International Certification Scheme 1.0

Scope

The Certified Energy Manager (CEM®) is an individual who optimizes the energy performance of a facility, building or industrial plant. The CEM is a systems integrator for electrical, mechanical, process and building infrastructure, analyzing the optimum solutions to reduce energy consumption in a cost effective approach.

Certified Energy Managers demonstrate competency in the following areas that are included in the CEM Body of Knowledge to gain certification: energy accounting and economics, energy audits and instrumentation, electrical systems, HVAC systems, motors and drives, industrial systems, building envelope, CHP systems and renewable energy, building automation and control systems, thermal energy storage systems, lighting systems, boiler and steam systems, maintenance, building commissioning and measurement and verification.

Competencies

1. Know the techniques of energy optimization and its application to buildings and industrial plants, detecting and evaluating the opportunities for saving and improving energy efficiency.
2. Apply the principles of efficient use of energy.
3. Know the methods of analysis and management for the implementation of energy saving and efficiency measures to buildings and industrial plants.
4. Be able to perform an energy audit of buildings and industrial plants, obtaining a reliable knowledge of energy consumption to identify where and how energy is consumed and the factors that affect the different processes.
5. Apply the knowledge of generation and distribution of compress air and electric technologies applicable to the building industrial sector.
6. Ability to perform energy analysis in buildings and industrial plants facilities (calculation of yields, primary energy consumption, demands, etc.).
7. Ability to provide solutions and technological proposals to improve the efficiency in the energy consumption of a facility.
8. Apply knowledge of generation and distribution of heat or cold to industrial facilities and know the different configurations of cogeneration – multigeneration applicable to the building and the industrial sector.
9. Know and apply knowledge of basic sciences and technologies to the practice of Energy Engineering
10. To have the ability to analyze available data in an appropriate manner to determine the potential opportunities that might exist across products, systems and processes and determine reasonable estimates of levels of energy improvement/ reduction that can be achieved.
11. Ability to plan and manage time with given constraints
12. Calculate an economic evaluation of the proposed improvement opportunities

CEM Body of Knowledge / Job Tasks & Descriptions

Body of Knowledge	Percent of Exam
The Following Sections I and II are Mandatory:	
Energy Accounting and Economics	11 – 13 %
Energy Audits and Instrumentation	11 – 13 %
Choose 9 Out of the Following 13 Sections:	
Electrical Systems	5 – 7 %
Heating, Ventilating, and Air Conditioning Systems	5 – 7 %
Motor and Drive Systems	5 – 7 %
Industrial Systems	5 – 7 %
Building Envelope	5 – 7 %
Combined Heat and Power Systems and Renewable Energy Systems	5 – 7 %
Building Automation Systems	5 – 7 %
Control Systems	5 – 7 %
Thermal Energy Storage Systems	5 – 7 %%
Lighting Systems	5 – 7 %
Boiler and Steam Systems	5 – 7 %
Maintenance and Building Commissioning	5 – 7 %
Financing, Performance Contracts, and Measurement and Verification	5 – 7 %

I. ENERGY ACCOUNTING AND ECONOMICS

- Solve problems using Life Cycle Cost Analysis
- Demonstrate an understanding of discounting cash flows and its advantage over non-discounted cash flows
- Apply simple payback analysis in project economic analysis
- Apply energy unit conversions to determine overall energy reduction
- Demonstrate an understanding and applied usage of the time value of money
- Analyze project alternatives using present worth analysis, net present value and present worth method
- Solve cash flow analysis calculations using various economic performance measures
- Describe corporate factors that go into determining the MARR
- Determine various utility billing components costs given consumption data and energy rate tariff details
- Determine overall facility Energy Use Index (EUI) when multiple fuel sources are involved
- Determine source fuel costs from unit fuel costs using various efficiency or efficacy measures

II. ENERGY AUDITS AND INSTRUMENTATION

- Identify the primary role of an energy audit
- Identify the primary types of instrumentation used auditing equipment, systems and buildings

