuel cell application, fuel cell characterization/ performances analysis and is capable of carrying out good research. At the same time, this programme is intended to deliver capable graduate and suitable holding onto post as researcher, academician and engineer which contribute to scientific development in fuel cell technology.

Duration of Studies

The duration on a full-time basis is between four (4) to six (6) semesters

The duration on a part-time basis is between six (6) to eight (8) semesters

Program Learning Outcome

1. **Knowledge and Understanding** - Ability to master new knowledge through research in the field of fuel cell engineering, hydrogen energy and/or energy management and policy.
2. **Cognitive Skills** - Ability to use critical thinking and scientific skills to solve problems in the field of fuel cell engineering, hydrogen energy and/or energy management and policy.
3. **Practical Skills** - Ability to adapt practical skills in competitive research in the field of fuel cell engineering, hydrogen energy and/or energy management and policy.
4. **Interpersonal and Communication Skills** - Ability to connect ideas and issues related to society and the environment in the field of fuel cell engineering, hydrogen energy and/or energy management and policy as well as deliver information/ideas/reports professionally and confidently.
5. **Digital and Numerical Skills** - Ability to adapt information technology or digital technology in analyzing numerical and graphical data to support learning and research.

6. **Leadership, Autonomy and Responsibility** - Ability to effectively lead and manage projects and take responsibility for conducting significant research.
7. **Personal and Entrepreneurial Skills** - Ability to master personal skills and career development as well as entrepreneurial characteristics through learning and self-development.
8. **Ethics and Professionalism** - Ability to conduct research responsibly and adhere to valid codes of practice with integrity, ethics and professionalism.

Doctor of Philosophy (Research)

Introduction

The Doctor of Philosophy program is intended to cultivate a graduate with a systematic and profound understanding of fuel cell technology. The program will produce graduates who are highly skilled and capable of generating and imparting knowledge in the field of fuel cell technology. The award of a doctorate degree will be taken into account the extensive knowledge and ability of students to conduct research independently in the related field.

Duration of Studies

The duration on a full-time basis is between six (6) to twelve (12) semesters
The duration on a part-time basis is between eight (8) to fourteen (14) semesters

Program Learning Outcome

1. **Knowledge and Understanding** - Ability to generate new knowledge through research in the field of fuel cell engineering, hydrogen energy and/or energy management and policy.
2. **Cognitive Skills** - Ability to use critical thinking and develop scientific skills to formulate and solve problems in the field of fuel cell engineering, hydrogen energy and/or energy management and policy.
3. **Practical Skills** - Ability to plan and adapt practical skills in competitive research in the field of fuel cell engineering, hydrogen energy and/or energy management and policy.
4. **Interpersonal and Communication Skills** - Ability to provide expert advice on issues related to society and the environment in the field of fuel cell engineering,

hydrogen energy and/or energy management and policy as well as convey information/ideas/reports in a professional and confident manner.

5. **Digital and Numerical Skills** - Ability to adapt information technology or digital technology in data processing and critical evaluation of numerical and graphic data to support learning and research.
6. **Leadership, Autonomy and Responsibility** - Ability to effectively lead and manage projects and take responsibility for conducting significant research in collaboration with colleagues and stakeholders.
7. **Personal and Entrepreneurial Skills** - Ability to master personal skills and career development as well as entrepreneurial characteristics through learning and self-development.
8. **Ethics and Professionalism** - Ability to conduct research responsibly with minimal supervision and adhere to valid codes of practice with integrity, ethics and professionalism.

Admission Requirements to the Master of Science Programme

The minimum admission requirements to the Master of Science programme by research mode offered at the Fuel Cell Institute are considered based on the following criteria:

- i) Bachelor's Degree with Honours and have a CGPA of 2.75 and above from Universiti Kebangsaan Malaysia or the equivalent from any institution of higher learning recognized by the Senate; OR
- ii) Bachelor's Degree with Honours and have a GPA between 2.50-2.74 from Universiti Kebangsaan Malaysia or the equivalent from any institution of higher learning recognized by the Senate and have at least one (1) year of work experience in a related field. If there is no work experience, the candidate must be a Research Assistant (RA) for a minimum period of six (6) months and show good performance and be confirmed by the supervisor. The institute will also conduct an internal assessment for approval purposes before being given an offer to study at the Fuel Cell Institute; OR
- iii) Bachelor's Degree with Honours and have a GPA between 2.00-2.49 from Universiti Kebangsaan Malaysia or the equivalent from any institution of

higher learning recognized by the Senate and have at least five (5) years of work experience in a related field. If there is no work experience, the candidate must be a Research Assistant (RA) for a minimum period of one (1) year and show good performance and be confirmed by the supervisor. The institute will also conduct an internal assessment for approval purposes before being given an offer to study at the Fuel Cell Institute.

Admission Requirements to the Doctoral Programme

The minimum admission requirements to the Doctoral programme by research mode offered at the Fuel Cell Institute are considered based on the following criteria:

- i) Bachelor's Degree with Honours and have a CGPA of 3.67 and above from Universiti Kebangsaan Malaysia or the equivalent from any institution of higher learning recognized by the Senate; OR
- ii) Master's degree from Universiti Kebangsaan Malaysia or the equivalent from any institution of higher learning recognized by the Senate

English Language Requirements

1. International candidates must meet the English language requirement as follows:
 - i) Obtain a minimum TOEFL pBT score of 453; OR
 - ii) Obtain a minimum TOEFL iBT score of 46; OR
 - iii) Obtain a minimum TOEFL ITP score of 585; OR
 - iv) Obtain a minimum IELTS score of 5.5; OR
 - v) Obtain a minimum MUET score of band 3.5; OR
 - vi) Obtain a minimum Pearson Test of English score of 51; OR
 - vii) Obtain a minimum Cambridge English Qualifications and Test score of 160
2. International candidates who do not meet the English language competency requirements may be given the following Conditional Offers:
 - i) Students are allowed to attend the internal English Preparatory Course (Progressive English Programme, PEP) at UKM with a maximum period of two (2) years, but students are still subject to the regulations of the Immigration Department of Malaysia which is in force.
3. International candidates originating from a country that uses English as the official language or who have academic qualifications obtained from any institution of higher learning that uses English as the medium of instruction may be fully exempted from condition (a) above.

Application for Admission

Application for admission at the Fuel Cell Institute can be done via the following website: <https://join.ukm.my/>. All documents must be uploaded through the system. Please read the updated application guide carefully.

Course Requirements

1. Master's student must register and pass 6 credits of the following course:
 - 4 credits of RARA6014 Research Methodology (Science and Technology)
 - 2 credits of (any of a course)
 - RARA6022 Hydrogen Energy; OR
 - RARA6032 Energy Management and Policy; OR
 - RARA6042 Fuel Cell Electrochemistry; OR
 - RARA6052 Fuel Cell System and Application

2. Doctoral's student must register and pass 8 credits of the following courses:
 - 4 credits of RARA8014 Advanced Research Methodology (Science and Technology)
 - 4 credits of (any of 2 courses)
 - RARA8022 Advanced Hydrogen Energy; OR
 - RARA8032 Advanced Energy Management and Policy; OR
 - RARA8042 Advanced Fuel Cell Electrochemistry; OR
 - RARA8052 Advanced Fuel Cell System and Application

Manuscript Publication as a Requirement for Graduation

Manuscript publication requirements as a condition of graduation for the research mode graduate studies programmes at the Fuel Cell Institute are shown in the table below:

Manuscript Publication Requirements	
Master of Science (MSc)	Doctor of Philosophy (PhD)
At least 1 article has been accepted for publication in an indexed journal of WoS .	At least 2 articles have been accepted for publication in indexed journals of WoS .

Courses Offered for the Master of Science Programme

RARA6014 Research Methodology

This course aims to provide the background and methods of conducting a scientific research. The research ethics discussed are the research principles and the role of the researcher, misconduct such as plagiarism and others, so that students are able to display good ethics while conducting research. The course emphasizes the basics of manual and online information retrieval techniques, experimental design, data processing and analysis, preparation of research proposals, oral and written presentation of research results, and introduction to research activities at the Fuel Cell Institute, UKM. Data management methods are also taught so that students can benefit in their research. Legal aspects related to intellectual property, security aspects in the workplace, and thesis writing format according to UKM style are also discussed. The evaluation of this course is based on the quality of the written research proposals prepared by students and the presentation of the proposals in the seminar.

Basic Readings:

1. Kornuta, H.M., Germaine R.W. 2019. *A Concise Guide to Writing a Thesis or Dissertation: Educational Research and Beyond*. Second Ed. Routledge.
2. Miles, M.B., Huberman, A.M., Saldana, J.M. 2019. *Qualitative Data Analysis: A Methods Sourcebook*. SAGE Publications Ltd.
3. Efron S.E., Ravid, R. 2018. *Writing the Literature Review: A Practical Guide*. First Ed. The Guilford Press.
4. Ramakrishna, B., Anil Kumar, H.S. 2017. *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers*. First Ed. Notion Press.
5. Talib, O. 2017. *Aplikasi Penulisan Artikel Jurnal*. MPWS.

RARA 6022 Hydrogen Energy

The objective of this course is to give a fundamental introduction to the students on hydrogen energy. Students are introduced with basic overview in utilizing the hydrogen energy during the early stage. Next, the students are also exposed to different methods of fuel processing, hydrogen storage and the use of hydrogen in generating energy. Social issues and safety issues related to the use of hydrogen energy will be discussed as well.

Basic Readings:

1. Dagdougui, H., Sacile, R., Bersani, C., Ouammi, A. 2018. *Hydrogen Infrastructure for Energy Applications: Production, Storage, Distribution and Safety*. London: Academic Press-Elsevier.
2. Sankir, M., Sankir, N.D. 2017. *Hydrogen Production Technologies*. New Jersey: Scrivener Publishing-Wiley.

3. Mirandam, P.E. 2019. *Science and Engineering of Hydrogen-Based Energy Technologies: Hydrogen Production and Practical Applications in Energy Generation*. Oxford: Academic Press-Elsevier.
4. Lanzini, A. Calise, F., Ferrero, D., Santarelli, M., D'Accadia, M.D. 2019. *Solar Hydrogen Production: Processes, Systems and Technologies*. Oxford: Academic Press-Elsevier.

RARA6032 Energy Management and Policy

This course discusses key issues for the policymaking and management of energy on the global context. Various factors such as political, technological, and social that influence policy making and management of energy are also looked into. Interrelated topics such as energy law and economics with respect to energy policy, management, and sustainability are viewed through the lense of a rapidly changing global landscape. Students will be able to evaluate, conclude, and criticize the connections in global energy management and policy making.

