CIEP BODY OF KNOWLEDGE AND STUDY GUIDE
Preparation for the CIEP™ Certification Exam

The CIEP™ Certification Exam is a four-hour open book exam. The examination questions are based on the Body of Knowledge listed below. Because of the diversity and background and experience of Industrial Energy Professionals, the examination has 13 different subject sections, all of which are included in the exam. You must bring a hand-held calculator to the exam as the CIEP exam does not allow computers, tablets, or cell phones to be used during the test.

It is highly recommended that you review the complete Study Guide and answer the 21 Exam Review questions included in the Study Guide to determine your readiness for the exam.

The CIEP™ Examination contains the following mandatory subjects:

Body of Knowledge 2.0	Percent of Exam
1. Introduction to Industrial Energy Management	5 – 7%
2. Control Systems	5 – 7%
3. Audit Tools	5 – 7%
4. Industrial Water Systems	5 – 7%
5. Heat Exchange Systems	6 – 8%
6. Industrial Refrigeration Systems	6 – 8%
7. Furnaces, Boilers, and Fired Equipment	7 – 11%
8. Steam Systems	7 – 11%
9. Turbine Systems	6 – 8%
10. Motor Systems	8 – 12%
11. Pump Systems	7 – 11%
12. Fan Systems	6 – 10%
13. Compressed Air Systems	8 – 12%

CERTIFIED INDUSTRIAL ENERGY PROFESSIONAL (CIEP™) EXAM

The following is a list of the subjects for the CIEP™ exam.

The primary references include:

Industrial Energy Systems Handbook, 1st Edition, by Albert Williams

Energy Management Handbook, 9th Edition by Stephen Roosa, Steve Doty, and Wayne C. Turner

Guide to Energy Management, 8th Edition by Barney L. Capehart, Wayne C. Turner and William J. Kennedy

Certified Industrial Energy Professional (CIEP) Training Workbook (available to AEE training attendees)

The reference book is available through the AEE eLibrary, which is a great resource for accessing searchable content as well as highlighting and taking notes. *Digital books cannot be accessed during the certification exam.*

This study guide is intended to help prepare candidates taking the Certified Industrial Energy Professional (CIEP™) exam.

The exam will: be open book, last four hours, and have 100 multiple choice questions to answer. There are 13 sections listed below from which questions mainly are drawn.

BODY OF KNOWLEDGE: STUDY GUIDE TOPICS & REFERENCES

1	**Introduction to Industrial Energy Management**
101	Define the objectives of energy management
102	Awareness on climate change & clean energy
103	Conceptualize the need for industrial energy management
104	Understand energy basics
105	Understand energy systems efficiency
106	Understand energy balance
107	Calculate sensible and latent heat transfer
108	Overview of the energy audit types
109	Overview of the ISO50002 energy audit standard
110	Overview of the ISO50001 energy management systems standard and elaborate on its model
111	Identify relevant driving variable(s) through regression analysis
112	Develop an energy review, baseline, and energy performance indicators

REF: Williams (2022). **Industrial Energy Systems Handbook,1st Ed.** Chapters 1, 2, 3, 4, 5, and 6

2	**Control Systems**
201	Understand the basic process and concepts of control systems
202	Determine the types of control systems
203	Identify field input elements (thermocouples, RTD's, transmitters, transducers)
204	Identify field output elements (control valves, actuators, relays)

205	Understand control algorithms, and control technologies
206	Define Energy Information Systems (EIS)
207	Identify Energy Efficiency Measures (EEMs) on control system effectiveness

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 7
REF: Roosa, Doty, Turner. **Energy Management Handbook, 9th Ed.** Chapter 12

3	**Audit Tools**
301	Consider industrial safety
302	Understand electrical metering equipment and data loggers
303	Understand combustion metering
304	Understand rotor and vibration metering
305	Understand temperature metering
306	Understand compressed air leak detection
307	Understand pressure metering
308	Understand flow metering (velocity, differential pressure, displacement, open flow)
309	Understand solar PV and other commercial building metering

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 8
REF: Roosa, Doty, Turner. **Energy Management Handbook, 9th Ed.** Chapter 3

