Singapore Certified Energy Manager Programme
Professional Level

Part A:		
1.	**Module Type and Title**:	Module Type: Core Module Title: Energy Management and Economics
2.	**Rationale for this module:**	Engineering professionals who intend to build their careers as energy managers need to understand principles related to the management and economics of energy.
3.	**Module Description / Overview**:	The main aims of this module are to provide an understanding of: • Developing an energy management system • Energy pricing • Financial evaluation of energy management projects
4.	**Pre-requisites/ Co-requisites/ Assumed Skills & Knowledge of candidates**:	Candidate must have a relevant degree in engineering or science. Have at least 1 year of relevant engineering experience after obtaining Degree certification Candidates are assumed to • Be able to interpret process diagrams • Have computer literacy
5.	**Total Workload hours**:	**24 hours**

6.	**Profile of Trainer/s**:	The trainer must be a suitably qualified person who fulfils the following criteria: • At least a tertiary education (an engineering degree with relevant experience in mechanical or electrical engineering) • At least 5 years practical experience in Energy Management

7.	**Maximum Class Size**:	25
8.	**Learning Outcomes**:	**On successful completion of this module, the participants will be able to:** 1. Develop an energy management system 2. Define roles and responsibilities of energy management team members 3. Set up (or develop) energy policy, energy planning, procedure for evaluating performance of energy systems and energy performance review, documentation and communication processes. 4. Integrate energy management system into business practice 5. Understand Singapore's energy market tariff structure to enable better evaluation of supply contracts for reducing energy costs 6. Evaluate financial attractiveness of energy retrofit projects 7. Understand the various energy performance contracting models
9.	**Syllabus/module content**:	**Energy Management System (12 hrs)** 1. Energy management drivers 2. Introduction to Energy Management System and ISO 50001 3. Formation of Energy Management (EM) team: Appointing energy manager and other members, Defining responsibilities of team members, Recommended guidelines for energy manager 4. Class exercise on selection of appropriate persons to be members of EM team of an organization 5. Effective tools for appraising energy management performance 6. Setting up of Energy Accounting Centers (EAC) 7. Baseline and bench marking 8. Energy Performance Indicators (EnPI): Normalized indicators, sectoral indicators 9. Class exercise on setting up of EAC and EnPI of an organization 10. Methodology for setting up of Energy Management System • Energy policy • Energy planning • Implementation and operation • Checking: (a) monitoring, measurement and analysis, (b) non conformities, correction, corrective and preventive action, (c) Internal audit • Management review • Documentation • Communication 11. Class exercise on setting up of Energy Management System of an organization 12. Training and awareness of EM team members

		13. Miscellaneous • Additional features of ISO 50001 • Additional features of AEMAS 14. Singapore Energy Management Policies • Energy Policy • Enengy Efficiency Programme Office • Energy Efficiency for Public Sector • Energy Management Training • Green Mark Master plan • Energy Efficiency National Partnership • Different Incentives for Energy Management Projects **Energy Market Overview (6 hrs)** 1. Energy Supply and Demand in Singapore 2. National Electricity Market of Singapore (NEMS) • Main players and their roles and responsibilities • Contestable and non-contestable consumers • Trading of energy, regulation & reserve • Types of generating cycles and relative efficiency 3. Electricity cost structure • Generation cost • Wholesale Energy Price and Uniform Singapore Energy Price • Vesting Contracts • Components of utility rates **Economic Analysis in Energy Efficiency Investments (6 hrs)** 1. Financial evaluation of energy management projects • Simple payback period • Return of investment • Cash flow analysis • Time value of money • Discounting rate • Present value and net present value • Internal rate of return • Sensitivity analysis • Calculation of life cycle cost 2. Introduction to energy performance contracting • Typical energy performance contracting models (such as guaranteed savings, shared savings, etc.) 3. Case studies
10.	**Workload**	(i) Lecture/Class: 18 (ii) Class Exercise / Case Study 6

		Total	24 hrs
11.	**Illustrative Reading List**:		
	(a) Compulsory reading:		
	(b) Supplementary reading:	Guide to Energy Management, Barney, L.C., W.C. Turner, W.J. Kennedy, Lilburn, GA : Fairmont Press, 2006. Applied Industrial Energy and Environmental Management, Morvay, Z., D.D. Gvozdenac, Chichester, West Sussex, U.K., 2008. Practical Guide to Energy Management for Facilities Engineers and Plant Managers, Mull, T.E., New York : ASME Press, 2001 ISO 50001 Website of Singapore Energy Market Authority http://www.ema.gov.sg/ Website of Energy Market Company http://www.emcsg.com/ Contemporary Engineering Economics, Park, C.S., Pearson Education International, Pearson Prentice Hall, 2007 Engineering Economic Analysis, Newnan, D.G., T.G. Eschenbach, J.P. Lavelle, Oxford University Press, Inc. 2004	