Basic Readings:

1. Marc Ozawa, Jonathan Chaplin, Michael Pollitt, David Reiner, Paul Warde (Ed.). 2019. *In Search of Good Energy Policy. Series: Cambridge Studies on Environment, Energy and Natural Resources Governance*. Cambridge University Press. 388 p.
2. *Power Trip: The Story of Energy Hardcover*. 2019. Michael E. Webber. Basic Books. 304 p.
3. Jeremy Rifkin. 2019. *The Green New Deal: Why the Fossil Fuel Civilization Will Collapse by 2028, and the Bold Economic Plan to Save Life on Earth*. St. Martin's Press. 292 p.
4. Walter A. Rosenbaum. 2019. *Environmental Politics and Policy* (11 Ed.). CQ Press. 352 p.
5. IRENA. 2019. *Global Energy Transformation: A Roadmap to 2050*.

RARA6042 Fuel Cell Electrochemistry

This course introduces the general theory of electrochemistry, instrumentation and electrochemical characterization methods for fuel cells. At first, students will be exposed to introductory topics of fuel cells, catalytic materials, conducting membranes and types of fuel cell. Also discussed in this course are basic electrochemical topics, electrocatalyst, thermodynamic of fuel cells and fuel cell redox reactions. Electrochemical analysis methods such as cyclic voltammetry, electrochemical impedance spectroscopy in measuring the catalyst/bio-catalyst performance and fuel cell membranes will also be discussed further in this course. Lastly, students are required to conduct a fuel cell related project and will be evaluated based on presentations and written reports.

Basic Readings:

1. Sorensen, B. & Spazzafumo, G. 2019. *Hydrogen and Fuel Cells. 3rd Edition.* Elsevier/Academic Press.
2. O'Hayre, R., Cha, S-W., Colella, W. & Prinz, F. B. 2016. *Fuel Cell Fundamentals.* John Wiley & Sons.
3. Jiang, S. P., Li, Q. 2021. *Introduction to Fuel Cells: Electrochemistry and Materials.* Springer Singapore.
4. Breitung C., Swider-Lyons K. 2016. *Handbook of Electrochemical Energy.* New York: Springer.
5. Koper, M. & Wieckowski, A. 2019. *Fuel Cell Catalysis: A Surface Science Approach.* Wiley.

RARA6052 Fuel Cell System and Application

The aim of this course is to discuss important topics related to high and low temperature fuel cell systems and their applications in various fields. This course discusses fuel cell concepts, electrochemistry, theories and overview of fuel system for understanding of students. Stack design, performance analysis, water and heat management, control and monitoring as well as fuel cell operating conditions are also described for the understanding in various aspects of fuel cell process system engineering. Current problems and issues in the fuel cell system are described by combining various disciplines to help students to make critical evaluation and explanations on a specific fuel cell system. Students are also exposed to the fuel cell system through the laboratory visit. Finally, students are required to do projects related to the fuel cells and evaluated based on presentations written reports and presentation.

Basic Readings:

1. Albarbar, A., Alrweq, M. 2018. *Proton Exchange Membrane Fuel Cells: Design, Modelling and Performance Assessment Techniques.* Springer International Publishing.
2. Su, H., Gomez, J.C.C., Reddy, H., Sita, C., Pasupathi, S., Bujlo, P. 2016. *Recent Advances in High-Temperature PEM Fuel Cells.* Academic Press.
3. Hacker, V., Mitsushima, S. 2018. *Fuel Cells and Hydrogen: From Fundamentals to Applied Research.* Elsevier.
4. Fergus, J., Hui, R., Li, X., Wilkinson, D.P. & Zhang, J. 2016. *Solid Oxide Fuel Cells: Materials Properties and Performance.* First Ed. Boca Raton: CRC Press.
5. Kaur, G. 2020. *Intermediate-temperature Solid Oxide Fuel Cells: Electrolyte, Electrodes and Interconnects.* Oxord: Elsevier.

Courses Offered for the Doctoral Programme

RARA8014 Advanced Research Methodology

This course aims to describe the method of conducting a scientific research in detail. Research ethics that encompasses research principles, role of researchers, misconduct activities such as plagiarism and others are discussed in depth so that students are able to display the best and professional research ethics. Topics related to research management including manual and online information retrieval techniques, experimental design, processing, analyzing and formulating data, preparation of research proposals, oral and written presentation of research results, and introduction to research activities at the Fuel Cell Institute, UKM are emphasized as well. Data management and statistical methods are also taught so that students can benefit in their research. Legal aspects related to intellectual property, security aspects in the workplace, and thesis writing format according to UKM style are also discussed. The evaluation of this course is based on the quality of the written research proposals prepared by students and the presentation of the proposals in the seminar.

Basic Readings:

6. Kornuta, H.M., Germaine R.W. 2019. *A Concise Guide to Writing a Thesis or Dissertation: Educational Research and Beyond*. Second Ed. Routledge.
7. Miles, M.B., Huberman, A.M., Saldana, J.M. 2019. *Qualitative Data Analysis: A Methods Sourcebook*. SAGE Publications Ltd.
8. Efron S.E., Ravid, R. 2018. *Writing the Literature Review: A Practical Guide*. First Ed. The Guilford Press.
9. Ramakrishna, B., Anil Kumar, H.S. 2017. *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers*. First Ed. Notion Press.
10. Talib, O. 2017. *Aplikasi Penulisan Artikel Jurnal*. MPWS.

RARA8022 Advanced Hydrogen Energy

The objective of this course is to give a further introduction to the students on hydrogen energy. Students are introduced with overview in utilizing the hydrogen energy during the early stage. Next, the students are also exposed to different methods of fuel processing, hydrogen storage and the use of hydrogen in generating energy. The relations of the production process up to the usage of hydrogen will be discussed. Social issues and safety issues related to the use of hydrogen energy will be discussed as well.

Basic Readings:

1. Dagdougui, H., Sacile, R., Bersani, C., Ouammi, A. 2018. *Hydrogen Infrastructure for Energy Applications: Production, Storage, Distribution and Safety*. London: Academic Press-Elsevier.

2. Sankir, M., Sankir, N.D. 2017. *Hydrogen Production Technologies*. New Jersey: Scrivener Publishing-Wiley.
3. Mirandam, P.E. 2019. *Science and Engineering of Hydrogen-Based Energy Technologies: Hydrogen Production and Practical Applications in Energy Generation*. Oxford: Academic Press-Elsevier.
4. Lanzini, A. Calise, F., Ferrero, D., Santarelli, M., D'Accadia, M.D. 2019. *Solar Hydrogen Production: Processes, Systems and Technologies*. Oxford: Academic Press-Elsevier.

RARA8032 Advanced Energy Policy and Management

This course discusses and describes the key issues in depth for the policymaking and management of energy on the broad global context. Various factors such as political, technological, and social that influence policy making and management of energy are also looked into and related to various economical scenarios and energy management. Interrelated topics such as energy law and economics with respect to energy policy, management, and sustainability are viewed through the lense of a rapidly changing global landscape. Students will be able to describe, conclude, and criticize the connections in global energy management and policy making.

Basic Readings:

6. Marc Ozawa, Jonathan Chaplin, Michael Pollitt, David Reiner, Paul Warde (Ed.). 2019. *In Search of Good Energy Policy*. Series: *Cambridge Studies on Environment, Energy and Natural Resources Governance*. Cambridge University Press. 388 p.
7. Power Trip: *The Story of Energy Hardcover*. 2019. Michael E. Webber. *Basic Books*. 304 p.
8. Jeremy Rifkin. 2019. *The Green New Deal: Why the Fossil Fuel Civilization Will Collapse by 2028, and the Bold Economic Plan to Save Life on Earth*. St. Martin's Press. 292 p.
9. Walter A. Rosenbaum. 2019. *Environmental Politics and Policy (11 Ed.)*. CQ Press. 352 p.
10. IRENA. 2019. *Global Energy Transformation: A Roadmap to 2050*.

RARA8042 Advanced Fuel Cell Electrochemistry

This course aims to discuss topics related to advanced electrochemistry in various fuel cell systems. At the early stage, students will be exposed to in-depth concepts and theories related to fuel cell thermodynamics and electrochemical reactions, types of fuel cells, fuel cell components, and fuel cell performances. Advanced electrocatalyst and electrolyte materials for fuel cells, as well as material selection methods for specific electrochemical systems, are also discussed in detail in this

course. Techniques related to electrochemical characterization for these systems will also be discussed for students to interpret and make critical assessments and explanations on the topic.

Basic Readings:

6. Sorensen, B. & Spazzafumo, G. 2019. *Hydrogen and Fuel Cells. 3rd Edition.* Elsevier/Academic Press.
7. O'Hayre, R., Cha, S-W., Colella, W. & Prinz, F. B. 2016. *Fuel Cell Fundamentals.* John Wiley & Sons.
8. Jiang, S. P., Li, Q. 2021. *Introduction to Fuel Cells: Electrochemistry and Materials.* Springer Singapore.
9. Breitkopf C., Swider-Lyons K. 2016. *Handbook of Electrochemical Energy.* New York: Springer.
10. Koper, M. & Wieckowski, A. 2019. *Fuel Cell Catalysis: A Surface Science Approach.* Wiley.

RARA8052 Advanced Fuel Cell System and Application

The aim of this course is to discuss further on important topics related to high and low temperature fuel cell systems and their applications in various fields. Fuel cell concepts will be linked to the fuel cell system in depth to enable students to think critically. Stack design, performance analysis, water and heat management, control and monitoring as well as fuel cell operating conditions are also described and combined with various problems to enable students to evaluate and explain various aspects of fuel cell process system engineering. Current problems and issues in the fuel cell system are described by combining various disciplines to help students to make critical evaluation and explanations on a specific fuel cell system. Students will also be exposed to the fuel cell system through the laboratory visit. Finally, students are required to do projects related to the fuel cells and evaluated based on presentations written reports and presentation.

Basic Readings:

1. Albarbar, A., Alrweq, M. 2018. *Proton Exchange Membrane Fuel Cells: Design, Modelling and Performance Assessment Techniques.* Springer International Publishing.
2. Su, H., Gomez, J.C.C., Reddy, H., Sita, C., Pasupathi, S., Bujlo, P. 2016. *Recent Advances in High-Temperature PEM Fuel Cells.* Academic Press.
3. Hacker, V., Mitsushima, S. 2018. *Fuel Cells and Hydrogen: From Fundamentals to Applied Research.* Elsevier.
4. Fergus, J., Hui, R., Li, X., Wilkinson, D.P. & Zhang, J. 2016. *Solid Oxide Fuel Cells: Materials Properties and Performance.* First Ed. Boca Raton: CRC Press.

