THE CEA BODY OF KNOWLEDGE AND STUDY GUIDE

Preparation for the CEA Certification Exam

The CEA 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 Energy Auditors, the examination has 10 different subject sections, all of which are included in the exam. You must bring a hand-held calculator to the exam as the CEA 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 10 Exam Review question included in the Study Guide to determine your readiness for the exam.

The CEA Examination contains the following mandatory subjects:

Body of Knowledge	Percent of Exam
Developing an Audit Strategy & Plan	12 - 18 %
Utility Analysis, Renewable Opportunities	11 - 17 %
Data Collection & Economic Analysis	11 – 17 %
Lighting Systems	7 - 10 %
HVAC & Heating Systems	16 - 24 %
Motors, Drives & Compressed Air	7 - 10 %
Ventilation Systems	4 - 6 %
Domestic Hot Water Systems	4 – 5 %
Building Envelope	3 – 5 %
Water Conservation	3 - 4 %

CERTIFIED ENERGY AUDITOR™ (CEA® EXAM)

The following is a list of the subjects for the CEA exam. Each subject covers a number of topics. Following the list of topics are suggested references with chapter numbers. The primary references are the Handbook of Energy Audits, 9th Edition, by Albert Thumann, Terry Niehus, and William J. Younger, the Commercial Energy Auditing Reference Handbook, 2nd Edition by Steve Doty, and the Energy Management Handbook, 8th Edition by Steve Doty and Wayne C. Turner. However, some other books are also referenced as appropriate.

The study guide will not lead you to answers to all of the questions, but it will certainly lead you to a very large number of correct answers. A person with the necessary experience who reviews the study guide should not have any problem passing the exam.

The exam will: be open book, last four hours, and have 140 multiple choice questions to answer. Each question is valued at 7.2 points for a total of 1,008 points available on the exam. There are 10 sections listed below from which questions mainly are drawn.

BODY OF KNOWLEDGE: STUDY GUIDE TOPICS & REFERENCES

Developing an Energy Audit Strategy and Plan

Energy auditing fundamentals
Energy and power units; Conversion factors
Audit instrumentation
Safety requirements and procedures
Plan Energy Audit
Define Required Audit procedures
Select the Project team
Analyze & Breakdown Energy end use
Determine Appropriate Audit Level
Define Pre- audit tasks
Define Data required for energy analysis
Estimate cooling and heating loads for the system or facility
Plan a Pre-audit interview-
Communicate procedures and data gathering
Identify operations and maintenance team and create pre-audit O&M interview questions.
Define audit report format and requirements
Draft Audit report
Select appropriate instrumentation

REF: Doty and Turner, **Energy Management Handbook**, Chapters 2 and 3
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapter 1

Utility Analysis

Demand and energy
Power factor
Define Required utility information
Review Rate classifications
Establish utility costs baseline

Establish utility usage baseline
Facility benchmarking
Estimate savings potential
Identify billing errors
Verify Energy bill calculations
Select optimal Rate options

REF: Doty and Turner, **Energy Management Handbook**, Chapter 4
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapters 2 and 3
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 1

Data Collection and Economic Analysis

Energy accounting
Define pre-site Data collection
Collect pre-site Data
Define on-site Data collection
Collect on-site Data
Calculate Energy savings and payback
Evaluate Energy management opportunities
Evaluate O&M characteristics and opportunities
Detailed financial analysis
Interactive effects of measures
Computer simulations

REF: Doty and Turner, **Energy Management Handbook**, Chapter 4
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapter 4
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 6

Lighting Systems

Measurement of light
Determine Efficiency/efficacy of light source
Determine Appropriate Light color-CCT/CRI
Evaluate Lamp lumen depreciation
Calculate replacement period given Lamp lumen depreciation
Determine Lamp types and characteristics
Evaluate Lamp types & characteristics for replacement
Audit Lighting Control System
Calculate replacement period given Lamp lumen depreciation
Lighting power allowances

REF: Doty and Turner, **Energy Management Handbook**, Chapter 13
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapters 7
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 16