- Demonstrate the ability to calculate energy and cost savings associated with basic audit or energy saving recommendations
- Utilize partial load factor in estimating annual energy consumption for various equipment and facilities
- Determine combustion efficiency from combustion analyzer data
- Demonstrate where to apply power factor correction
- Identify measured parameters available from various electric metering equipment available
- Identify measured parameters available from various energy and electric metering equipment available
- Demonstrate the ability to interpret energy rate tariff components and calculate utility bills
- Utilize energy conversion factors to compare multiple fuel sources
- Explain the difference between higher- and lower-heating values of fuels
- Explain how ECI has advantages over EUI based on fuel mix
- Differentiate the level of detail involved in Level 1, 2, and 3 audits
- Identify how ISO 50001 can be used to strengthen a corporate energy program

III. ELECTRICAL SYSTEMS

- Differentiate between energy and demand
- Determine partial load factor given basic performance data
- Calculate real power parameters given equipment parameters or measured data
- Calculate power factor given equipment parameters or measured data
- Calculate power and energy for single-phase equipment and multi-phase equipment
- Determine capacitor capacity sizing to reduce or eliminate power factor penalties in electric rate tariff
- Calculate peak demand reduction potential of select energy saving measures
- Calculate potential power and energy savings achievable through the application of more efficient motors and drives given specific operating characteristics
- Calculate the differential in power and energy requirements of motor driven systems given the application of VSDs given specific operating characteristics
- Demonstrate an understanding of the application of the 3 affinity laws as applied to motors and drives
- Calculate the level of voltage imbalance for a system given field measurements
- Identify primary measures of power quality

IV. HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS

- Identify energy saving opportunities in heating systems
- Calculate energy consumption of ventilation equipment given operating characteristics
- Identify energy saving opportunities in cooling systems
- Explain the purpose of an economizer and how it can save energy
- Determine the efficiency of various HVAC equipment
- Identify ways to improve the operating efficiency of cooling tower
- Calculate cooling efficiency based on heat and energy transfer among components of the vapor compression cycle
- Determine the efficiency of a basic absorption cycle
- Demonstrate an understanding of the application of the 3 affinity laws as applied to motors and drives
- Demonstrate the use of the psychrometric chart in determining thermodynamic properties of air with humidity

- Demonstrate the use of Heating Degree Days and Cooling Degree Days is estimating annual energy consumption associate with space heating and cooling equipment
- Calculate heat transfer potential from waste heat recovery opportunity
- Identify alternative primary components in different ventilation systems
- Calculate thermal energy flow given specific parameters
- Calculate HVAC energy consumption given operating parameters
- Explain Demand Control Ventilation and how it can save energy
- Calculate energy savings for ventilation heat recovery given operating parameters

V. MOTOR AND DRIVE SYSTEMS

- Identify energy-saving opportunities with AC induction motor systems
- Identify why synchronous motors might be applied to industrial motor systems
- Identify applications where DC motors are best applied
- Calculate power and energy savings from the application of high-efficiency motors
- Calculate power requirement of a partially loaded motor
- Calculate energy savings potential with higher-efficiency motors
- Differentiate the efficiency characteristics of motor driven system with different motor speed control options
- Identify the best applications of Variable Frequency Drives
- Demonstrate how the affinity laws can be used to save energy in pump and fan systems
- Identify energy saving opportunities in variable-flow systems
- Understand the various categories of single-phase motors and how the compare in efficiency
- Calculate power factor given motor operating characteristics

VI. INDUSTRIAL SYSTEMS

- Select heat exchanger type best suited for specific applications
- Determine energy savings associate with heat recovery applied to boiler systems
- Calculate energy savings potential using pipe insulation
- Determine least expensive fuel selection given operating characteristic
- Identify several methods to save energy in industrial steam systems
- Demonstrate the use of steam tables in determining thermodynamic properties of steam, feedwater, and condensate
- Determine the energy lost through a failed steam trap
- Calculate energy savings from improvement in pump system efficiency
- Demonstrate how the affinity laws can be used to save energy in pump systems
- Identify the major compressor types
- Identify several methods to save energy in compressed-air systems
- Identify some of the control opportunities for saving energy in compressed-air systems
- Identify methods for quantifying compressed air leakage

VII. BUILDING ENVELOPE

- Determine the thermal resistance of an overall system (wall, roof, etc.) based on its component materials