5. Kaur, G. 2020. *Intermediate-temperature Solid Oxide Fuel Cells: Electrolyte, Electrodes and Interconnects*. Oxord: Elsevier.

Research Areas

1. Process System Engineering
2. Fuel Cell Plate Material and Manufacture
3. Fuel Cell Electrochemical Process
4. Direct Liquid Fuel Cell
5. Solid Oxide Fuel Cell
6. Biohydrogen and Biofuel Cell
7. Fuel Processing
8. Solar Hydrogen
9. Energy Policy and Management
10. Energy Storage

Conversion from Master Programme to Doctoral Programme

1. Criteria for the application are as follows:
 - a) Master students by research mode (dissertation only), registered in full time basis, are eligible to apply for the conversion to Doctor of Philosophy Program.
 - b) Application should be made before the third semester of study so that the application can be processed, and the result can be announced before the registration date of the fourth semester.
 - c) Students who have accomplished the research objectives for the Master programme (usually in the end of third semester) are not eligible to apply for conversion and are required to complete the Master programme.
 - d) Result of the progress report is satisfactory, and the conversion is approved by the supervisor.
2. Process for the application of conversion:
 - a) The applicant prepares a new research proposal for the Doctor of Philosophy programme which includes:
 - Additional research scope
 - The significance of research
 - Additional research objectives

- Additional time frame of the research
 - New ideas of the new proposed research
 - New findings expected from the research
- b) The application should be submitted to the Director, with the recommendation from the Main supervisor/Chairman of the Supervisory Committee for approval.
 - c) The Postgraduate Status Change Committee (JPSPP) will be formed to examine and evaluate the candidate's proposal.
 - d) Applicant will have to present the Doctor of Philosophy proposal in front of the JPSPP and lecturers.
 - e) JPSPP will express views and comments on the proposal.
 - f) Applicant will have to amend the proposal according to the suggestions given by the committee (JPSPP).
 - g) Applicant then will have to submit the new amended proposal to the Head of Administrative for the approval of the Institute's Academic Committee and the Director of Institute.
 - h) Any decision will be notified to the applicant.

Writing Thesis/Dissertation by Compilation

1. Requirements for thesis/dissertation compilation formats:

- a) The supervisor agrees that the thesis/dissertation of the conducted research is written in the form of compilation.
- b) Students must submit a written application to the Director to write a thesis/dissertation in the form of compilation.
- c) Students have published or their papers have been accepted for publication in well-known journals in the areas recognized by the Institute. However, each discipline requires a different degree of impact to ensure that the quality is equivalent to the Doctorate or Masters degree.
- d) The paper should cover the scope and objectives of the research conducted by the students. Papers presented in conferences or seminars, and papers published in indexed conference proceedings or seminars may only be accepted as publication support materials only.

- e) Requirements and the number of publications is as follows:
- Doctor of Philosophy program:
 - i. At least **FOUR (4)** articles have been published or accepted for publication in the indexed journals of **WoS** with the quartile scores of **Q1/Q2**.
 - ii. **TWO (2)** of the articles in Item (i) **MUST** be published or accepted for publication in the indexed journals of **WoS** with the quartile scores of **Q1**.
 - Master degree program:
 - i. At least **TWO (2)** articles have been published or accepted for publication in the indexed journals of **WoS** with the quartile scores of **Q1/Q2**.
 - ii. **ONE (1)** of the articles in Item (i) **MUST** be published or accepted for publication in the indexed journals of **WoS** with the quartile scores of **Q1**.
- f) Students are required to obtain copyright permission from the publisher of the papers if the student wants to publish a book out of the thesis/dissertation.
- g) The student is the **first** or **corresponding author** for each of the papers in Item (e) and all the papers were written with the supervisor.
- h) Students with more than one affiliation are required to place the Universiti Kebangsaan Malaysia as the first affiliation in their publication.
- i) For local students, where the thesis must be written in Bahasa Melayu except with the permission of the Institute, all the papers can be written and published in the form of the required language. However, candidates need to include a summary of the papers and publication journal information in Bahasa Melayu according to the format in Article 2.

2. The format and contents of the thesis/dissertation are as follows:

- a) A statement that the thesis/dissertation is written according to the compilation format.
- b) List of publications is included as a chapter in the thesis/dissertation.

- c) The entire thesis/dissertation should be prepared according to the writing format of the UKM style.
- d) Introduction Chapter - This chapter gives an introduction to the issues studied and describes the relevance of published papers. This is to ensure the thesis/dissertation is presented in an integrated form.
- e) Chapter of the published papers - Each published paper is required to be presented as a separate chapter in the thesis/dissertation. Abstract papers and journal publication information should be included for the thesis/dissertation written in a language other than the thesis/dissertation language.
- f) Conclusions – This chapter synthesise the findings of the study and provides a comprehensive conclusion on the conducted research.
- g) References - list of references should include references from the Introduction and Conclusion chapter.

PROGRAM PENGAJIAN SISWAZAH (KERJA KURSUS)

Program Sarjana Sains Teknologi Karbon Rendah Dan Hidrogen (Kerja Kursus)

Pengenalan

Program Sarjana Sains Teknologi Karbon Rendah dan Hidrogen bertujuan untuk melahirkan lebih graduan yang berpengetahuan dalam bidang yang berkaitan dengan teknologi karbon rendah dan hidrogen, seterusnya dapat menyumbangkan lebih tenaga kerja mahir dalam bidang demi memastikan kelestarian tenaga sedunia dan alam sekitar yang hangat dibicarakan dalam era Revolusi Industri 4.0 dan ekonomi kitaran. Program ini juga bertujuan untuk memindah pengetahuan bersifat multi-disiplin daripada pakar bidang dan pengamal industry kepada graduan.

Tempoh Pengajian

Sepenuh masa adalah tiga (3) semester

Separuh masa adalah maksimum lapan (8) semester

Hasil Pembelajaran Program

1. Berkebolehan untuk menggunakan pengetahuan tentang teori-teori lanjutan dan kaedah-kaedah kejuruteraan dan sains untuk menyelesaikan masalah kompleks dalam bidang teknologi karbon rendah, tenaga hidrogen serta pengurusan dan dasar tenaga
2. Berkebolehan untuk menganalisis, menilai dan menyelesaikan masalah yang kompleks dengan menggunakan kemahiran saintifik dan pemikiran kritis dalam bidang teknologi karbon rendah, tenaga hidrogen serta pengurusan dan dasar tenaga
3. Berkebolehan untuk menerapkan kemahiran praktikal dan memperkasa daya saing dalam bidang teknologi karbon rendah, tenaga hidrogen serta pengurusan dan dasar tenaga
4. Berkebolehan untuk menghubungkan idea-idea dan isu-isu yang berkaitan dengan kemasyarakatan dan persekitaran serta menyampaikan maklumat atau idea secara profesional
5. Berkebolehan mengadaptasi teknologi maklumat atau teknologi digital dan kemahiran berangka dengan cekap untuk menyokong tugas, projek dan pembelajaran
6. Berkebolehan untuk memimpin dan bekerja secara kolaboratif sebagai sebahagian daripada pasukan yang menjalankan pelbagai peranan yang berbeza

dan bertanggungjawab semasa menjalankan pelbagai aktiviti terhadap rakan sekerja dan pihak berkepentingan

7. Berkebolehan untuk menguasai kemahiran diri dan menunjukkan ciri-ciri keusahawanan melalui pembelajaran dan pembangunan sendiri
8. Berkebolehan untuk melaksanakan tugas, projek dan pelbagai aktiviti dengan bertanggungjawab, berpegang teguh pada kod amalan yang sah, berintegriti, beretika dan professional

Syarat Kemasukan

Syarat kemasukan ke Program Sarjana Sains Teknologi Karbon Rendah dan Hidrogen adalah dipertimbangkan berdasarkan kriteria-kriteria yang ditunjukkan di bawah:

- a) Ijazah Sarjana Muda Kejuruteraan atau Ijazah Sarjana Muda Sains atau Ijazah Sarjana Muda Teknologi dengan PNGK 2.50 dan lebih tinggi dari mana-mana universiti yang diiktiraf; ATAU
- b) Ijazah Sarjana Muda Kejuruteraan atau Ijazah Sarjana Muda Sains atau Ijazah Sarjana Muda Teknologi dengan PNGK 2.00-2.49 dengan sekurang-kurangnya 5 tahun pengalaman bekerja dalam bidang sains dan teknologi setelah memperoleh ijazah untuk pemohon Malaysia atau bukti pengalaman bekerja mesti diperakui oleh kedutaan negara masing-masing untuk pemohon bukan warganegara Malaysia; ATAU
- c) Memenuhi Akreditasi Pembelajaran Pengalaman Sebelumnya (APEL A) untuk calon warganegara Malaysia sahaja:
 - i. umur minimum 30 tahun pada tarikh permohonan
 - ii. lulus Diploma dalam bidang berkaitan atau kelayakan yang setaraf dengannya yang diiktiraf oleh Kerajaan Malaysia dan diluluskan oleh Senat Universiti
 - iii. kelayakan setaraf lain; DAN mempunyai sijil MQA APEL dengan MQF Tahap 7

Keperluan Bahasa Inggeris

1. Calon luar negara mesti memenuhi syarat bahasa Inggeris seperti berikut:
 - i) Mendapat keputusan TOEFL pBT dengan skor minimum 453; ATAU
 - ii) Mendapat keputusan TOEFL iBT dengan skor minimum 46; ATAU
 - iii) Mendapat keputusan TOEFL ITP dengan skor minimum 585; ATAU
 - iv) Mendapat keputusan IELTS dengan skor minimum 5.5; ATAU
 - v) Mendapat keputusan MUET dengan skor minimum Band 3.5; ATAU

- vi) Mendapat keputusan Pearson Test of English dengan skor minimum 51; ATAU
 - vii) Mendapat keputusan Cambridge English Qualifications and Test dengan skor minimum 160
2. Calon antarabangsa yang tidak memenuhi syarat kecekapan berbahasa Inggeris boleh diberikan tawaran bersyarat berikut:
- a) Pelajar dibenarkan mengikuti Kursus Persediaan Bahasa Inggeris dalam (*Progressive English Programme, PEP*) di UKM dengan had tempoh selama dua (2) tahun maksimum, namun pelajar masih tertakluk kepada peraturan Jabatan Imigresen Malaysia yang sedang berkuat kuasa.
3. Calon antarabangsa yang berasal dari negara yang menggunakan Bahasa Inggeris sebagai bahasa rasmi atau yang memiliki kelayakan akademik yang diperoleh dari mana-mana institusi pengajian tinggi yang menggunakan Bahasa Inggeris sebagai bahasa pengantar sepenuhnya boleh dikecualikan daripada syarat (a) di atas.