Singapore Certified Energy Manager Programme
Professional Level

Part A:		
1.	**Module Code and Title**:	Energy Measurement and Appraisal
2.	**Rationale this module:**	Accurate energy measurement and analysis are essential for any energy improvement program. Accurate and continuous measurement of sub-systems energy demand and efficiency has been proven to lead to sustainable and highly efficient buildings. Unfortunately, it is common practice to only measure energy demand (KW) or consumption (KWH) of whole building. Therefore, there is a severe lack of skills and knowledge in accurate measurement and analysis of energy demand and efficiency of sub-systems such as chiller plant KW/RT, fans W/CMH or lighting W/m^2. Without empowering adequate energy engineers with the skills of accurate and continuous energy, the industry will be mired with disagreements about the claims in energy efficiency.
3.	**Module Description / Overview**:	This module will equip energy managers with knowledge in accurate measurement and analysis of energy demand and efficiency of common mechanical systems in buildings. The energy managers will learn fundamental principles of measurement instruments, their accuracy ranges and calibration. They will be taught how to conduct different levels of energy audit on common mechanical systems in buildings. They will learn how to apply the appropriate measuring instruments, collect data and analyze the data and draw useful conclusions.
4.	**Pre-requisites/ Co-requisites/ Assumed Skills & Knowledge of candidates**:	Candidates must have a degree, preferably in mechanical or electrical engineering. Pre-reading / self-study on the use of MS Excel is mandatory. Candidates are assumed • To be familiar in data organization using MS Excel. • Have attended the other 3 core modules so are familiar with fundamentals of ACMV, motor driven systems and energy management.
5.	**Total Workload hours**:	**24 hours**

6.	**Profile of Trainer/s**:	The trainer must be a suitably qualified person who fulfils the following criteria: • At least a tertiary education (an engineering degree with relevant experience in mechanical or electrical engineering); • At least five (5) years of experience in energy audits. • Preferably still working as an energy auditor • Preferably a KQP or QTP.
7.	**Maximum Class Size**:	25
8.	**Learning Outcomes**:	**<u>On successful completion of this module, the learner will be able to</u>:** See "Intended performance outcomes" in each topic of the proposed syllabus.
9.	**Syllabus/module content**:	**9.1 The need for energy M&A (1 hour)** <u>Topics</u> a. The opportunity cost of poor M&A b. What is good energy M&A and how it helps improve energy efficiency. c. Key legislation concerning energy M&A such as BCA Green Mark <u>Intended performance outcomes</u> a. Understand the importance of energy M&A b. Aware of legislation requirements. **9.2 Introduction to different levels of energy M&A (0.5 hour)** <u>Topics</u> a. General overview of Level 1, 2 & 3 audits objectives & work scope <u>Intended performance outcomes</u> a. Appreciate the different levels of M&A b. Appreciate the depth and skills required for each level c. Able to discern which type of M&A to do internally and which to outsource.

		9.3 Overview of Measurement instruments (3.5 hours) <u>Topics</u> Principles, accuracy, calibration of a. KW meters b. Water temperature meter c. Water flow meter d. Water pressure meter e. Air temperature meter f. Air flow meter g. Air pressure meter h. Lux meter <u>Intended performance outcomes</u> a. Understand the principles of different instruments b. Understand the accuracy ranges c. Understand the calibration methods **9.4 M&A of chiller plant (3.0 hours)** <u>Topics</u> a. L1 to L3 scope of work b. Instruments i. Type, accuracy c. Data to be collected i. Useful metrics ii. Type of data to be collected iii. Duration &freq of data collection d. Data analysis i. Data arrangements ii. Graphical representation iii. Heat balance validation e. Benchmarking i. Codes and standards ii. Best practices f. Case studies i. Good practices ii. Common pitfalls <u>Intended performance outcomes</u> a. Acquire L1 & L2 skills in chiller plant M&A. Appreciate the depth of L3 M&A and able to assess the outcome of L3 audits