- Understand how to use heat transfer coefficients in performing energy calculations
- Understand how to use Heating Degree Days and Cooling Degree Days data to estimate energy flow and fuel consumption in weather-related systems
- Recognize how infiltration and exfiltration contribute to space-heating and –cooling loads
- Determine insulation properties of components and air films given material components and operating characteristics
- Explain how vapor barriers should be applied to insulation
- Calculate changes in energy flow given changes in the solar heat gain factors
- Calculate changes in energy flow given changes in solar shading factors
- Differentiate between thermally-light and thermally-heavy facilities and its impact on insulation requirements and cooling system operation
- Calculate heat transfer for basic systems and equipment
- Calculate heat transfer using psychrometric chart data and ventilation data
- Calculate heat transfer using flow and temperature data

VIII. COMBINED HEAT AND POWER SYSTEMS AND RENEWABLE ENERGY SYSTEMS

- Know the basic prime movers in common power generation systems
- Know the basic power cycles associated with each of the common prime movers
- Determine least expensive fuel selection given operating characteristics
- Understand where the heat recovery opportunities are within a combined power cycle
- Differentiate the characteristics of the various operating strategies or combined heat and power systems, as well as its impact on operating costs and savings potential
- Differentiate between a topping and bottoming cycle
- Determine the cost savings associated with the application of a Combined Heat and Power system
- Identify potential advantages of Distributed Generation for an industrial client or building
- Calculate electricity delivery, thermal offsets, and fuel requirements of a generation system provided operating characteristics
- Calculate power, thermal and overall system efficiency based on operating characteristics
- Understand the basic interconnectivity requirements of renewable energy systems
- Understand the application of net-metering as applied to distributed generation applications
- Identify application opportunities of solar thermal energy systems and how they may offset traditional energy consumption
- Identify the types of regulations that assist or hinder the application of DG/RE/CHP
- Identify the source fuels associated with RE systems

IX. BUILDING AUTOMATION SYSTEMS

- Identify and differentiate between various energy management control strategies and how they can reduce energy consumption
- Differentiate between distributed and centralized control systems
- Differentiate between a BAS and individual equipment control system
- Identify additional inputs that can be used to optimize existing equipment control strategies
- Describe how intelligence can be integrated into different control strategies
- Explain various building control strategies that can be integrated into a BAS

- Differentiate between a BAS and EIS
- Differentiate between open and proprietary control protocols
- Identify advantages and limitations for open and proprietary control protocols

X. CONTROL SYSTEMS

- Identify the purpose of a control system
- Identify input signals of a control system
- Identify output signals of a control system
- Describe the basic control algorithm
- Identify sources of open communication protocols for control systems
- Differentiate between an open- and closed-loop control cycle
- Calculate the control output given the input, range, and gain for a control system
- Identify the advantages of DDC over analog control signals
- Identify how a PLC is used to send a control signal
- Be able to define key control terminology
- Identify advantages and limitations for open and proprietary control protocols
- Identify various signal carriers used in control systems
- Identify advantages and limitations of pneumatics as a signal carrier
- Identify advantages and limitations of electricity as a signal carrier
- Identify advantages and limitations of digital (binary data) as a signal carrier
- Differentiate between proportional, integral, and differential control algorithms
- Understand how adjusting set-points can be used to save energy

XI. THERMAL ENERGY STORAGE SYSTEMS

- Differentiate between full-storage and partial-storage design strategies
- Differentiate between load-leveling and load-shifting operating strategies
- Differentiate between the storage media options (ice, slurry, water, and eutectic salts)
- Identify how facility partial load factor (daily load profile shape) can impact the appropriateness of TES as a cost-saving strategy
- Identify rate tariff characteristics necessary to economically justify a TES compared to a conventional cooling system
- Solve for the storage capacity requirements of a chilled-water-based TES given specific load parameters and operating characteristics
- Solve for the storage capacity requirements of an ice-based TES given specific load parameters and operating characteristics
- Solve for the chiller equipment and storage system capacity of a full-storage system
- Solve for the chiller equipment and storage system capacity of a partial-storage system
- Solve for storage volume requirements for both ice- and water-storage systems
- Solve for storage volume requirements for both partial- and full-storage requirements
- Identify when a partial-storage system can be operated as a full-storage system during the off-peak cooling season