Permohonan Kemasukan

Permohonan kemasukan ke Institut Sel Fuel boleh dilakukan dengan mengisi borang di atas talian (*online*) melalui <https://join.ukm.my/>. *Semua dokumen sokongan perlu dimuatnaik melalui sistem tersebut. Sila baca panduan permohonan yang dikemaskini dengan teliti.*

Struktur Kurikulum

Kriteria kursus-kursus yang wajib diambil untuk memenuhi jumlah 42 kredit adalah seperti di dalam jadual di bawah:

Taraf Kursus	Bilangan Kursus Ditawarkan	Bilangan Kursus Wajib Diambil	Jumlah Kredit
Kursus Teras Program	5	5	15
Projek (Mini Disertasi)	2 (Projek I dan II)	2	12
Kursus Elektif CESMED Universiti	2	1	3

Kursus Elektif Program	6	4	12
Kursus Audit Universiti	2	1 (<i>pelajar antarabangsa sahaja</i>)	-
Jumlah Kredit			42

Kursus Teras Program (termasuk Projek)

RARE6113 Kaedah Penyelidikan
RARE6123 Polisi dan Pengurusan Tenaga Global
RARE6133 Teknologi Karbon Rendah
RARE6143 Teknologi Hidrogen
RARE6153 Sistem Sel Fuel
RARE6004 Projek I
RARE6008 Projek II

Kursus Elektif Program

RARE6213 Penyimpanan dan Pengangkutan Tenaga
RARE6223 Bahan Tenaga Termaju
RARE6233 Pemodelan dan Pengoptimuman dalam Sistem Tenaga
RARE6243 Keselamatan Proses untuk Teknologi Hidrogen
RARE6253 Ekonomi Kitaran
RARE6263 Elektrokimia untuk Penghasilan Tenaga

Kursus Elektif Keusahawan*

CMIE6213 Inovasi Produk & Keusahawanan
CMIE6013 Keusahawanan Sosial

Kursus Audit Universiti* (Lulus/Gagal)

LMCM1083 Bahasa Melayu Komunikasi Antarabangsa
LMCM1093 Bahasa Melayu untuk Pelajar Nusantara
*Penawaran tertakluk kepada perubahan oleh pusat tanggungjawab

Syarat Pengijazahan

Calon perlu memenuhi jumlah 42 kredit seperti dihuraikan dalam Bahagian Struktur Kurikulum, dengan memperolehi Purat Nilai Gred Keseluruhan (PNGK) ≥ 3.00 supaya dilayakkan untuk pengurniaan ijazah Sarjana Sains Teknologi Karbon Rendah dan Hidrogen. Calon mempunyai peluang untuk memperbaiki gred kursus mengikut Peraturan-peraturan Universiti Kebangsaan Malaysia (Pengajian Siswazah) 2021 (Bahagian 'Penilaian Kursus').

Purata Nilai Gred	Taraf Pencapaian	Kelayakan Meneruskan Pengajian	Kelayakan Pengurnian Ijazah
PNGK \geq 3.00	Lulus	Layak	Layak
2.00 \leq PNGK < 3.00	Lulus Bersyarat	Percubaan	Tidak Layak
PNGK \leq 2.00	Gagal dan Diberhentikan	Tidak Layak	Tidak Layak

Kursus-kursus yang Ditawarkan

RARE6113 Kaedah Penyelidikan

Kursus ini memperkenalkan latar belakang serta kaedah di dalam menjalankan sesebuah penyelidikan saintifik. Antara tajuk yang akan dibahaskan meliputi falsafah dan etika penyelidikan, pencarian maklumat atas talian, reka bentuk eksperimen, analisis jurang penyelidikan dan hipotesis, kaedah analisis kualitatif dan kuantitatif, teknik persembahan data, menganalisis dan merumus data serta kefahaman terhadap harta intelek. Format penulisan tesis menggunakan gaya UKM turut diketengahkan. Di akhir kursus, kebolehan pelajar akan dinilai berdasarkan laporan kajian terhadap topik penyelidikan terpilih.

Bacaan Asas

1. Pourhashemi, A., Deka, S.C. & Haghi, A.K. 2020. *Research Methods and Applications in Chemical and Biological Engineering*. AAP.
2. Kornuta, H.M. & Germaine, R.W. 2019. *A Concise Guide to Writing a Thesis or Dissertation: Educational Research and Beyond*. Second Ed. Routledge.
3. Miles, M.B., Huberman, A.M. & Saldana, J.M. 2019. *Qualitative Data Analysis: A Methods Sourcebook*. SAGE Publications Ltd.
4. Efron, S.E. & Ravid, R. 2018. *Writing the Literature Review: A Practical Guide*. First Ed. The Guilford Press.
5. Martinson, D.G. 2018. *Quantitative Methods of Data Analysis for the Physical Sciences and Engineering*. Cambridge University Press.
6. Ramakrishna, B., Kumar, H.S.A. 2017. *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers*. First Ed. Notion Press.
7. Talib, O. 2017. *Aplikasi Penulisan Artikel Jurnal*. MPWS.

RARE6123 Polisi & Pengurusan Tenaga Global

Kursus ini membincangkan isu-isu utama bagi pembuatan polisi dan pengurusan tenaga dalam konteks global. Pelbagai faktor seperti politik, teknologi, dan sosial yang mempengaruhi pembuatan polisi dan pengurusan tenaga juga diteliti. Topik yang saling kait-mengait antara satu sama lain seperti undang-undang dan ekonomi tenaga berkenaan dengan polisi, pengurusan, dan kelestarian tenaga dilihat melalui lensa landskap global yang cepat berubah. Pelajar akan dapat menilai, membuat kesimpulan, dan mengkritik mengenai hubungan yang terdapat dalam pengurusan dan pembuatan polisi tenaga global.

Bacaan Asas:

1. Marc Ozawa, Jonathan Chaplin, Michael Pollitt, David Reiner, Paul Warde (Ed.). 2019. *In Search of Good Energy Policy*. Series: Cambridge Studies on Environment, Energy and Natural Resources Governance. Cambridge University Press.
2. Michael E. Webber. 2019. *Power Trip: The Story of Energy* (Hardcover). Basic Books.
3. Jeremy Rifkin. 2019. *The Green New Deal: Why the Fossil Fuel Civilization Will Collapse by 2028, and the Bold Economic Plan to Save Life on Earth*. St. Martin's Press.
4. Walter A. Rosenbaum. 2019. *Environmental Politics and Policy* (11 Ed.). CQ Press.
5. IRENA. 2019. *Global Energy Transformation: A Roadmap to 2050*.

RARE6133 Teknologi Karbon Rendah

Kursus ini memberi gambaran keseluruhan tentang peralihan penjanaan tenaga daripada sumber bahan api fosil ke sumber tenaga teknologi karbon rendah. Kursus ini dimulakan dengan tinjauan tenaga dunia serta penyimpanan dan pengurusan tenaga karbon rendah untuk pelbagai jenis proses termasuk tenaga keterbaharuan dan tidak keterbaharuan. Teknologi karbon rendah yang akan dibincangkan merangkumi teknologi sel fuel, pertukaran biojisim kepada biotenaga, tenaga nuklear, suria, hidro, gelombang laut dan geoterma untuk mengurangkan pelepasan gas rumah hijau yang menyebabkan pemanasan global. Pelajar juga akan diperkenalkan dengan pengurusan tenaga bersih mengikut kawasan setempat yang akan termasuk dalam kajian kes. Selain itu, pemahaman terhadap keperluan sistem integrasi antara teknologi-teknologi karbon rendah ini juga akan dibincangkan. Kursus ini juga akan membolehkan pelajar memahami kepentingan teknologi karbon rendah dalam meningkatkan kualiti kehidupan manusia.

Bacaan Asas:

1. Zou, C. 2020. *New Energy*. Singapore: Springer
2. Sharma, A., Shukla, A. & Singh, R. 2020. *Low Carbon Energy Supply Technologies and System*. New York: CRC Press

3. Sharma, A., Shukla, A. & Aye, A. 2018. *Low Carbon Energy Supply*. Singapore: Springer
4. Bhatia, S.C. & Gupta, R.K. 2018. *Textbook of Renewable Energy*. Woodhead Publishing India
5. Ockwell, D. & Mallett, A. 2012. *Low Carbon Technology Transfer: From Rhetoric to Reality*. London and New York: Routledge Taylor and Francis

RARE6143 Teknologi Hidrogen

Kursus ini bertujuan untuk membincangkan topik-topik penting berkaitan teknologi hidrogen. Pada peringkat awal, prinsip asas tenaga hidrogen akan diperkenalkan. Seterusnya, pelajar akan didedahkan dengan penghasilan hidrogen dari pelbagai sumber dan kaedah. Jenis penstoran dan pengangkutan hidrogen akan diuraikan. Isu-isu sosial, ekonomi dan keselamatan berkaitan tenaga hidrogen turut akan dibincangkan. Penggunaan tenaga hidrogen dan isu-isu semasa akan dibahasakan untuk pelajar membuat penilaian dan penerangan secara kritis terhadap tenaga hidrogen.

Bacaan Asas:

1. Basile, A., Dalena, F., Tong, J., & Veziroğlu, T.N. 2017. *Hydrogen Production, Separation and Purification for Energy*. London: The Institution of Engineering & Technology.
2. Mehmet Sankir, M. & Sankir, N.D. 2017. *Hydrogen Production Technologies*. New Jersey: Scrivener Publishing-Wiley.
3. Paulo Emilio Miranda. 2019. *Science and Engineering of Hydrogen-Based Energy Technologies: Hydrogen Production and Practical Applications in Energy Generation*. Oxford: Academic Press-Elsevier.
4. Andrea Lanzini, Francesco Calise, Domenico Ferrero, Massimo Santarelli & Massimo Dentice D'Accadia. 2019. *Solar Hydrogen Production: Processes, Systems and Technologies*. Oxford: Academic Press-Elsevier.

RARE6153 Sistem Sel Fuel

Kursus ini bertujuan untuk membincangkan topik-topik penting berkaitan sistem sel fuel bersuhu tinggi dan rendah dan aplikasinya dalam pelbagai bidang. Pada peringkat awal, konsep, proses elektrokimia dan teori-teori sel fuel akan dibincangkan dan dihubungkan dengan sistem sel fuel. Reka bentuk stek, analisis prestasi, pengurusan air dan haba, kawalan dan pemantauan serta keadaan operasi sel fuel juga diuraikan secara meluas dalam kursus ini untuk membolehkan pelajar memahami pelbagai aspek kejuruteraan sistem proses sel fuel. Masalah-masalah dan isu-isu semasa dalam sistem sel fuel dibahasakan untuk dengan menggabungkan pelbagai disiplin ilmu untuk membantu pelajar membuat penilaian dan penerangan secara kritis terhadap sesuatu sistem sel fuel.