4	**Industrial Water Systems**
401	Establish water context and the need for water treatment
402	Overview industrial water uses (Oil & gas, food & beverage, mining, construction, forestry, pulp & paper, desalination)
403	Understand basics and types of water treatment
404	Understand reverse osmosis system basics
405	Evaluate cooling towers and its water loss
406	Understand ion exchange, hardiness, and blowdown in steam systems
407	Compare water desalination methods and its energy consumption
408	Identify energy and water efficiency measures on industrial water systems

REF: Capehart, Turner, and Kennedy. **Guide to Energy Management. 8th Ed.** Chapter 15
REF: Roosa, Doty, Turner. **Energy Management Handbook, 9th Ed.** Chapters 10 and 21

5	**Heat Exchange Systems**
501	Define heat exchanger basics and design
502	Understand main heat exchangers types used in industry and its applications
503	Assess heat exchange fouling
504	Understand heat exchangers in boiler systems
505	Understand heat exchangers in buildings
506	Understand heat rejection and approach temperatures in cooling towers

507	Identify EEMs on heat exchangers

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapters 10 and 16
REF: Roosa, Doty, Turner. **Energy Management Handbook, 9th Ed.** Chapter 8

6	**Industrial Refrigeration Systems**
601	Differentiate between different refrigerants and its impact
602	Understand the basic refrigeration cycle
603	Overview different complex industrial refrigeration systems (single stage, multistage, cascade, liquid overfeed, absorption)
604	Consider different types of refrigeration equipment
605	Calculate system efficiency metrics
606	Identify EEMs on refrigeration systems

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 16

7	**Furnaces, Boilers, and Fired Equipment**
701	Differentiate fuel types and heating values
702	Understand furnace types
703	Test furnace efficiency
704	Describe fired heater construction and components
705	Understand boiler types and operation
706	Understand fuel train, construction, function, and firing rate control
707	Describe burner systems, mix design styles, flames, and combustion
708	Minimize flaring
709	Identify EEMs on furnaces, boilers, and fired equipment

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 9
REF: Roosa, Doty, Turner. **Energy Management Handbook, 9th Ed.** Chapter 5

8	**Steam Systems**
801	Understand steam properties and use saturated and superheated steam tables
802	Calculate and improve boiler efficiency (direct & indirect method)
803	Determine boiler losses (shell, blowdown, stack)
804	Ascertain common methods to reduce Stack Temperature Rise
805	Evaluate deaerator tanks
806	Audit the distribution system (steam leaks, piping, insulation)
807	Assess the end use (steam traps, condensate return, flash steam)
808	Identify EEMs on boilers, steam systems

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 11
REF: Roosa, Doty, Turner. **Energy Management Handbook, 9th Ed.** Chapter 5

9	Turbine Systems
901	Explore steam turbines and has turbines
902	Understand the Rankine cycle, the Brayton cycle, and the combines cycle
903	Overview on combustion chambers, turbine blades and nozzles, seals and glands
904	Classify turbines on design, steam flow, and blade types
905	Maintain turbines and optimize its control
906	Compare CHP technologies
907	Integrating conventional power stations with renewable energy, distributed generation, and smart grids
908	Identify EEMs on turbine systems

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 11
REF: Roosa, Doty, Turner. **Energy Management Handbook, 9th Ed.** Chapter 7

10	Motor Systems
1001	Understand electrical fundamentals (induction, electromagnets, power factor)
1002	Understand electric motor basics, types, construction, causes of failure
1003	Comprehend electric motor nameplate data (Frame size, kW, insulation class, SF, Volt, etc.)
1004	Evaluate motor efficiency and efficiency classes
1005	Evaluate losses in motors
1006	Understand motor drives and speed control
1007	Compare transmission types (gears, belts)
1008	Identify EEMs in motors

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 12
REF: Roosa, Doty, Turner. **Energy Management Handbook, 9th Ed.** Chapter 11

11	Pump Systems
1101	Differentiate pump components and pump type classifications
1102	Illustrate impellers, seals, bearings, couplings
1103	Calculate delivered power, total head and efficiency of a pump
1104	Calculate total head, friction head, static head, velocity head
1105	Determine distribution losses
1106	Analyze pump and system performance curves
1107	Appreciative impact of changes in speed
1108	Analyze pump in series and in parallel
1109	Identify pump cavitation, its causes, and remedies
1110	Calculate Net Positive Suction Head available
1111	Establish pump maintenance and reliability aspects
1112	Identify EEMs on pump systems (operation, maintenance, and control)