		9.5 M&A of AHUs, FCUs and Mechanical Ventilation System (1 hour) <u>Topics</u> a. L1 to L3 scope of work b. Instruments i. Type, accuracy c. Data to be collected i. Useful metrics ii. Type of data to be collected iii. Duration &freq of data collection d. Data analysis i. Data arrangements ii. Graphical representation e. Benchmarking i. Codes and standards ii. Best practices f. Case studies i. Success projects ii. Common pitfalls <u>Intended performance outcomes</u> a. Acquire L1 & L2 skills in AHU/FCU M&A. Appreciate the depth of L3 M&A and able to assess the outcome of L3 audits **9.6 M&A of lighting system (1 hour)** <u>Topics</u> a. L1 to L3 scope of work b. Instruments i. Type, accuracy c. Data to be collected i. Useful metrics ii. Type of data to be collected (Including some IEQ related data) iii. Duration &freq of data collection d. Data analysis i. Data arrangements ii. Graphical representation e. Benchmarking i. Codes and standards ii. Best practices f. Case studies i. Success projects ii. Common pitfalls <u>Intended performance outcomes</u> a. Acquire L1 & L2 skills in lighting audit b. Appreciate the depth of L3 M&A and able to assess the outcome of L3 audits

		9.7 Brief discussion on M&A of industrial systems (1.5 hour) <u>Topics</u> a. Hot water system b. Steam system c. Compressed air system <u>Intended performance outcomes</u> a. Understand basic information about audit of industrial systems. Detail information will be covered in the elective modules. **9.8 Practical session and assignments (6 hours)** <u>Topics</u> a. Demo of instruments such as flow meter, KW meter, temperature meter etc b. Walk-through audit of chiller plant / building c. Presentation of findings <u>Intended performance outcomes</u> a. Acquire hands-on experience on identifying saving opportunities. b. Acquire experience in conducting L1 & L2 audits of chiller plant, AHU and lighting. c. Reinforce fundamentals and concepts taught by trainer. **9.9 Data plotting and analysis assignments (6 hours)** <u>Topics</u> Break up into groups and perform data analysis using spreadsheet software a. Computation of various parameters b. Prepare templates c. Prepare data plots d. Analysis of data <u>Intended performance outcomes</u> a. Appreciate requirements for data analysis. b. Reinforce fundamentals and concepts taught by trainer. **9.10 Briefing on safety (0.5 hour)** <u>Topics</u> a. Basic risk assessment relating to energy audit scope of work. b. Legislation on electrical safety <u>Intended performance outcomes</u> a. Acquire basic safety knowledge relating to energy audit scope of work.

10.	**Workload**	(i) Lecture/Class:	12
		(ii) Practical session & Case study :	12
		Total	24hrs
11.	**Illustrative Reading List**:		
	(a) Compulsory reading:	Green Mark Guideline on measurement	
	(b) Supplementary reading:	Ashare Guideline 22 Ashrae Guideline 14	

Singapore Certified Energy Manager Programme
Professional Level

1	**Module Code and Title**	**Motor Driven Systems**
2	**Rationale for module:**	In industrial plants and facilities, electric motors and motor driven systems are a part of everyday life. Engineers with job functional responsibilities for energy and facility management need a good understanding of how motor driven systems work. By gaining a good basic understanding of these integrated systems, engineers will be able to appreciate their potential and limitations.
3	**Module Description / Overview**	This module is a core requirement for applicants of the SCEM – Professional Programme. The objective of the module is to provide participants with basic understanding and knowledge of Motor Driven Systems and applications of these systems.
		Topics to be discussed include: **1. <u>Concept of Power and Energy</u>** a) Calculation of energy savings b) Power factor correction • Implementation at component or device level • Implementation at system level • Economic benefits • Technical advantage/disadvantage comparison **2. <u>Motors</u>** a) Operation and characteristics of electric motors • Conventional DC Motors - shunt, series and compound • AC Induction Motors – cage and wound rotor types • Conventional synchronous motor • PM synchronous motor • Brushless DC Motor (BLDC, self synchronous motor) b) Motor efficiency • Various losses in motors: copper , iron, core, stray, windage, hysteresis, eddy current losses • Motor loading and efficiency • High efficiency motors c) Speed control methods • Variable applied voltage • Variable armature current • Variable motor field • Variable frequency • Combination of the above d) Selection and sizing of motors (including industry standards)