HVAC Systems

HVAC basics
Heat Pump classifications
Heat Pump operations
Audit & determine types of HVAC systems
Calculate estimated heating & cooling loads

Identify any special ventilation code requirements that may or may not be met at this time.
Determine existing HVAC efficiencies
Identify existing control strategies including locations of thermostats, scheduling of loads and occupants.
Evaluate ductwork and fan systems for leaks, insulation and or pressure drop
Identify HVAC system components
Audit & determine types of chillers: electric, gas driven, absorbers
Identify piping arrangements for chilled water and or refrigerant systems
Audit & determine types of heat pump, chillers, or split system units
Analyze heat pump or split system efficiencies

REF: Doty and Turner, **Energy Management Handbook**, Chapter 10
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapter 9
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 11

Heating Systems

Audit & determine types of boilers: fire tube, water tube, cast iron
Audit & determine types of furnaces: electric, gas, pulse, condensing
Evaluate distribution systems, (ductwork and or piping), for insulation, pressure drop, leaks.
Compare terminal units

REF: Doty and Turner, **Energy Management Handbook**, Chapter 10
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapters 8
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 1

Motors and Drives

Audit & determine types and sizes of motors
Evaluate appropriate types of motors
Determine operating characteristics of motors and drives
Calculate efficiencies of motors and drives
Review potential energy savings of variable frequency drives

REF: Doty and Turner, **Energy Management Handbook**, Chapter 11
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapters 7
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 12

Compressed Air Systems

Analyze existing conditions for improvement opportunities
Evaluate for upgrade to DDC
Perform savings calculations

REF: Doty and Turner, **Energy Management Handbook**, Chapter 3
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapter 10
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 14

Cogen Opportunities

Evaluate option for Cogen opportunity
Perform savings calculations

REF: Doty and Turner, **Energy Management Handbook**, Chapter 7

REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapter 2

Renewable Energy

Evaluate opportunities for use of renewable energy source

REF: Doty and Turner, **Energy Management Handbook**, Chapter 16
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapter 16

Ventilation Systems

Audit & determine types of ventilation systems
Define characteristics
Ventilation requirements, (code related).
Ventilation control options
Determine heat recovery options

REF: Doty and Turner, **Energy Management Handbook**, Chapter 3
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapters 10
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 14

Domestic Hot Water Systems

Audit & determine types of hot water systems
Calculate efficiencies
Identify temperature set points
Evaluate circulating pumps
Evaluate energy savings opportunity for heat pump water heaters

REF: Doty and Turner, **Energy Management Handbook**, Chapter 5
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapter 13
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 18

Building Envelope

Heat flow concept
Determine R and U values
Evaluate efficiency of walls, roofs, windows
Evaluate replacement with Low E glass
Audit building envelope infiltration
Balance point temperature
Thermal weight

REF: Doty and Turner, **Energy Management Handbook**, Chapter 9
REF: Thumann, Niehus, and Younger, **Handbook of Energy Auditing**, Chapter 6
REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 17

Water Conservation

Water conservation methods
Determine Rate structures
Apply Water conservation methods
Evaluate Irrigation and landscaping installation and efficiency
Survey Leak detection system

Audit water use

REF: Doty, **Commercial Energy Auditing Reference Handbook**, Chapter 18

EXAM REVIEW QUESTIONS (Sample Only)

Some of these review questions may be more complex or difficult than the exam but will be good practice problems.

1. Which of the following is not always correct?
   (A) 10 kWh = 34,120 Btus
   (B) 5 therms = 500,000 Btus
   (C) 3 tons = 36,000 Btu/hr
   (D) 1 MCF = 1 MMbtu

2. A factory has a kWh usage in August of 550,000 and a peak demand of 3,000 kW. Calculate the July energy and demand charges if the utility costs forthis rate class are $0.06/kWh and $15/kW-month for demand.
   (A) $33,000
   (B) $60,000
   (C) $78,000
   (D) $45,000

3. The lighting efficacy term is lumens per watt.
   (A) True
   (B) False

4. A chiller has a full load rating of 0.7 kW/ton. What is the full load kW if this unit has a 200 ton rating?
   (A) 286
   (B) 140
   (C) 900
   (D) 75