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 14

12	Fan Systems
1201	Establish fan system fundamentals and components
1202	Differentiate fan types and their various applications considering impeller efficiency and dust loading
1203	Analyze fan and system performance curves
1204	Assess fan controls methods (dampers, inlet louvre dampers, variable inlet vanes, variable speed)
1205	Calculate the effect of variable flow by using the fan laws or affinity laws
1206	Establish fan maintenance practices
1207	Identify EEMs on fan systems (low cost, retrofit, maintenance)

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 13

13	Compressed Air Systems
1301	Establish compressed air system fundamentals
1302	Consider heat recovery and compressor operation conditions
1303	Understand compressor types (reciprocating, rotary vane, screw, axial, centrifugal
1304	Investigate load control and its application on screw and centrifugal compressors
1305	Understand air treatment (condensate, drains, dryers, filters)
1306	Understand air distribution (piping, storage tanks)
1307	Measure leaks and perform leakage tests
1308	Identify and reduce artificial demand
1309	Identify and reduce inappropriate use
1310	Identify EEMs on compressed air systems (supply side, treatment, distribution, demand side)

REF: Willaims (2022). **Industrial Energy Systems Handbook, 1st Ed.** Chapter 15
REF: Roosa, Doty, Turner. **Energy Management Handbook, 9th Ed.** Chapter 22

EXAM REVIEW QUESTIONS (Sample Only)

1. A water system fed by a pump has a static head of 3 m and a friction head of 10 m at a flow of 100 m^3/h. What is the electrical power consumption of the pump system at a flow of 60 m^3/h? The pump is driven directly and at 60% flow the motor efficiency is 91% and the pump efficiency is 78%.
   A. 1.1 kW
   B. 1.5 kW
   C. 2.7 kW
   D. 5.2 kW

2. Modulating (throttling) inlet control allows the output of a compressor to be varied to meet flow requirements. Throttling is usually accomplished by closing the inlet valve, thereby restricting inlet air to the compressor. This control method:
   A. Can be used on all kind of compressors
   B. Cannot be used on reciprocating or lubricant-free rotary screw compressor
   C. Can be used on centrifugal compressors
   D. Answers B and C
   E. Can only be used on lubricant-injected rotary screw compressors

3. A natural-gas fired boiler produces 1.4 kg/s of steam at 1 bar, 250°C. Calculate the power savings from returning the condensate to the boiler (a study shows that 70% can be recovered) as feed water. Incoming makeup water temperature is 15°C and boiler efficiency is 80%. Assume condensate is saturated water at 1.0 bar.
   A. 434 kW
   B. 996.3 kW
   C. 1,417.5 kW
   D. 1,996.3 kW

4. Calculate the percentage of blow-down for a boiler that has an allowable limit of 500 ppm of impurities and uses feed water with 10 ppm of impurities.
   A. 0.6%
   B. 1.2%
   C. 2.0%
   D. 3.8%
   E. 4.0%

5. If electricity is selling for $0.08 per kilowatt-hour and is used for electric heating with an efficiency of 100%, what is the equivalent price of natural gas per GJ if it can be burned with an efficiency of 80%?
   A. $8.00 /GJ
   B. $15.10 /GJ
   C. $17.77 /GJ
   D. $21.20 /GJ
   E. $24.30 /GJ

6. An industrial plant uses 500 kilolitres of no. 6 oil in the month of June (calorific value 41.72MJ per litre). The electrical equipment in the plant reaches a maximum demand of 15 MW. The monthly load factor is 0.78. The plant produces 30,500 tons in that month. Calculate the overall energy intensity.
    A. 0.68 GJ/ton
    B. 0.99 GJ/ton
    C. 1.68 GJ/ton
    D. 1.96 GJ/ton

7. The energy audit identifies in quantitative terms:
    A. How and where energy enters the facility, department, system or piece of equipment
    B. Where it goes and how it is used
    C. Any variances between inputs and uses
    D. How it can be used more effectively or efficiently
    E. All of the above