Bacaan Asas:

1. Albarbar, A., Alrweq, M. 2018. Proton Exchange Membrane Fuel Cells: Design, Modelling and Performance Assessment Techniques. Springer International Publishing.
2. Su, H., Gomez, J.C.C., Reddy, H., Sita, C., Pasupathi, S., Bujlo, P. 2016. Recent Advances in High-Temperature PEM Fuel Cells. Academic Press.
3. Hacker, V., Mitsushima, S. 2018. Fuel Cells and Hydrogen: From Fundamentals to Applied Research. Elsevier.
4. Fergus, J., Hui, R., Li, X., Wilkinson, D.P. & Zhang, J. 2016. Solid Oxide Fuel Cells: Materials Properties and Performance. First Ed. Boca Raton: CRC Press.
5. Kendall, K. and Kendall, M. 2016. High-temperature Solid Oxide Fuel Cells for the 21st Century: Fundamentals, Design and Applications. Second Ed. London: Academic Press.

RARE6004 Projek I

Projek I merangkumi kajian kepustakaan, persediaan dan kajian awal serta penulisan laporan tentang tajuk disertasi yang dipilih. Tajuk disertasi perlu berkaitan dengan Teknologi Karbon Rendah dan Hidrogen. Projek penyelidikan yang dijalankan akan diteruskan dalam Projek II. Setiap pelajar akan dibimbing oleh sekurang-kurangnya seorang penyelia.

Bacaan Asas:

1. Blockley, D. 2020. Creativity, Problem Solving and Aesthetics in Engineering: Today's Engineers Turning Dreams into Reality. Springer Nature Switzerland AG.
2. Ranjit, K. 2019. Research Methodology A Step By Step For Beginners. SAGE Publications Ltd.
3. John, W.C., Creswell, J.D. 2018. Research Design Qualitative Quantitative and Mixed Methods Approaches. SAGE Publications Ltd.
4. David, E.G. 2017. Doing Research In The Real World. SAGE Publications Ltd.
5. Fisher, A. 2011. Critical Thinking: An introduction. Cambridge University Press.

RARE6008 Projek II

Projek II adalah penerusan aktiviti penyelidikan yang dijalankan dalam Projek I, Projek II ini melibatkan kerja amali dan/atau pemodelan, analisis data, perbincangan dan kesimpulan hasil penyelidikan. Pelajar dikehendaki untuk menyediakan manuskrip, menulis disertasi dan diikuti dengan pembentangan hasil penyelidikan pada hujung semester.

Bacaan Asas:

1. Blockley, D. 2020. *Creativity, Problem Solving and Aesthetics in Engineering: Today's Engineers Turning Dreams into Reality*. Springer Nature Switzerland AG.
2. Booth, A., Sutton, A., Papaioannou, D. 2016. *Systematic Approaches to a Successful Literature Review*. SAGE Publications Ltd.
3. Fisher, A. 2011. *Critical Thinking: An introduction*. Cambridge University Press.
4. Pfeiffer W.S., 2003. *Technical Writing: A Practical Approach*. Prentice Hall-New Jersey.
5. Taylor, S. 2002. *Essential Communication Skills*. New York: Longman.

RARE6213 Penyimpanan dan Pengangkutan Tenaga

Kursus ini bertujuan memperkenalkan jenis-jenis teknologi yang berkaitan dengan penyimpanan dan pengangkutan tenaga. Pelajar akan juga belajar menggabungkan penyimpanan tenaga dengan sumber tenaga. Topik utama meliputi asas termodinamik, jenis-jenis sistem penyimpanan tenaga, termasuk penyimpanan tenaga dalam mekanikal, elektrokimia, termal, kimia dan hidrogen, pengangkutan tenaga serta integrasi dan aplikasi penyimpanan tenaga.

Bacaan Asas:

1. Kutscher, C.K., Milford, J.B. and Kreith, J. 2019. *Principles of Sustainable Energy Systems (Third Edition)*. Boca Raton: CRC Press
2. Hipple, J. 2017. *Chemical Engineering for Non-Chemical Engineers*. New Jersey: Wiley
3. Santhanam K.S.V., Miri, M.J., Bailey, A.V., Takacs, G.A. 2017. *Introduction to hydrogen technology (2nd edition)*. New Jersey: Wiley.

RARE6223 Bahan Tenaga Termaju

Kursus ini membolehkan pelajar menguasai ilmu dalam memahami sifat-sifat bahan tenaga termaju untuk aplikasi teknologi karbon rendah. Pada peringkat awal, pengenalan, kaedah sintesis dan ciri-ciri bagi bahan termaju berasaskan logam, seramik, polimer dan komposit dibincangkan dan dihubungkan dengan bidang tenaga secara umum. Kaedah pencirian dan analisis yang sesuai diuraikan untuk membolehkan pelajar memahami ciri-ciri penting bahan termaju. Kefahaman dan kemahiran pelajar dinilai melalui Latihan pengoperasian instrumentasi secara maya dijalankan untuk meningkatkan kefahaman dan kemahiran pelajar dalam mengendalikan instrumen.

Bacaan Asas:

1. B.K. Hodge. 2017. *Alternative Energy Systems and Applications* Second Edition. Wiley.
2. Xiao Su-Yi, Shanyi Du, Litong Zhang. 2018. *Composite Materials Engineering Volume 1: Fundamental of Composite Material*. Springer.
3. Jayeeta Chattopadhyay, Rahul Singh, Om Prakash. 2017. *Innovation in Materials Science and Engineering*. Springer International Publishing.
4. Vijay Kumar Thakur, Manju Kumari Thakur, Michael R. Kessler. 2017. *Handbook of Composites From Renewable Materials Volume 8*. Elsevier.
5. Li, Bowen, Jian Li, Shadia Ikhmayies, Mingming Zhang, Yunus Eren Kalay, John S. Carpenter, Jiann-Yang Hwang. 2018. *Characterization of Minerals, Metals, and Materials*. Springer International Publishing
6. Bhushan, Bharat, ed. 2017. *Springer handbook of nanotechnology*. Springer.

RARE6233 Pemodelan dan Pengoptimuman Dalam Sistem Tenaga

Kursus ini akan memperkenalkan pengembangan model reka bentuk, menyelesaikan model dan simulasi serta pengoptimuman sistem tenaga. Pelajar akan didedahkan dengan kaedah pemodelan yang digunakan dalam proses penjanaan tenaga dan pengagihan sistem serta interaksi antara tenaga, ekonomi, dan persekitaran. Kecekapan tenaga, eksergi, dan termodinamik akan diterapkan dalam model sistem. Kursus ini juga akan memperkenalkan penyelesaian melalui simulasi untuk gambarajah proses dan keseimbangan loji menggunakan perisian. Bahagian terakhir memperkenalkan aplikasi pengoptimuman terhadap prestasi dan analisis ekonomi menggunakan kaedah terpilih untuk menyelesaikan masalah pelbagai pemboleh ubah.

Bacaan Asas:

1. Bossel, Hartmut. 2018. *Modeling and Simulation*. CRC Press.
2. Farzaneh, Hooman. 2019. *Energy System Modeling*. Springer.
3. Kunjumammed, L., Kuenzel, S., & Pal, B. 2019. *Simulation of Power System with Renewables*. Elsevier.
4. Sieniutycz, S., & Jezowski, J. 2018. *Energy Optimization in Process Systems and Fuel Cells*. Elsevier.
5. Shkarlet, S., Morozov, A., & Palagin, A. 2020. *Mathematical Modeling and Simulation Systems*. Springer.

RARE6243 Keselamatan Proses untuk Teknologi Hidrogen

Kursus ini bertujuan untuk membincangkan topik-topik penting berkaitan keselamatan proses teknologi hidrogen dalam menangani kemungkinan ancaman dan impak terhadap individu, peralatan dan persekitaran yang dijangka berlaku. Ia merangkumi kajian hidrogen dan aplikasinya kepada masyarakat umum, dan keselamatan analisis risiko. Kursus ini juga akan mendedahkan pelajar terhadap

teknik-teknik utama dalam analisis risiko seperti HAZOP, HIRARC dan FMEA yang boleh digunakan dalam menganalisis proses dalam penghasilan, penyimpanan, pengagihan dan penggunaan hidrogen untuk pelbagai aplikasi. Pelan keselamatan dan analisis risiko penggunaan hidrogen dalam sistem sel fuel juga dihuraikan secara meluas untuk membolehkan pelajar memahami dan melakukan pertimbangan yang baik dan teliti untuk mengenal pasti dan menganalisis kelemahan keselamatan teknologi hidrogen. Prinsip pengurusan, analisis risiko, kajian kes serta kod dan standard turut diperkenalkan agar pelajar mampu membuat penilaian dan perancangan dalam bidang keselamatan teknologi hidrogen.

Bacaan Asas:

1. Alexei Kotchourko & Thomas Jordan. 2020. *Hydrogen Safety for Energy Applications*. Elsevier.
2. Bahr, N. J. 2018. *System Safety Engineering and Risk Assessment: A Practical Approach*, 2 nd Edition. CRC Press.
3. Hallenbeck, W. H. 2018. *Quantitative Risk Assessment for Environmental and Occupational Health*. CRC Press.
4. Hyatt, N. 2018. *Guidelines for Process Hazards Analysis, Hazards Identification & Risk Analysis*. Ontario: CRC Press.
5. Kazunari Sasaki, Hai-Wen Li, Akari Hayashi, Junichiro Yamabe, Teppei Ogura & Stephen M. Lyth. 2016. *Hydrogen Energy Engineering*. Springer Japan.
6. Ostrom L. T., Wilhelmsen, C. A. 2019. *Risk Assessment: Tools, Techniques, and their Applications*. Hoboken: John Wiley & Sons, Inc.
7. Paul Amyotte. 2018. *Hydrogen Safety (Green Chemistry and Chemical Engineering Book 13)* 1st Edition, Kindle Edition. CRC Press.

