澳門大學 UNIVERSIDADE DE MACAU UNIVERSITY OF MACAU

持續進修中心 Centro de Educação Contínua Centre for Continuing Education

SKL-IOTSC 智慧城市物聯網國家重點實驗室(澳門大學)

澳電 cem

Power System Engineering Training Towards Carbon Neutrality
電力系統邁向碳中和培訓課程

Course Objectives

The course “Power System Engineering Training Towards Carbon Neutrality” is designed for electrical engineers who are keen to understand and to contribute toward global target of net-carbon zero by 2050. The training course will provide a holistic view of different elements and various aspects to construction, maintain and operate a net-carbon-zero power system. Recap of traditional power system knowledge, extending to focus on zero-carbon implication will be emphasized. Complementary teaching in modern generation, AMI, asset management and artificial intelligent will also form part of the course.

Course Highlights

- Guest speakers from Companhia de Electricidade de Macau - CEM, S.A. (CEM) will be invited to participate in each module, to share their expertise and insights which will greatly enhance the learning experience for the participants;
- A field trip/visit to relevant facilities in the Greater Bay area will be organized, which will provide a fantastic opportunity for the participants to further deepen their understanding and practical knowledge in the area.

Course Details

Application Deadline	2024/8/23
Lecture Date(s) / Time	2024/8/31 - 2025/4/12 (Saturday) 09:30-13:30 & 14:30 - 17:30
Instructing Language	English
Lecture Hours	87 hours
Tuition Fee	MOP24,900 (non-refundable)
Target Students	Macao residents who are already engaged in or are aspiring to engage in related field in Macao
Application Requirement	♦ Holder of Macao resident identity cards ♦ Holding a bachelor’s degree in Electrical or Electromechanical Engineering (priority will be given to CAEU Registered Engineers) ***Applicants are subject to selection for admission***
How to Apply	Register on the website of the Centre for Continuing Education of the University of Macau and upload the following electronic files to the registration system: 1. Copy of valid Macau Resident Identity Card 2. Copy of supporting documents for bachelor’s degree or above in Electrical or Electro-mechanical Engineering or similar field 3. Copy of supporting documents for CAEU Registered Engineers (priority condition)

Website： https://cce.um.edu.mo/ Phone： 8822-4545 Email： cce.enquiry@um.edu.mo Fax： 2883-8321

Updated on: 2024/08/13

For Course Details, Application Procedures, and Notices

Course Schedule

Date	Day of Week	Time	Venue
31/08/2024	Saturday	9am-1:30pm & 2:30pm-5:30pm	University of Macau
14/09/2024	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
28/09/2024	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
19/10/2024	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
09/11/2024	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
30/11/2024	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
14/12/2024	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
18/01/2025	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
15/02/2025	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
08/03/2025	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
29/03/2025	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
12/04/2025	Saturday	9:30am-1:30pm & 2:30pm-5:30pm	University of Macau
TBC	Saturday	TBC	Field trip/utility visit (s) in the Greater Bay Area

【Application will be closed once all seats are filled】

For seat reservation, please fill out the online application form and you will be confirmed by email.

【Alumni and Retired Staff Privilege】

Cardholders of "UM Alumni Card" or "UM Retired Staff Card" can enjoy a **20% discount** on tuition fee. Quota for this offer is limited for each course and is available on a first-come-first-served basis. CCE reserves the right to make final judgment on the dispute and otherwise in respect of this offer. For any enquiries, please contact us.

【CEM staff and Macau residents Discount】

"CEM staff" or "Macau residents" can enjoy a **10% discount** on tuition fee. CCE reserves the right to make final judgment on the dispute and otherwise in respect of this offer. For any enquiries, please contact us.