		3. <u>Drive Systems</u> a) Power Electronic Converter and Inverter Switching Devices b) Main Components of VSD c) Types of VSD • Voltage Source Inverter • Current source inverter, • PWM d) Key features of VSD • Rectification • Inverting • Harmonic filtering • Power factor correction • Voltage level regulation / adjustment • Energy reversal e) Selection, sizing and efficiency of VSD for variable Torque load / constant torque load. f) Application of converters for AC/ DC motor speed/torque control g) Application of converters for Permanent Magnet Synchronous (PMSM) speed/torque control **4. <u>Efficient Driven Systems</u>** a) Types of transmission (belts, gears, coupling, chain etc) b) Comparative features of transmission system c) Selection, Sizing and Efficiency of transmission system d) Typical Driven Systems- Pumps, Fans, Compressor, Hoist, Conveyor, etc • Parallel and series pumping • Losses in pumps, pump efficiency • Fan losses and fan efficiency e) Affinity Laws – use affinity law to determine the min % of reduction in speed for a given % of reduction in quantity of delivery, f) Flow of regenerative energy g) Energy Saving opportunities in applying variable speed to motors driving centrifugal pumps and fans and application of affinity laws h) Sizing of motors for variable torque load such as for centrifugal pumps, Fans and Compressors as well as for constant torque load. i) Energy saving opportunities in linear load • Geared/gearless elevator systems and escalators • Counterbalance j) Case studies – examples (please refer to Section 9.3.5 for details using adjustable speed drives on centrifugal pumps and fans for energy savings under various forms of control and operations).

4	**Pre-requisites / Co-requisites / Assumed Skills & Knowledge of candidates:**	As per requirements of the SCEM Professional Programme. Pre-reading / self study in the basics of magnetic circuits, electric motors, power electronics and elements of mechanical & electrical engineering is expected of applicants. Candidates are assumed to a) be able to interpret schematic diagrams b) have computer literacy
5	**Total Workload Hours:**	24 Hours
6	**Profile of Trainers:**	The trainer must have an engineering degree with at least 5 years of relevant experience.
7	**Maximum Class Size:**	25
8	**Learning Outcome:**	On successful completion of this module, the participants will be able to: a) Appreciate and better understand the essential parameters and operational characteristics of motors driven systems currently used in industry b) Identify components within driven systems that increase energy consumption and suggest improvements. c) Apply simplified calculation methods to compute energy consumption and potential savings in using such systems.

9	**Syllabus / Module content**	1. <u>**Motors and Saving Potential (6 Hours)**</u> 1.1. Conventional DC machines 1.1.1. Different types of excitation • Separately excited DC Machine • Shunt excited DC Machine • Compound excited DC Machine 1.1.2. Equivalent Circuit of a DC Motor 1.1.3. No-Load Speed of a DC Motor 1.1.4. Steady-state characteristic 1.1.5. Speed-Torque characteristic of a DC Motor 1.1.6. Base Speed speed and field weakening 1.1.7. Characteristic of a DC Motor 1.1.8. Speed-Torque characteristics of a separately excited DC Motor 1.1.9. Speed Control of DC Motor 1.1.10. Effect of variation of armature voltage 1.1.11. Four quadrant operation and regenerative braking Controlling the speed of a hoist
		1.2. **DC Shunt Motor** 1.2.1. Steady-state characteristics 1.2.2. Speed-armature current (Load) characteristics 1.2.3. Speed-torque characteristics 1.3. **DC Series Motor** 1.3.1. Speed-armature steady state operating characteristics 1.3.2. Torque-armature current (Load) characteristics 1.3.3. Speed-torque characteristics 1.3.4. Field weakening in series motor 1.4. **DC Compound Motor** 1.4.1. Characteristics of a DC Compound Motor