RARE6253 Ekonomi Kitaran

Kursus ini bertujuan untuk membincangkan topik-topik yang berkaitan dengan ekonomi kitaran bagi teknologi karbon rendah dan tenaga hidrogen dan kesannya terhadap masyarakat, persekitaran dan sumber semula jadi. Pada tahap awal, had penggunaan linear, sejarah, perspektif dan prinsip ekonomi kitaran akan dibincangkan dan dihubungkan dengan ekonomi linear. Penilaian kitaran hayat dalam bidang ini akan dibincangkan untuk mereka bentuk ekonomi kitaran. Kajian kes tentang cara ekonomi kitaran serta penyelesaian kepada sumber tenaga yang terhad juga dijelaskan secara meluas dalam kursus ini untuk membolehkan pelajar memahami pelbagai aspek ekonomi kitaran. Ketersediaan peluang perniagaan melalui ekonomi kitaran dibincangkan dengan menggabungkan pelbagai perspektif dan sifat keusahawanan untuk membantu pelajar membuat penilaian dan penjelasan kritikal mengenai peredaran ekonomi tertentu.

Bacaan Asas:

1. Walter R Stahel. 2020. *The Circular Economy : A User's Guide*. Taylor & Francis Ltd, UK.
2. Ken Webster. 2017. *The Circular Economy: A Wealth of Flows*, 2nd Edition. Ellen MacArthur Foundation Publishing.
3. Mika Sillanpää and Chaker Ncibi. 2019. *The Circular Economy: Case Studies About the Transition from the Linear Economy*. Elsevier Inc.
4. Peter Lacy, Jessica Long and Wesley Spindler. 2020. *The Circular Economy Handbook*. Palgrave Macmillan UK.
5. Catherine Weetman. 2016. *A circular economy handbook for business and supply chains : repair, remake, redesign, rethink*. New York : Kogan Page Ltd.

RARE6263 Elektrokimia untuk Penghasilan Tenaga

Kursus ini bertujuan untuk membincangkan topik-topik berkaitan pelbagai sistem elektrokimia untuk penghasilan tenaga seperti sistem sel fuel, sel elektrolisis, sel photovoltaik, sel fotoelektrokimia dan sel bateri. Pada peringkat awal, kursus ini akan mendedahkan pelajar kepada konsep-konsep dan teori-teori yang berkaitan dengan tindak balas elektrokimia untuk sistem penghasilan tenaga. Komponen-komponen utama dalam sebuah sistem elektrokimia seperti elektromangkin dan elektrolit serta kaedah pemilihan bahan untuk komponen tertentu bagi suatu sistem elektrokimia juga dibincangkan secara terperinci dalam kursus ini. Teknik-teknik berkaitan dengan pencirian elektrokimia untuk sistem-sistem ini juga akan dibahaskan untuk membantu pelajar membuat penilaian dan penerangan secara kritis terhadap sesuatu sistem elektrokimia.

Bacaan Asas:

1. Artur Braun, 2019. *Electrochemical Energy Systems: Foundations, Energy Storage and Conversion*. Walter de Gruyter GmbH, Berlin.
2. Boddula, R. & A. M. Asiri, 2020. *Methods for Electrocatalysis: Advanced Materials and Allied Applications Ed.:* Springer International Publishing.
3. Browne, W. R., 2018. *Electrochemistry Ed.:* Oxford University Press.
4. Geng, D., Y. Cheng & G. Zhang, 2019. *Layered Materials for Energy Storage and Conversion Ed.:* Royal Society of Chemistry.

CMIE6013 Keusahawanan Sosial

Kursus memberi pengetahuan, kemahiran dan pencerahan mengenai keusahawanan sosial dalam komuniti. Pelajar berpeluang memahami dan menghargai keusahawanan sosial dalam komuniti sebagai satu bidang baru dan berpotensi menjana pertumbuhan ekonomi, mengurangkan kemiskinan, memperbaiki taraf sosioekonomi dan kebajikan golongan B40 dan M40 serta membawa perubahan sosioekonomi secara positif. Permasalahan yang berkaitan dengan kemiskinan dilihat sebagai satu peluang penyelesaian masalah yang inovatif sambil menjana pendapatan. Kursus ini menekankan aspek nilai keusahawanan sosial yang mengutamakan

kesejahteraan komuniti sebagai matlamat penubuhan perniagaan, sementara keuntungan hanya sebagai alat mencapai kesejahteraan komuniti.

Bacaan Asas:

1. MacMillan I. C & Thompson. J. D. 2013. *The Social Entrepreneur's Playbook, Expanded Edition: Pressure Test, Plan, Launch and Scale Your Social Enterprise*. Philadelphia: Wharton Digital Press.
2. Paramasivan, C. 2016. *Social Entrepreneurship*. New Delhi: New Century Publications.
3. Ridley-Duff, R & Bull, M. 2015. *Understanding Social Enterprise: Theory and Practice*. Edisi ke-2. USA: SAGE Publications Ltd.
4. Schwartz, B. 2012. *Rippling: How Social Entrepreneurs Spread Innovation Throughout the World*. San Francisco: Jossey Bass.
5. Yunus, M. 2011. *Building Social Business: The New Kind of Capitalism that Serves Humanity's Most Pressing Needs*. New York: Public Affairs.

CMIE6213 Inovasi Produk dan Keusahawanan

Kursus ini bertujuan membimbing pelajar untuk merancang penubuhan perniagaan. Ia memberi kemahiran meninjau dan mengaplikasi faktor-faktor luaran yang mempengaruhi perniagaan. Faktor diaplikasikan dari sudut dalaman melalui empat fungsi perniagaan (kewangan, pemasaran, pengeluaran dan sumber manusia). Kursus ini mensintesis kemahiran menghasilkan rancangan perniagaan melalui tuntas bicara kepada pembiayaan dan pelabur yang berpotensi. Pelajar dibimbing untuk membina rancangan perniagaan berasaskan pengetahuan dan pengalaman tentang persekitaran ekonomi dan penerokaan peluang perniagaan.

Bacaan Asas:

1. Ashton, R. 2012. *How to Start your own Business for Entrepreneurs*. Edisi ke-2. London: Pearson Education.
2. Bessant, J. & Tidd, J. 2015. *Innovation and Entrepreneurship*. Edisi ke-3. New York: Wiley.
3. Mullins J., 2013. *The New Business Road Test: What Entrepreneurs and Executives Should Do Before Writing a Business Plan*. Edisi ke-4. London: FT Press.
4. Shapiro, R.M. & Barker, J. 2014. *Perfecting Your Pitch: How to Succeed in Business and in Life by Finding Words That Work*. New York: Plume.
5. Westfall, C. 2012. *The New Elevator Pitch*. Dallas: Marie Street Press.

GRADUATE STUDIES PROGRAMME (COURSEWORK)

Master of Science In Low Carbon And Hydrogen Technology (Coursework)

Introduction

The Master of Science in Low Carbon and Hydrogen Technology is aimed to fulfil the market demand for skilled workers trained in low carbon and hydrogen technology following the global trend in achieving the energy and environmental sustainability which is a hot debate in the era of industrial revolution 4.0 and circular economy. Also, it is aimed to transfer multidisciplinary-based knowledge from subject matter experts and industrial practitioners to the students.

Duration of Studies

The duration on a full-time basis is three (3) semesters

The duration on a part-time basis is with the maximum of eight (8) semesters.

Program Learning Outcome

1. Ability to demonstrate knowledge of advanced theories and methods of engineering and science to solve complex problems in the field of low carbon technology, hydrogen energy as well as energy management and policy.
2. Ability to analyze, evaluate and solve complex problems using the scientific skill and critical thinking in the field of low carbon technology, hydrogen energy as well as energy management and policy.
3. Ability to apply practical skill and empowering competitiveness in the field of low carbon technology, hydrogen energy as well as energy management and policy.
4. Ability to connect ideas and issues related to society and the environment as well as communicate information or ideas professionally.
5. Ability to use information technology or digital technology and numerical skills competently to support assignments, projects, and learning.
6. Ability to lead and work collaboratively as part of a team that carries out a variety of different roles and be responsible while carrying out various activities towards colleagues and stakeholders.
7. Ability to master personal skills and demonstrate entrepreneurship characteristics through self-learning and self-development.
8. Able to perform assignments, projects, and various activities responsibly, adhere to the valid code of conduct, high integrity, ethics, and professionalism.

Admission Requirements

Admission to the Master of Science in Low Carbon and Hydrogen Technology program is considered based on the criteria shown below:

- a) Bachelor's Degree with Honors and have a CGPA of 2.75 and above from Universiti Kebangsaan Malaysia or equivalent from any institution of higher learning recognized by the Senate; OR
- b) Bachelor's Degree with Honors and have a CGPA between 2.50-2.74 from Universiti Kebangsaan Malaysia or equivalent from any institution of higher learning recognized by the Senate and have at least 1 year working experience in a related field. If there is no working experience, the candidate must be a Research Assistant (RA) for a minimum period of 6 months and show a good performance and certified by the supervisor; OR
- c) Bachelor's Degree with Honors and have a CGPA between 2.00-2.49 from Universiti Kebangsaan Malaysia or equivalent from any institution of higher learning recognized by the Senate with at least 5 years working experience in a related field. If there is no work experience, the candidate must be a Research Assistant (RA) for a minimum period of 1 year and show a good performance and certified by the supervisor.

English Language Requirements

1. International candidates must meet the English language requirements as follows:
 - i) Obtain a minimum TOEFL pBT score of 453; OR
 - ii) Obtain a minimum TOEFL iBT score of 46; OR
 - iii) Obtain a minimum TOEFL ITP score of 585; OR
 - iv) Obtain a minimum IELTS score of 5.5; OR
 - v) Obtain a minimum MUET score of band 3.5; OR
 - vi) Obtain a minimum Pearson Test of English score of 51; OR
 - vii) Obtain a minimum Cambridge English Qualifications and Test score of 160
2. International candidates who do not meet the English language competency requirements may be given the following Conditional Offers:
 - iii) Students are allowed to attend the internal English Preparatory Course (Progressive English Programme, PEP) at UKM with a maximum period of two (2) years, but students are still subject to the regulations of the Immigration Department of Malaysia which is in force.
3. International candidates originating from a country that uses English as the official language or who have academic qualifications obtained from any

institution of higher learning that uses English as the medium of instruction may be fully exempted from condition (a) above.

Application for Admission

Application for admission at the Fuel Cell Institute can be done by filling in the online form through <https://join.ukm.my/>. All documents must be uploaded through the system. Please read the updated application guide carefully.