XII. LIGHTING SYSTEMS

- Differential multiple lighting sources in terms of life, typical efficacy, available capacity range, typical CRI range
- Define efficacy
- Differentiate lamp life definitions between LED and other lamp types
- Differentiate strike time among various lamp types
- Determine energy and cost savings for specific lighting retrofit alternatives
- Understand basic light level measurement
- Solve for number of luminaires required to achieve maintained light level given room characteristics and luminaire characteristics
- Solve basic illumination problem using inverse square law
- Identify the advantages and limitations of LED as an alternative to other lighting sources
- Calculate RCR for Zonal Cavity Analysis given room characteristics
- Solve for number of luminaires required to achieve maintained light level given CU and lamp characteristics
- Identify various sources of light loss factors
- Recognize the impact Lamp Lumen Depreciation has on potential energy saving measures
- Identify lighting control opportunities for reducing power or energy consumption
- Identify opportunities for dimming control to reduce lighting power and save energy
- Differentiate between CRI and color temperature
- Know what color temperature is and how it is important in lighting applications
- Identify various characteristics that impact lighting quality
- Identify various characteristics that impact lighting comfort factor
- Know ballast terminology and how it impacts efficacy and total lumen output of a luminaire
- Identify the function of ballasts and drivers and their impact on efficacy
- Recognize how group relamping can be used to reduce energy and power requirements when considered in the initial lighting design

XIII. BOILER AND STEAM SYSTEMS

- Solve for energy savings given an improvement in combustion efficiency
- Differentiate the impact fuel type has on combustion efficiency
- Distinguish between excess air and excess oxygen measurements in combustion exhaust
- Recognize the importance of combustion control in efficient boiler operation
- Demonstrate the use of steam tables in determining thermodynamic properties of steam, feedwater, and condensate
- Determine energy savings when using an economizer to reduce waste heat loss in a boiler
- Determine the energy lost through a failed steam trap and the cost of lost energy
- Determine the energy loss through a steam leak and determine the cost of the steam leak
- Solve for the value of increase condensate return to a boiler system
- Identify the purpose of boiler blowdown in efficient boiler operation
- Solve the savings achieved through reduced boiler blowdown
- Identify waste heat recovery opportunities in boiler and steam systems
- Solve for the amount of flash steam generated by high-pressure condensate
- Identify opportunities to reduce scaling and fouling in boilers

- Condensing Boilers
- Solve for the potential fuel savings of replacing a conventional boiler with a condensing boiler

XIV. MAINTENANCE AND BUILDING COMMISSIONING

- Recognize the importance of combustion control in efficient boiler operation
- Calculate energy savings from reducing compressed air leakage
- Determine the energy loss through a steam leak and determine the cost of the steam leak
- Identify and contrast the various methods of checking for proper steam trap operation
- Determine the energy lost through a failed steam trap and the cost of lost energy
- Identify opportunities to reduce scaling in boilers
- Solve for the energy loss associated with scaling in boiler operation
- Estimate energy loss through uninsulated pipes
- Recognize how group relamping can be used to reduce energy and power requirements when considered in the initial lighting design
- Describe how a maintenance management system can be used to reduce overall maintenance cost
- Describe the advantage and benefits of good commissioning
- Identify when commissioning should be integrated into the building design
- Identify how commissioning can be integrated into the building design
- Differentiate re-commissioning, real-time commissioning, monitoring-based commissioning, and continuous commissioning
- Differentiating new building commissioning from recommissioning
- Identify the use of M&V in support of commissioning
- Identifying both monetary and non-monetary benefits of commissioning

XV. FINANCING, PERFORMANCE CONTRACTS, & MEASUREMENT AND VERIFICATION (M&V)

- Identify the primary sources of capital used to fund energy projects
- Differentiate the primary sources of capital used to fund energy projects
- Differentiate primary project financing options
- Differentiate a capital lease from other financing options
- Identify the tax impact for a capital lease
- Identify the advantages of performance contracting
- Identify the role of the ESCO in a performance contract
- Differentiate between utility financing and performance contracts
- Differentiate the role of risk management for different financing options
- Identify when contract adjustments may be required in a performance contract
- Identify how baseline energy is determined preparing for a performance contract
- Identify the factors involved in determining post-retrofit energy usage for comparison to the baseline energy
- Identify the primary components of an M&V plan
- Identify major M&V protocol sources
- Describe the primary purpose of the IMPVP
- Differentiate the four major M&V option categories
- Differentiate between spot measurement and continuous measurement for M&V

- Identify an energy project where utility bill comparison may be sufficient to validate energy savings as a form of M&V
- Identify an energy project where modeling would be the best method to determine realized energy savings as a form of M&V