Course Outline

Date	Topic	Remarks
August 31 2024	**Electrical Energy System Fundamentals** a. Power system layout, generation, transmission, distribution and services structure, interconnected power system. System fault level, series/ parallel operation of electrical apparatus. b. Roles of substation, circuits, transformer, supply point interface and smart meter. Load and no-load making devices, fault and non-fault making devices. Fault breaking devices and compliance with fault level. HRC Fuse as fault level limiting devices. Basic protection concept of sensitivity, selectivity, discrimination. c. Overhead lines and cable: single core, bundle and three core design, sheath circulation current and induced sheath voltage for HV/MV/LV circuits due to load and fault. Factors affecting rating, meaning of continuous vs cyclic rating and concept of thermal inertia in power system equipment. d. Tariff design purposes, tariff structure, maximum demand and time of use tariff, elasticity of load demand.	Quick overview of conventional power system and its components. Use of tariff structure to encourage and absorb renewable energy resource.
September 14 2024	**Power System Circuit Analysis, Active & Passive Load Flow Control** a. Mathematical analysis of passive AC load flow to balance active power and reactive power. voltage compensation, frequency and voltage regulation. b. AC circuits, sinusoidal sources, average and RMS values, phasor diagram, complex number, energy stored in capacitance/reactance, active and reactive power, power factor and power factor correction. Three-phase circuit. c. Magnetic circuits and mutual inductance, transformer fundamentals, transformer noise, leakage and magnetization flux, voltage and current transformers. d. Passive transmission of AC load. DC and AC circuit analysis, Kirchoff's laws, Thevenin and Norton theorems. Capacitance, Inductance, RC Circuits and Transients. e. Electrical Measurement, measurement uncertainty, resistance measurement, four-probe method, capacitance and inductance measurement using AC bridge, electromechanical and digital Power and Energy measurement, three phase power by two-wattmeter method.	Cover the transmission of AC electrical power and the limiting factors. Understand the role of reactive power and magnetic circuit in AC power system. Introduction of DC power transmission.
September 28 2024	**(Continuation of session 2)** f. Reactive power compensation: System Q-V Characteristics, Reactive power support theory, customer and EV load characteristics, synchronous condenser, static var compensator. g. Basic power electronics – thyristor & IGBT and operating principles and use cases. h. HVDC Transmission i. Flexible AC/DC transmission principles and building blocks.	Introduction of active power flow control and their building blocks. Use of active power flow control to extract full capacity of lines and circuits. Introduction to multi-nodal power flow control using VSC (voltage source convertor).

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October 19 2024	**Modern Generation Technology** a. Energy resources and type: Renewable and non-renewable. Paris agreement and 2050 carbon neutrality meaning. Percentage of renewable and non-renewable generation capacity and energy supplied in China and world trend. b. Combined cycle, cogeneration and trigeneration. Major parts of a combined cycle generation unit, thermal cycle and performance indices of combined cycle generation. Emission and control, NOx and other pollutant control/ absorption method and costs. Minimum load of gas turbine, start-up and shutdown cost. c. Overview of wind energy, wind turbine technology, onshore and offshore wind farms. Wind resource forecast and monitoring. Seasonal and daily fluctuation. d. PV technology, PV panels and photovoltaic conversion system. Solar resources forecast and monitor. e. CCUS: carbon capture, utilization, and storage f. RE100 and other green energy certificate, carbon certification and carbon market	Focus on advance gas turbine technology, pollution control/ absorption, co-generation and role of gas turbine to provide fast ramping and two shifting. Operation limits of gas turbine operation. Introduction to characteristics of wind turbine and prediction of wind generation. Introduction of PV and advance grid scale and building base PV technology, aging effect and useful life of PV system.
November 9 2024	**Power Transmission and Distribution Equipment** a. Introduction to electrical insulation, breakdown mechanism and partial discharge. b. Transformers – Construction and operating principle. Equivalent circuit, voltage regulation, noise/flux level and efficient, parallel operation, three phase transformer and vector group, per-phase analysis, reactors; Cyclic loading and overload time curve. c. Switchgear – AC and DC current interruption, Arc extinction and transient recovery voltage, fault current limiting fuse, SF6 and vacuum interruption, current chopping. MCB and MCCB principle, time characteristics and fault breaking capacity. d. HV/MV/LV cable type, insulation, conductor and joints and termination, LV cable colour code. Arial Bundled Cable (ABC) type and phase/earth identification. e.Transformer copper and Iron loss, and percentage loss w.r.t. loading, dissipation of losses. Low carbon choice of transformer rating and loss reduc-	Introduction to high voltage system and main electrical equipment. Sources and limit of equipment loss and possibility to reduce transmission and distribution loss. Loss reduction on transmission and distribution network and equipment.
November 30 2024	**Fault analysis, system protection and Grid Code** a. Sequence network fundamentals. b. Fault level calculation, system earthing, fault current distribution across transformer. c. Protection principles – non unit protection and unit protection, protection grading in general and OCEF in particular. d. Protection input devices – CT/VT, primary and secondary connection, zero sequence CT. e. Protection Schemes – distance protection, pilot wire protection, current differential, transformer protection, generator protection and busbar protection. f. Station battery and Breaker Failure protection. g. Protection grading of non-unit protection from MV to customer side LV ACB/ MCCB, MV current distribution for different types of LV faults. h. Principle of redundant protection scheme for HV network. Impact analysis of relay mis-operation and mal-operation. i. Protection design and consideration of distributed energy resources, loss of main protection and rate of change of frequency protection, islanding detection and low voltage/low frequency ride through.	Basic protection system from LV to HV. Practical LV grading in practice. Introduction of grid code and assessment of embedded generation on protection system. Evolution for grid code as amount of embedded generation increases.