Curriculum Structure

The candidate is compulsory to fulfil a total of 42 credits with the courses selection criteria as shown as below:

Course Status	Number of courses offered	Number of courses to be registered	Total credits
Program compulsory course	5	5	15
Project (mini dissertation)	2 (Project I dan II)	2	12
Elective course (entrepreneurship)	2	1	3
Elective course	6	4	12
University audit course	2	1 (<i>for international students only</i>)	-
Total credits			42

Program Core Courses (include project)

RARE6113 Research Methodology
 RARE6123 Policy & Management of Global Energy
 RARE6133 Low Carbon Technology
 RARE6143 Hydrogen Technology
 RARE6153 Fuel Cell System
 RARE6004 Project I
 RARE6008 Project II

Program Elective Courses

RARE6213 Energy Storage and Transportation
 RARE6223 Advanced Energy Materials
 RARE6233 Modeling and Optimization in Energy System

RARE6243 Process Safety for Hydrogen Technology
 RARE6253 Circular Economy
 RARE6263 Electrochemistry for Energy Generation

Elective course (entrepreneurship)*

CMIE6213 Product Innovation and Entrepreneurship
 CMIE6013 Social Entrepreneurship

University audit course (Pass/Fail)*

LMCM1083 Bahasa Melayu Komunikasi Antarabangsa
 LMCM1093 Bahasa Melayu untuk Pelajar Nusantara

**The course offered is subjected to alteration by the Responsibility Center*

Graduation Requirements

The candidate needs to fulfill a total of 42 credits as described under the ‘Curriculum Structure’ section and obtain the cumulative grade point average (CGPA) ≥ 3.00 to be eligible for the conferment of Master of Science in Low Carbon and Hydrogen Technology. The candidate has the chance to improve the CGPA following the guideline in Universiti Kebangsaan Malaysia Regulation (Graduate Studies) 2021.

Grade Point Average	Achievement Level	Eligibility and Continuation of Study	Eligibility of Degree Conferment
CGPA ≥ 3.00	Pass	Eligible	Eligible
$2.00 \leq \text{CGPA} < 3.00$	Conditional pass	Probation	Not Eligible
CGPA ≤ 2.00	Failed and Dismissed	Not Eligible	Not Eligible

Courses Offered

RARE6113 Research Methodology

This course introduces the background and methods in conducting scientific research. The topics will be discussed include research philosophy and ethics, online information retrieval techniques, experimental design, research gap analysis and hypothesis, qualitative and quantitative analysis, data presentation techniques, data analysis and summary as well as the understanding on intellectual property. Thesis writing format using UKM style is also highlighted. At the end of this course, the student will be assessed based on the research report related to the selected research topic.

Basic Readings:

1. Pourhashemi, A., Deka, S.C. & Hagi, A.K. 2020. *Research Methods and Applications in Chemical and Biological Engineering*. AAP.
2. Kornuta, H.M. & Germaine, R.W. 2019. *A Concise Guide to Writing a Thesis or Dissertation: Educational Research and Beyond*. Second Ed. Routledge.
3. Miles, M.B., Huberman, A.M. & Saldana, J.M. 2019. *Qualitative Data Analysis: A Methods Sourcebook*. SAGE Publications Ltd.
4. Efron, S.E. & Ravid, R. 2018. *Writing the Literature Review: A Practical Guide*. First Ed. The Guilford Press.
5. Martinson, D.G. 2018. *Quantitative Methods of Data Analysis for the Physical Sciences and Engineering*. Cambridge University Press.
6. Ramakrishna, B., Kumar, H.S.A. 2017. *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers*. First Ed. Notion Press.
7. Talib, O. 2017. *Aplikasi Penulisan Artikel Jurnal*. MPWS.

RARE6123 Policy & Management of Global Energy

This course discusses key issues for the policymaking and management of energy on the global context. Various factors such as political, technological, and social that influence policy making, and management of energy are also looked into. Interrelated topics such as energy law and economics with respect to energy policy, management, and sustainability are viewed through the lense of a rapidly changing global landscape. Students will be able to evaluate, conclude, and criticize the connections in global energy management and policy making.

Basic Readings:

1. Marc Ozawa, Jonathan Chaplin, Michael Pollitt, David Reiner, Paul Warde (Ed.). 2019. *In Search of Good Energy Policy*. Series: Cambridge Studies on Environment, Energy and Natural Resources Governance. Cambridge University Press.
2. Michael E. Webber. 2019. *Power Trip: The Story of Energy* (Hardcover). Basic Books.
3. Jeremy Rifkin. 2019. *The Green New Deal: Why the Fossil Fuel Civilization Will Collapse by 2028, and the Bold Economic Plan to Save Life on Earth*. St. Martin's Press.
4. Walter A. Rosenbaum. 2019. *Environmental Politics and Policy* (11 Ed.). CQ Press.
5. IRENA. 2019. *Global Energy Transformation: A Roadmap to 2050*.

RARE6133 Low Carbon Technology

This course provides an overview of the transition of energy generation from fossil fuel sources to low carbon technology energy sources. The course begins with a world energy outlook as well as low carbon energy storage and management for various processes in the field of renewable energy and non-renewable energy. The low carbon technologies that will be discussed include fuel cell technology, the conversion of biomass to bioenergy, nuclear, solar, hydro, ocean waves and geothermal to reduce greenhouse gas emissions that cause global warming. Students will also be introduced to clean energy management according to local areas which will be included in case study. Furthermore, the understanding towards the need of system integration between the different low carbon technologies will be discussed. This course will also enable students to understand the importance of low carbon technology in improving the quality of human life.

Basic Readings:

1. Zou, C. 2020. *New Energy*. Singapore: Springer
2. Sharma, A., Shukla, A. & Singh, R. 2020. *Low Carbon Energy Supply Technologies and System*. New York: CRC Press
3. Sharma, A., Shukla, A. & Aye, A. 2018. *Low Carbon Energy Supply*. Singapore: Springer
4. Bhatia, S.C. & Gupta, R.K. 2018. *Textbook of Renewable Energy*. Woodhead Publishing India
5. Ockwell, D. & Mallett, A. 2012. *Low Carbon Technology Transfer: From Rhetoric to Reality*. London and New York: Routledge Taylor and Francis

RARE6143 Hydrogen Technology

This course aims to discuss important topics related to hydrogen technology. Initially, the basic principles of hydrogen energy will be introduced. Next, students will be introduced to hydrogen production from a variety of sources and methods. Types of hydrogen storage and transport will be described. Social, economic and security issues related to hydrogen energy will also be explored. The application of hydrogen energy and related current issues will be discussed for students to make a critical assessment and explanation of hydrogen energy.

Basic Readings:

5. Basile, A., Dalena, F., Tong, J., & Veziroğlu, T.N. 2017. *Hydrogen Production, Separation and Purification for Energy*. London: The Institution of Engineering & Technology.
6. Mehmet Sankir, M. & Sankir, N.D. 2017. *Hydrogen Production Technologies*. New Jersey: Scrivener Publishing-Wiley.
7. Paulo Emilio Miranda. 2019. *Science and Engineering of Hydrogen-Based Energy Technologies: Hydrogen Production and Practical Applications in Energy Generation*. Oxford: Academic Press-Elsevier.

8. Andrea Lanzini, Francesco Calise, Domenico Ferrero, Massimo Santarelli & Massimo Dentice D'Accadia. 2019. *Solar Hydrogen Production: Processes, Systems and Technologies*. Oxford: Academic Press-Elsevier.

RARE6153 Fuel Cell System

This course aims to discuss important topics related to high and low temperature fuel cell systems and their applications in various fields. At an early stage, fuel cell concepts, electrochemistry process and their theories will be discussed and linked to the fuel cell system. Stack design, performance analysis, water and heat management, control and monitoring as well as fuel cell operating conditions are also described extensively in this course to enable students to understand various aspects of fuel cell process system engineering. Current problems and issues in the fuel cell system are discussed by combining various disciplines to help students to make critical evaluation and explanations on a specific fuel cell system.

Basic Readings:

1. Albarbar, A., Alrweq, M. 2018. *Proton Exchange Membrane Fuel Cells: Design, Modelling and Performance Assessment Techniques*. Springer International Publishing.
2. Su, H., Gomez, J.C.C., Reddy, H., Sita, C., Pasupathi, S., Bujlo, P. 2016. *Recent Advances in High-Temperature PEM Fuel Cells*. Academic Press.
3. Hacker, V., Mitsushima, S. 2018. *Fuel Cells and Hydrogen: From Fundamentals to Applied Research*. Elsevier.
4. Fergus, J., Hui, R., Li, X., Wilkinson, D.P. & Zhang, J. 2016. *Solid Oxide Fuel Cells: Materials Properties and Performance*. First Ed. Boca Raton: CRC Press.
5. Kendall, K. and Kendall, M. 2016. *High-temperature Solid Oxide Fuel Cells for the 21st Century: Fundamentals, Design and Applications*. Second Ed. London: Academic Press.

RARE6004 Project I

Project I covers literature review, preparation and initial research as well as report writing of chosen dissertation title. The dissertation title should be related to Low Carbon and Hydrogen Technology. The research project will be resumed in Project II. Every student will be supervised by at least one supervisor.

Basic Readings:

1. Blockley, D. 2020. *Creativity, Problem Solving and Aesthetics in Engineering: Today's Engineers Turning Dreams into Reality*. Springer Nature Switzerland AG.

2. Ranjit, K. 2019. *Research Methodology A Step By Step For Beginners*. SAGE Publications Ltd.
3. John, W.C., Creswell, J.D. 2018. *Research Design Qualitative Quantitative and Mixed Methods Approaches*. SAGE Publications Ltd.
4. David, E.G. 2017. *Doing Research In The Real World*. SAGE Publications Ltd.
5. Fisher, A. 2011. *Critical Thinking: An introduction*. Cambridge University Press.

RARE6008 Projek II

Project II is the continuation of the research work that was conducted in Project I. This project involves experimental and/or modelling works, data analysis, discussion, and summary of the research results. Students are required to prepare manuscript, write dissertation, and followed by presentation on the research outcomes at the end of the semester.

Basic Readings:

1. Blockley, D. 2020. *Creativity, Problem Solving and Aesthetics in Engineering: Today's Engineers Turning Dreams into Reality*. Springer Nature Switzerland AG.
2. Booth, A., Sutton, A., Papaioannou, D. 2016. *Systematic Approaches to a Successful Literature Review*. SAGE Publications Ltd.
3. Fisher, A. 2011. *Critical Thinking: An introduction*. Cambridge University Press.
4. Pfeiffer W.S., 2003. *Technical Writing: A Practical Approach*. Prentice Hall-New Jersey.
5. Taylor, S. 2002. *Essential Communication Skills*. New York: Longman.

RARE6213 Energy Storage and Transportation

The purpose of this course is to introduce the technologies that are related to energy storage and transportation. Students will also learn to integrate the energy storage with the source of energy. The main topics cover basic thermodynamics, the types of energy storage system, including mechanical, electrochemical, thermal, chemical and hydrogen energy storage, energy transportation as well as energy storage integration and applications.