8. In a DDC control system distributed processing means:
    A. The algorithms for central control are located with the host computer
    B. The network carries the central station commands to the individual control panels for execution
    C. The decision-making and control process is largely handled by the local control panel
    D. All of the above

9. What is the flow rate of 16°C water through a control valve with a flow coefficient of 0.01 and a pressure difference of 100 kPa?
    A. 0.1 LPS
    B. 0.2 LPS
    C. 0.4 LPS
    D. 0.6 LPS

10. In selecting a control valve for a chilled water coil, which of the following will generally be true?
    A. The valve will be slightly smaller than the coil connection size
    B. The pressure drop for K_V calculation will be about 27-35 kPa
    C. The valve will be either a ball or globe type
    D. All are true
    E. None are true

11. Which of the following equipment can be used to conduct a steam trap operation audit?
    A. Infrared pyrometer
    B. Stethoscope
    C. Ultrasonic leak detector
    D. Thermocouple
    E. All the above

12. In operating a boiler with dual fuel capability, which is the lowest cost of fuel given the following: Natural gas $4.00/GJ; efficiency = 92%. Fuel oil $123/ton; efficiency = 88% (42,000 kJ/kg)
    A. Natural gas
    B. Fuel oil

13. Which factor(s) is considered an essential parameter in selecting a waste heat device?
    A. Amount and type of contaminant in discharge fluid
    B. Chemical composition
    C. Flow Rate
    D. All of the above

14. Determine the water saved per annum if you replace 50 standard shower heads with a flow rate of 20 liters per minutes each, with 50 water-efficient shower heads with a flow rate of 10 liters per minute in a hotel. Assume that the average person showers for 7 minutes once per day, and that the hotel is at full capacity for 200 days of the year.
    A. 285.71 litres
    B. 2,000 litres
    C. 14,000 litres
    D. 25,550 litres
    E. None of the above

15. Cleaning the heat exchange surfaces on boiler tubes will result in
    A. Reduced stack temperature
    B. Increased O_2
    C. A reduction in the steam to coal ratio
    D. None of the above

16. Which of the following heat exchanger types is most likely to allow cross contamination between heat exchange fluids?
    A. Shell & tube
    B. Heat pipe
    C. Heat wheel
    D. Recuperator

17. What is the overall efficiency of the co-generation plant described below:

    - Heat in = 1000 kW
    - Electricity generated = 200 kW
    - Thermal energy = 600 kW

    A. 20%
    B. 40%
    C. 60%
    D. 80%
    E. 100%

18. How does steam injection into a gas turbine affect the operation?
    A. Increases thermal efficiency
    B. Reduces NO_x
    C. Increases NO_x
    D. Answers A and B
    E. Answers A and C

19. An automotive shock manufacturer has been approached by a cogeneration developer who claims that they can reduce the plants' energy costs. They plan to install a 150 kW packaged cogeneration system with the following specifications listed below:

    - Output: 150 kW_e
    - Electrical Efficiency: 30 %
    - Total Efficiency: 75 %
    - Fuel Cost: $ 5 / GJ
    - Current electric Cost: $ 0.20 / kWh
    - Existing boiler efficiency: 85 %
    - Hot Water Usage of centre: 100 000 litres / day (19 °C)

    What is the hourly fuel consumption in GJ/hr?
    A. 1.8 GJ/h
    B. 2.3 GJ/h
    C. 4.3 GJ/h
    D. 12.3 GJ/h
    E. 23 GJ/h

20. Five bucket steam traps are stuck open in your facility. They all exhaust to the drain. If LPG gas for the boiler costs $50 /GJ and your steam system is 78% efficient, what is the cost of these malfunctioning steam traps per year? Each trap has a 3.2 mm orifice. The steam line pressure is 690 kPa.
    A. $22,489 /yr
    B. $56,500 /yr
    C. $110,000 /yr
    D. $220,489 /yr
    E. $224,890 /yr

21. Cosine ϕ correcting capacitors may be located:
    A. At the inductive load
    B. At load control centres
    C. At the primary transformer (customer side)
    D. All of the above
    E. Answers A and B

Answer Key:

1- A
2- D
3- A
4- C
5- C
6- C
7- E
8- C
9- A
10- D
11- E
12- B
13- D
14- E
15- A
16- C
17- D
18- D
19- A
20- C
21- D