Course Outline

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December 14 2024	**Energy Storage & Grid Integration** a. Types of utility scale energy storage systems: pumped hydroelectric storage, advanced battery energy storage, electro-chemical battery, redox battery and green hydrogen generation. Battery discharge time and system power relation. Sustainability and environmental impact of battery and other storage media. b. Integrating renewable energy resources into the power grid. Grid code development in advanced countries, rid-through capability and ancillary services. Load levelling, energy demand response, recovery from disturbance. c. EV battery as dispatchable load and grid energy storage. d. Provision of system inertia, voltage support and system strength from RE. e.Green Hydrogen development, and hydrogen infra-structure and use cases.	Wholistic view of on-premises and grid level energy storage, usage, risk and sustainability. Reactive power, fault level and inertia support of Inverter Based Converter for PV/ battery storage. Comparison of hydrogen economy and with battery energy storage.
January 18 2025	**Network Design and Planning** a. Load forecast model. b. Generation Planning and spinning reserve. c. Transmission network topology and design; comparison reliability and resilience. d. Distribution network topology, transformer utilization factor and contingency management, load transfer; comparison of reliability and resilience of distribution and LV network. Resilient design of primary equipment. e. Introduction to transmission and distribution network congestion mitigation measures – active power flow control measures. f. LV network, redundancy, backup and interface to customer equipment. Backfeed design and provisions. g. Supply reliability and resilience comparison of common transmission busbar configuration, distribution and LV network. h. Demand side management, automatic demand response, virtual power plant with contestable, sheddable load. i. EV Charging, load management, Grid to Vehicle and Vehicle to Grid technology and potentials.	Conventional network design and planning. Network topology and its impact to reliability. Application of active power flow control and safety aspects of battery storage systems. Quantitative view of EV load on grid and means to support EV charging.
February 15 2025	**Advanced Metering Infrastructure & Power System Applications** a. Smart meter trend and capability. b. Technical and cost comparison of various communication media. c. Modern Power Line Carrier technology, availability, flexibility and reliability. d. Two-way and on-demand communication with Smart Meter . e. AMI potential use cases in customer services, loss reduction, power system planning, fault restoration, power system operation, grid connected energy storage and renewable generation, dispatchable load and flexible load and demand response. f. Advanced AMI/PLC application potential.	AMI basic structure and the choice of HPLC in CEM AMI. Design of AMI data structure and potential and limit for using AMI as operational tool. AMI to regulate embedded flexible load.