Basic Readings:

1. Kutscher, C.K., Milford, J.B. and Kreith, J. 2019. *Principles of Sustainable Energy Systems (Third Edition)*. Boca Raton: CRC Press
2. Hipple, J. 2017. *Chemical Engineering for Non-Chemical Engineers*. New Jersey: Wiley

3. Santhanam K.S.V., Miri, M.J., Bailey, A.V., Takacs, G.A. 2017. Introduction to hydrogen technology (2nd edition). New Jersey: Wiley.

RARE6223 Advanced Energy Materials

This course enables students to master the knowledge in understanding the properties of advanced energy materials for low carbon technology applications. Initially, the introduction, synthesis methods and characteristics of advanced materials based on metals, ceramics, polymers, and composites are discussed and related to the field of energy in general. Characterization and analysis methods of advanced energy materials are also described to enable students to know the important characteristics of advanced energy materials. Virtual instrumentation operation training that will be conducted to enhance students' understanding and skill in operating instruments.

Basic Readings:

1. B.K. Hodge. 2017. *Alternative Energy Systems and Applications* Second Edition. Wiley.
2. Xiao Su-Yi, Shanyi Du, Litong Zhang. 2018. *Composite Materials Engineering Volume 1: Fundamental of Composite Material*. Springer.
3. Jayeeta Chattopadhyay, Rahul Singh, Om Prakash. 2017. *Innovation in Materials Science and Engineering*. Springer International Publishing.
4. Vijay Kumar Thakur, Manju Kumari Thakur, Michael R. Kessler. 2017. *Handbook of Composites From Renewable Materials Volume 8*. Elsevier.
5. Li, Bowen, Jian Li, Shadia Ikhmayies, Mingming Zhang, Yunus Eren Kalay, John S. Carpenter, Jiann-Yang Hwang. 2018. *Characterization of Minerals, Metals, and Materials*. Springer International Publishing.
6. Bhushan, Bharat, ed. 2017. *Springer handbook of nanotechnology*. Springer.

RARE6233 Modeling and Optimization in Energy System

This course will introduce the development of the design model, solving the model and simulation as well as optimization of energy systems. Students will be exposed to the methods of modeling used in the energy generation process and system distribution as well as the interaction between energy, economy, and environment. Energy efficiency, exergy, and thermodynamics will be applied in the system model. This course will also introduce the solution via simulation for process diagram and balance of plant using the software. The last section introduces the application of optimization towards performance and economic analysis using selected methods to solve multi-variable problems.

Basic Readings:

1. Bossel, Hartmut. 2018. *Modeling and Simulation*. CRC Press.
2. Farzaneh, Hooman. 2019. *Energy System Modeling*. Springer.

3. Kunjumammed, L., Kuenzel, S., & Pal, B. 2019. *Simulation of Power System with Renewables*. Elsevier.
4. Sieniutycz, S., & Jezowski, J. 2018. *Energy Optimization in Process Systems and Fuel Cells*. Elsevier.
5. Shkarlet, S., Morozov, A., & Palagin, A. 2020. *Mathematical Modeling and Simulation Systems*. Springer.

RARE6243 Process Safety for Hydrogen Technology

This course aims to discuss important topics related to the safety of hydrogen technology processes in dealing with possible threats and impacts on individuals, equipment, and the expected environment. It covers the study of hydrogen and its application to the general public, and the safety of risk analysis. This course will also expose students to the key risk analysis techniques namely HAZOP, HIRARC and FMEA. Safety plans and risk analysis of hydrogen use in fuel cell systems are also extensively described to enable students to understand and make good and thorough judgments to identify and analyze the safety vulnerabilities of hydrogen technology. In addition, this course also exposes students to safety and risk assessment in the process of production, storage, distribution, and use of hydrogen as a source of power in vehicles and daily. Management principles, risk analysis, case studies as well as codes and standards are also introduced so that students are able to make assessments and planning in the field of hydrogen technology safety.

Basic Readings:

1. Alexei Kotchourko & Thomas Jordan. 2020. *Hydrogen Safety for Energy Applications*. Elsevier.
2. Bahr, N. J. 2018. *System Safety Engineering and Risk Assessment: A Practical Approach*, 2nd Edition. CRC Press.
3. Hallenbeck, W. H. 2018. *Quantitative Risk Assessment for Environmental and Occupational Health*. CRC Press.
4. Hyatt, N. 2018. *Guidelines for Process Hazards Analysis, Hazards Identification & Risk Analysis*. Ontario: CRC Press.
5. Kazunari Sasaki, Hai-Wen Li, Akari Hayashi, Junichiro Yamabe, Teppei Ogura & Stephen M. Lyth. 2016. *Hydrogen Energy Engineering*. Springer Japan.
6. Ostrom L. T., Wilhelmsen, C. A. 2019. *Risk Assessment: Tools, Techniques, and their Applications*. Hoboken: John Wiley & Sons, Inc.
7. Paul Amyotte. 2018. *Hydrogen Safety (Green Chemistry and Chemical Engineering Book 13)* 1st Edition, Kindle Edition. CRC Press.

RARE6253 Circular Economy

This course aims to discuss topics related to the circular economy of low carbon technology and hydrogen energy and its impact on human society, environment, and

natural resources. Initially, the limits of linear consumptions, history, perspectives, and principles of circular economic will be discussed and linked to linear economy. Life cycle assessment will be discussed for designing circular economy in this field. Case studies on how the circular economy works as well as solutions to energy shortage are extensively explained. The readiness business opportunities by the circular economy are discussed by combining various perspectives and entrepreneurial traits to help students make critical assessments and explanations of specific economic circulation.

Basic Readings:

1. Walter R Stahel. 2020. *The Circular Economy : A User's Guide*. Taylor & Francis Ltd, UK.
2. Ken Webster. 2017. *The Circular Economy: A Wealth of Flows*, 2nd Edition. Ellen MacArthur Foundation Publishing.
3. Mika Sillanpää and Chaker Ncibi. 2019. *The Circular Economy: Case Studies About the Transition from the Linear Economy*. Elsevier Inc.
4. Peter Lacy, Jessica Long and Wesley Spindler. 2020. *The Circular Economy Handbook*. Palgrave Macmillan UK.
5. Catherine Weetman. 2016. *A circular economy handbook for business and supply chains : repair, remake, redesign, rethink*. New York : Kogan Page Ltd.

RARE6263 Electrochemistry for Energy Generation

This course aims to discuss topics related to various electrochemical systems for energy production such as fuel cells, electrolysis cells and batteries. In the beginning, student will be exposed to the concepts and theories related to electrochemical reactions for energy generation. The main components in an electrochemical cell, such as electrocatalysts and electrolytes as well as the selection of the materials for the component will be discussed in detail in this course. The techniques related to electrochemical characterisations for these energy systems will be discussed to enable student to make critical assessments and explanation on it.

Basic Readings:

1. Artur Braun, 2019. *Electrochemical Energy Systems: Foundations, Energy Storage and Conversion*. Walter de Gruyter GmbH, Berlin.
2. Boddula, R. & A. M. Asiri, 2020. *Methods for Electrocatalysis: Advanced Materials and Allied Applications Ed.:* Springer International Publishing.
3. Browne, W. R., 2018. *Electrochemistry Ed.:* Oxford University Press.
4. Geng, D., Y. Cheng & G. Zhang, 2019. *Layered Materials for Energy Storage and Conversion Ed.:* Royal Society of Chemistry.

CMIE6013 Social Entrepreneurship

The course provides knowledge, skills, and enlightenment about social entrepreneurship in the community. Students have the opportunity to understand and appreciate social entrepreneurship in the community as a new field and the potential to generate economic growth, reducing poverty, improving the socio-economic status and welfare of B40 and M40 as well as bringing positive socio-economic changes. The problems related to poverty are seen as innovative problem-solving opportunities while generating income. This course emphasizes the value of social entrepreneurship that promotes the welfare of the community as the objective of the business, while profit is only a tool to achieve community wellbeing.

Basic Readings:

1. MacMillan I. C & Thompson. J. D. 2013. *The Social Entrepreneur's Playbook, Expanded Edition: Pressure Test, Plan, Launch and Scale Your Social Enterprise*. Philadelphia: Wharton Digital Press.
2. Paramasivan, C. 2016. *Social Entrepreneurship*. New Delhi: New Century Publications.
3. Ridley-Duff, R & Bull, M. 2015. *Understanding Social Enterprise: Theory and Practice*. Edisi ke-2. USA: SAGE Publications Ltd.
4. Schwartz, B. 2012. *Rippling: How Social Entrepreneurs Spread Innovation Throughout the World*. San Francisco: Jossey Bass.
5. Yunus, M. 2011. *Building Social Business: The New Kind of Capitalism that Serves Humanity's Most Pressing Needs*. New York: Public Affairs.

CMIE6213 Product Innovation and Entrepreneurship

This course aims to guide students to design the establishment of business. It provides expertise to review and apply the external factors that affect the business. Factors are applied from the inner corner through four business functions (finance, marketing, production, and human resources). This course synthesizes the skill to produce a business plan through a pitching to potential financiers and investors. Students are taught to build a business plan based on knowledge and experience about the economic environment and the exploration of business opportunities.

Basic Readings:

1. Ashton, R. 2012. *How to Start your own Business for Entrepreneurs*. Edisi ke-2. London: Pearson Education.
2. Bessant, J. & Tidd, J. 2015. *Innovation and Entrepreneurship*. Edisi ke-3. New York: Wiley.
3. Mullins J., 2013. *The New Business Road Test: What Entrepreneurs and Executives Should Do Before Writing a Business Plan*. Edisi ke-4. London: FT Press.
4. Shapiro, R.M. & Barker, J. 2014. *Perfecting Your Pitch: How to Succeed in Business and in Life by Finding Words That Work*. New York: Plume.

5. Westfall, C. 2012. *The New Elevator Pitch*. Dallas: Marie Street Press.

Maklumat Tambahan/ *Additional Information*

Untuk maklumat lanjut boleh didapati di laman web Pusat Siswazah:
(<http://www.ukm.my/pusatsiswazah/peraturan-ukm/>)

For further information can be found on Graduate Center Website:
(<http://www.ukm.my/pusatsiswazah/peraturan-ukm/>)

FUEL CELL

For further information:

Institut Sel Fuel

Fuel Cell Institute

Universiti Kebangsaan Malaysia

UKM Bangi, 43600 Selangor

Tel: +603-8911 8031

Fax: +603-8911 8530

Email: selfuel@ukm.edu.my