		1.5. **Induction Motor** 1.5.1. Production of rotating magnetic field with 3 phase winding and a 3 phase supply 1.5.2. Excitation Power and VA 1.5.3. Rotor frequency, rotor emf, rotor current and power factor. 1.5.4. Magnitude of stator, rotor emf rotor current and power factor. 1.5.5. Torque production and factors determining torque and torque-slip characteristic (small slip) 1.5.6. Rotor current and torque (small slip) 1.5.7. Rotor current and torque (large slip) 1.5.8. Stator current speed characteristic 1.5.9. Factors determining torque, torque-slip characteristic 1.5.10. Effect of variation of rotor resistance on torque-slip characteristic 1.5.11. Conditions for maximum torque and value of maximum torque 1.5.12. Stator , rotor losses and efficiency 1.5.13. Efficiency of Premium Motor vs. standard motor 1.5.14. Efficiency vs. and factors affecting efficiency 1.5.15. Determining of load factor 1.6. **Synchronous Motor** 1.6.1. Unique feature of Synchronous Motor 1.6.2. Torque Production and control 1.6.3. Excitation control and power factor 1.7. **Power factor and correction** 1.7.1. Effects of low power factor, means to correct and improve the power factor, location of power factors correction devices. 1.7.2. Sizing of KVAr rating of the power factor devices and highlighting some negative aspect of additional power factor devices to existing power systems, etc 1.8. **Sizing and selection of motors** 1.8.1. Motor Selection and Sizing of motors/ drives for continuous duty under • constant torque • variable torque loads 1.8.2. Power range for motors, maximum speed and speed range, constant torque & variable torque loads. Regenerative operation and braking, class of duty for sizing of drives and motors.

		2. <u>Variable Speed Drives (4 Hours)</u> 2.1. Introduction to basic adjustable frequency drives and their characteristics 2.2. Motor characteristics 2.3. Types of adjustable frequency drives (VVI, CSI, PWM) 2.4. VVI power conversion 2.5. VVI advantages and disadvantages 2.6. CSI power conversion 2.7. CSI advantages and disadvantages 2.8. PWM power conversion 2.9. PWM advantages and disadvantages 2.10. Sizing and selection of drive for variable torque and constant torque load
		3. <u>Efficient Driven Systems</u> <u>(14 Hours)</u> 3.1. Pumps **(2.5 hours)** 3.1.1. Affinity Laws 3.1.2. Duty Cycle 3.1.3. Pumps basic 3.1.4. Characteristic curve of piping systems 3.1.5. Pumps and systems curve 3.1.6. Adjustable speed operation
		3.2. Fans **(2.5 hours)** 3.2.1. Performance curve of Fans 3.2.2. System Curve 3.2.3. Combined Fans and System curves 3.2.4. Variable air volume control and energy saving 3.2.5. Outlet damper control 3.2.6. Variable inlet guide control 3.2.7. Adjustable speed control
		3.3. Compressors **(2 hours)** 3.3.1. Types of Compressors 3.3.2. Where is Energy wasted 3.3.3. Energy Efficient Solution 3.3.4. Duty Cycle 3.3.5. Pressure Reduction 3.3.6. Control System for load matching
		3.4. Lifts and Hoisting **(2 hours)** 3.4.1. Types of Liner load - drum, traction, hydraulic 3.4.2. Various Configuration – Direct & indirect drum, counter-balanced 3.4.3. Braking and Regenerative Energy

		3.5. Motor Driven Systems – Case study **(5 Hours)** Motor Driven Systems will be studied, analyzed and discussed using simulated examples. Economic aspects will be considered. The following examples that may be discussed demonstrate the application of adjustable speed drives for motor driven systems as applied to centrifugal pumps and fans to achieve energy saving under various forms of control and operations including the application of affinity laws: a) Constant speed system and adjustable speed control - Variable flow, variable pressure b) Adjustable speed control for parallel pump operation - Variable flow, variable pressure c) Adjustable speed control - Constant flow, variable pressure d) Adjustable speed control - Constant pressure, variable flow e) Adjustable speed control for Fans – Variable volume, variable pressure f) Adjustable speed control for Fans – Constant volume, variable pressure g) Adjustable speed control for Fans – Constant volume, variable pressure / static pressure control
10	**Workload**	Lecture / Class 24 Hours Total 24 Hours
11	**Illustrative Reading List**	a) Variable Speed Drive Fundamentals, Clarence A. Phipps, Fairmont Press (1999) b) Electric machines and power systems - Volume 1 Electric Machines by Syed A. Nasar, McGraw-Hill 1995 c) Power Electronics, Cyril W Lander, McGraw-Hill 1993