Course Outline

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March 8 2025	**Asset Management and Enhancement of Power System Apparatus** a. Principles of equipment aging and condition assessment. b. Maintenance and replacement/refurbishment strategy – time based, condition based, reliability centered, big-data driven, risk based c. Condition assessment technologies for aged equipment. d. Life-cycle cost of primary equipment and condition monitoring equipment e. Incident investigation, failure analysis and development of improvement techniques f. Quantitative measurement of power system availability and reliability.	Understand various asset management approach. Factors affecting equipment life. Use of big data to learn health indices of components. Measurement of reliability and principles behind.
March 29 2025	**Electrical Energy Saving Systems and Buildings** a. Energy saving control and monitoring systems: Theory of energy saving, concept of building energy efficiency, control and monitoring system, communication protocol and media, application examples. b. Light source (LED, discharge lamp and others), limitation of light power density, variable speed drives for HVAC systems and elevators, energy storage and regeneration for elevator, application of power electronics in motor drives, smart building management systems and smart sensors, c. Smart lighting, intelligent HVAC, advance building energy management systems. d. Trend in low carbon building design. e. Potential of heat pump in place of direct heating/cooling. f. Energy efficient enhancement for existing buildings. g. Low carbon data centre and IT equipment	Basis understanding of electric appliances and frameworks of energy saving technology and limit. Integrated view of smart building and how digitization and technology contribute to carbon reduction. Potential and limits for building demand response.
April 12 2025	**Introduction to Artificial Intelligence and deep learning** a. Basic understanding on deep learning technology b. Neutral network, backpropagation, deep auto-encode, convolutional neutral network, multi-layer perception c. Strategies for training deep architectures, handling overfitting cross-validation d. Example of deep learning in electrical equipment conditional monitoring and PV condition monitoring. e. Hand-on trial using Python	Introduction of AI with actual example of use in power system.
To be Confirmed (2025)	**Field trip/utility visit (s) in Greater Bay Area**	To learn the most updated power utility and knowledge in power plant in Power station/ plant in Greater Bay Area.

Payment Information

Application Fee	MOP 100.00
Payment Method	1. By UnionPay/VISA/MASTER card (online payment available) 2. By other electronic payments 3. By cheque/cashier's order, payable to "University of Macau"
Documents required	Application form, 1 copy of ID card, a copy of academic qualification.
Address	The Centre for Continuing Education Ground Floor, BOC Centennial Building, University of Macau, E3, Avenida da Universidade, Taipa, Macau
Office Hours	Mon to Fri 10:00-20:00; Sat 10:00-17:00; Sun 10:00-13:00 (Closed on Macao Public Holidays)

Notice

1. The Centre reserves the right to amend the course details.
2. The Centre reserves the right to postpone or cancel the course in case of insufficient enrolments. Please refer the guidelines to https://cce.um.edu.mo/download/ .
3. Certificate: Certificate will be issued to those students who have attended 80% of the entire programme and got a passing grade in the examination of each course. If examination is exempted for the course, attendance certificate will be issued to those students who have attended 80% of the entire programme. If a student who is absent from class and applies for justifiable absence, he/she must provide valid reasons and supporting documents. Medical certificate is required for health reason. Applicant should submit the application form to the Centre within 10 days after the first day of class absence. Applications are subject to the approval of the Centre.
4. UM Staff Discount is not applicable.
5. Any of the discount offers cannot be used in conjunction with any other offers. CCE reserves the right to make final judgment on the dispute and otherwise in respect of the offer.
6. Fee is non-refundable for voluntary withdrawal.
7. The Centre has the right to decide whether hosting certificate awarding ceremony.
8. Participants shall prepare their own electronic devices which support(s) distance learning software and/or video playing (laptop, desktop, tablet, mobile, etc). The Centre reserves the right to decide the combination of delivery mode/teaching method.