Singapore Certified Energy Manager Programme
Professional Level

Part A:		
1.	**Module Code and Title**:	Air Conditioning and Mechanical Ventilation (ACMV) systems
2.	**Rationale for module:**	Learners need the basic knowledge to run the ACMV plant and equipment which operate mostly under part load conditions in contrast to designing for a peak load scenario. Besides meeting the objectives of providing thermal comfort to occupants and other requirements, the learners must have the skills to operate the plant in an energy efficient manner.
3.	**Module Description / Overview**:	This module aims to integrate knowledge in thermodynamics, heat transfer and fluid mechanics to analyze the operating conditions of the ACMV plant with an objective of energy optimization. The module is designed for the energy manager who has had little influence on the original design of the ACMV system but who has the responsibilities to improve the energy performance of the system. Major topics discussed include occupant comfort and health, applications of refrigeration and air conditioning, vapour compression cycle, selection of chillers, pumps, fans, and cooling towers; psychrometrics of air conditioning processes, energy efficient design and sustainable practices, operations and maintenance
4.	**Pre-requisites/ Co-requisites/ Assumed Skills & Knowledge of candidates**:	Candidate has an engineering degree or equivalent. Pre-reading / self study / bridging course of the basics of Thermal Environmental Engineering needed if candidate does not have a Mechanical Engineering Background. Candidates are assumed to • Be able to interpret schematic diagrams • Have computer literacy
5.	**Total Workload hours**:	**24 hours**

6.	**Profile of Trainer/s**:	• At least an engineering degree with relevant experience in mechanical or electrical engineering • At least five (5) years of experience in design and/or operations of an ACMV plant

7.	**Maximum Class Size**:	25
8.	**Learning Outcomes**:	**<u>On successful completion of this module, the learner will be able to</u>:** 1. Understand the functions and components of the ACMV system 2. Analyze energy performance characteristics of ACMV systems and be able to analyze the potential energy savings in ACMV systems 3. Operate and maintain energy-efficient chilled water and air distribution systems, resulting in optimum ACMV system performance 4. Conduct pyschrometric calculations
9.	**Syllabus/module content**:	<u>a. ACMV Systems in Practice (6 hrs)</u> Psychrometrics of air conditioning processes. Occupant comfort and health; sensible and latent cooling load, unitary system, central cooling plant; all-air, all-water and air-water systems. <u>b. Air-conditioning plants and equipment (4 hrs)</u> Vapour-compression refrigeration, P-h diagram and coefficient of performance; chillers, cooling towers; ductwork, fans, piping and pumps; cooling and dehumidifying coils. <u>c. Regulatory Framework (2 hrs)</u> Interpretation of relevant **international and local** codes of practice and standards including **ASHRAE 90.1/90.2/189.1/62.1/62.2**, SS530, SS553, SS554, ETTV, public & environmental health code and green mark legislation. Implications of codes on energy efficiency with regard to selection of components / equipment - chillers, compressors, pumps, fans, cooling towers. <u>d. Designing for Energy Efficiency (5 hrs)</u> Hydronic balancing; reducing losses in ductwork and piping; low flow design; overview of variable speed drives for pumps and fans; cooling tower operations; ventilation, infiltration and exhaust <u>e. Sustainable practices (5 hrs)</u> Refrigerant and its impact on energy and environment; energy modeling ; other systems - district cooling plants; heat recovery systems - heat pipes, heat pumps; displacement ventilation, passive systems - chilled beams; desiccant cooling and dehumidification

		f. Operations and maintenance (2 hrs) Ventilation and impact on indoor air quality; operating with related mechanical ventilation systems; condenser cleaning; water treatment; facilitating accurate measurement and verification (M&V).
10.	**Workload**	(i) Lecture/Class: 20 (ii) Tutorial & Case study : 4 Total 24 hrs
11.	**Illustrative Reading List**:	
	(a) Compulsory reading:	Heating, Ventilating and Air Conditioning, McQuiston, F.C., J.D. Parker and J.D. Spitler, John Wiley & Sons, 2000.
	(b) Supplementary reading:	Grondzik, Walter T., "Air Conditioning System Design Manual", ASHRAE – BH, 2nd edition 2007 ASHRAE Handbook of Fundamentals, 2009 Kreider, J.F., P.S. Curtiss, and A. Rabl, "Heating and Cooling of Buildings", McGraw-Hill Inc., 2002 "Energy-efficient building systems", McGraw Hill, 2007

Module:	**Lighting Systems & Building Envelope**
Description of Contents:	Lighting System • Introduction of the factors that affect lighting system performance – Introduction of four (4) major units in lighting: Luminous flux (lumen); Luminous intensity (candela); Illuminance (Lux); Luc (Ix) and the concept of perfect diffusing surface – Review and comparison of the different types of lamps and fixtures – Definition and significant of luminous efficacy • Design of energy efficient lighting system – Luminance and power density requirements for different room types and usage in accordance to SS531 and SS530 standards respectively – Selection and design of lighting system for specific building types – Introduction and significance of daylighting in the design of new lighting system' – Examples and case studies on different lighting system design • Analyzing the possibilities of upgrading and improvement of existing lighting system – Analysis of the considerable factors which will reduce the lighting energy consumption – Introduction and selection of high efficiency lamps – Improvement of energy performance ny introducing lighting controls – Operation and maintenance of the lighting system – Case studies of light system efficiency improvement Building Envelope • Definition and components of building envelope • Components of the subsystems that affect the performance of building envelope • Introduction to building Envelope Thermal Transfer Value (ETTV) and Roof Thermal Transfer Value (RTTV) [1] – Definition and calculation of ETTV – Use and significance of ETTV on efficient building design including case studies – Walls, roofs, and fenestration energy saving measures – Envelope analysis for new and existing buildings

[1] Guidelines on ETTV and RTTV for buildings which are developed by Building and Construction Authority (BCA)

DETAILS OF ELECTIVE MODULES

Modules:	**Integrated Design for Energy Efficiency** **1. Objectives:** • Be able to analyze the potential energy saving in industrial processes • Understand and recognize industrial plants and systems energy performance characteristics, resource conservation and waste regeneration **2. Scope:** • The integrated design process • Components of whole building design - The integrated design approach and integrated team process • Planning and Conducting Integrated Design (ID) Charrettes • Holistic Life Cycle Analysis for component and system • Embodied Energy • Case studies

DETAILS OF ELECTIVE MODULES

<table>
<tr><td>Modules:</td><td>
<u>Steam and Compressed Air Systems</u>
1. Objectives:

Be able to analyze the potential energy saving in industrial processes
Understand and recognize industrial plants and systems energy performance characteristics, resource conservation and waste regeneration

2. Scope:

Steam technologies and application
- General introduction and application of steam
- Utilization and development of steam turbine & steam engine
- Technologies of boilers
- Calculation of steam turbine & steam engine’s efficiencies
- Steam management and pinch technology
Compressed air system technologies
- General introduction and application of compressed air systems
- The components of compressed air system
- Optimization of the compressed air system
Waste Heat Recovery
- Classification of waste heat recovery systems
- Advantages and application
- Commercially viable waste heat recovery equipment
- Saving potential
Safety consideration in Steam and compressed air systems

3. Course Accreditation: This course has been previously accredited 24 PDU under the Professional Engineers Board's Continuing Professional Development Programme for Engineers in Singapore. Course participants must complete this course with at least 75% attendance rate.
4. Trainers: Dr. Lal Jayamaha and Dr. Md Raisul Islam
(Please refer to page 9 for more information on trainers)
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DETAILS OF ELECTIVE MODULES

Modules:	**<u>Combined Heat and Power (CHP) Systems</u>** **1. Objectives:** • Be able to analyze the potential energy saving in industrial processes • Understand and recognize industrial plants and systems energy performance characteristics, resource conservation and waste regeneration **2. Scope:** • Introduction of district cooling, thermal storage and industrial plants with combined heat and power system - Feeding systems - Cooling systems - Power generation system - Exhausting system • Benefits of CHP • Determine the Economics of a CHP • Permitting, Installing, Operating, & Maintaining A Cogeneration System • Calculation on energy efficiency of a CHP • Definition of the possibilities of reducing the energy losses inside a CHP • Optimization of the CHP output energy **3. Course Accreditation:** This course has been previously accredited **24 PDU** under the **Professional Engineers Board's Continuing Professional Development Programme** for Engineers in Singapore. Course participants must complete this course with at least 75% attendance rate. **4. Trainers:** Dr. Lal Jayamaha, Dr. Md Raisul Islam and Mr. Gerald Ng (Please refer to page 9 for more information on trainers)

Singapore Certified Energy Manager Programme Professional Level

Part A:		
1.	**Module Code and Title**:	Energy Recovery and Reuse
2.	**Rationale for introducing this module:**	Pinch analysis for synthesizing and retrofitting heat exchanger networks was developed over the past three decades, and it has found many industrial applications for improving energy recovery and reuse. Its approach has also been extended to other applications such as wastewater minimization and hydrogen networks. Hence, engineers, particularly those dealing with heat exchange and heat transfer equipment such as furnaces, heat exchangers and coolers, should know pinch analysis concepts and applications for energy efficiency. The proposed module covers pinch analysis and other energy recovery techniques. Engineers from petroleum refining, petrochemicals, industrial chemicals and gases, pharmaceuticals, thermal power plants, incineration plants, process design and control, and other related industries, will benefit from this module.
3.	**Module Description / Overview**:	This module covers pinch analysis for designing heat exchanger networks, which has found many applications and has potential for improving energy efficiency of many processes including waste heat recovery processes. Other energy recovery techniques and opportunities are also discussed. Major topics in the module include pinch analysis concepts, data required and extraction, finding targets, heat exchanger network design, utilities, heat and power systems, and other energy recovery techniques. These will be discussed with illustrative examples in the lecture sessions, and candidates will solve selected examples in the practice sessions. Industrial applications will be outlined, and potential of energy recovery and reuse for improving energy efficiency in local industries will be discussed. This module is proposed as a technical elective in the SCEM programme.
4.	**Pre-requisites/ Co-requisites/ Assumed Skills & Knowledge of candidates**:	Candidate should have a degree, preferably in chemical, process or mechanical engineering, or equivalent qualifications. Pre-reading/self study of heat transfer concepts and equipment in process industries is needed. Candidates are assumed to be familiar with heat transfer equipment in process industries and heat exchanger calculations, and also to be computer literate (i.e., using Word, Excel etc.)

5.	**Total Workload hours**:	**24 hours** (8 hours on each of the 3 days)
6.	**Profile of Trainer/s**:	The trainer must be a suitably qualified person who fulfils the following criteria: • A chemical/mechanical/process engineering degree or higher • At least five (5) years of relevant knowledge / training / experience in pinch analysis and its applications for energy efficiency
7.	**Maximum Class Size**:	25
8.	**Learning Outcomes**:	**<u>On successful completion of this module, the candidate will be able to</u>:** 1. Describe pinch analysis and its methodologies, benefits and applications 2. Apply pinch analysis methods to find targets for heat exchanger networks 3. Apply pinch analysis methodology to design and evolve heat exchanger networks 4. Discuss other energy recovery techniques for chemical and process industries 5. Analyze and improve energy efficiency of chemical, thermal and related processes
9.	**Syllabus/module content**:	• <u>Introduction/Overview</u> (1 hour) Energy Reuse and Efficiency; Heat Exchanger Networks; Pinch Analysis; Industrial Experience; Contents and Learning Outcomes • <u>Heat Exchangers</u> (1 hour) Types, Basic Principles; Design Equations • <u>Pinch Analysis Concepts</u> (4 hours for lectures + 2 hours for a practice session) Main steps; Temperature-Enthalpy Diagram; Composite Curves, Problem Table, Pinch and its Significance; Grand Composite Curves; Choice of Minimum Driving Force; Heat Exchanger Network – Grid Representation and Design for Maximum Energy Recovery; Examples • <u>Targeting</u> (3 hours for lectures + 1 hour for a practice session) Utilities; Threshold Problems; Area and Number of Units; Optimal $(\Delta T)_{min}$; Examples • <u>Heat Exchanger Network Design</u> (3 hours for lectures + 2 hours for a practice session)

		Stream Splitting and Cyclic Matching; Network Relaxation; Threshold Problems; Examples • <u>Other Energy Recovery Techniques</u> (4 hours) Waste Heat Recovery using Absorption Chillers; Recompression and Reuse of Vapor Streams; Power Recovery from High Pressure Streams; Use of High Efficiency Pumps, Compressors and Drivers; Process Modifications for Energy Efficiency • <u>Industrial Applications</u> (2 hours) Case Studies (from Chemical Processes and/or Waste Heat Recovery Applications) • <u>Discussion and Conclusion</u> (1 hour) Discussion on energy recovery and reuse techniques, their application including an integrated approach for improving energy efficiency of processes *Illustrative examples will be used throughout the lectures. In addition, other examples will be used in the practice sessions.*
10.	**Workload**	(i) Lecture/Class: 19 (ii) Tutorial/Practice/Review: 5 (iii) Fieldwork/industrial visit/other activity (Describe): 0 Total 24 hrs
11.	**Illustrative Reading List**:	
	(a) Compulsory reading:	Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy, I.C. Kemp, Second Edition, Butterworth-Heinemann, Oxford, 2007.
	(b) Supplementary reading:	Chemical Process Design and Integration, R. Smith, John Wiley, England, 2005. Heat Exchanger Network Synthesis: Optimization Process by Energy and Resource Analysis, U.V. Shenoy, Gulf Publishing (1995).