5. An office building replaced 20 W CFLs with 14W LEDs. The lights are on 3,000 hrs/yr. The average electricity cost is $0.10/kWh and the LEDs are $12 each. Calculate the simple payback.
   (A) 6.67 years
   (B) 8.67 years
   (C) 0.15 years
   (D) 4.25 years

6. A customer wants to install an occupancy sensor in the break room. A data logger has shown that, on average, the lights can be turned off 5 hrs/week. The lights in this room have a combined wattage of 3 kW. Electricity is $0.09/kWh and an occupancy sensor cost $150 installed. What is the simple payback?
   (A) 0.47 years
   (B) 3.63 years
   (C) 0.90 years
   (D) 2.14 years

7. A commercial customer has set a peak demand of 100 kW and has used 45,500 kWh for January. Calculate the load factor.
   (A) 0.61
   (B) 0.42
   (C) 0.81
   (D) 1.63

8. The terms load factor and power factor can be used interchangeably.
   (A) True
   (B) False

9. A three phase induction motor draws 13 amps at 240 volts. The power factor is 0.9. Determine the kW.
   (A) 5.54
   (B) 5.16
   (C) 4.86
   (D) 6.32

10. A hospital uses 400,000 gallons of water per year just for showers. The showers have the old style showerheads that use 4.5 gpm. What is the annual amount of water saved if they replace the showerheads with new ones that comply with the maximum flow rates allowed per the Energy Policy Act of 1992?
    (A) 200,000 gallons per year
    (B) 285,765 gallons per year
    (C) 222,222 gallons per year
    (D) 177,778 gallons per year

11. An office building has the following:
    Existing: 100 T-12 fixtures @ 164 watt/fixture
    Proposed: 100 T-8 fixtures @ 106 watts/fixture
    4,000 hrs/yr operation
    Utility costs: $.10/kWh and $13/kW-month
    Installation cost: $100/fixture
    Determine the simple payback.
    (A) 0.32 years
    (B) 1.86 years
    (C) 3.10 years
    (D) 2.46 years

12. A company has a 1 MMBtu/hr boiler with an efficiency of 70%. They want to replace it with a 90% efficient condensing boiler. The average fuel usage for the last five heating seasons was 20,000 therms. If a therm cost $0.60, calculate the annual savings per heating season.
    (A) $4,388
    (B) $2,667
    (C) $10,000
    (D) $3,185

13. The speed of a three phase induction motor is determined by the line voltage.
    (A) True
    (B) False

14. A 20 HP standard fan motor runs 8,760 hours per year has an efficiency of 86.5%. What will the simple payback be for replacing this motor with a 20 HP premium one with an efficiency of 93.5%? The premium motor cost $725 installed. The utility charges are $0.05/kWh and $14.00/kW-month. Motor loading is 0.7.
    (A) 0.75 years
    (B) 2.65 years
    (C) 1.33 years
    (D) 3.33 years

15. How many Btu/hr of cooling are supplied by a chiller with a 45°F chilled water supply temperature, a 57°F chilled water return temperature and a 2.5 gpm water pump?
    (A) 9,252 Btu/hr
    (B) 12,000 Btu/hr
    (C) 120,000 Btu/hr
    (D) 15,000 Btu/hr

16. A building wall is made up of the following materials:
    Concrete block- R = 2.2
    Brick façade- R = 3.1
    Drywall- U= 0.5
    What is the total R value of this wall?
    (A) 5.8
    (B) 7.3
    (C) 6.4
    (D) 1.9

17. Motor slip is defined as:
    (A) Pulley displacement
    (B) Percentage of winding drift
    (C) The difference between the synchronous speed and actual speed
    (D) The difference between nominal efficiency and actual efficiency

18. An absorption chiller has a COP of 0.7. What is the EER?
    (A) 4.87
    (B) 13.2
    (C) 3.41
    (D) 2.39

19. A four ton heat pump with a SEER of 14 and an HSPF of 8.0 operates 3,100 full load hours/yr in the cooling mode and 1,200 hours/yr in the heating mode. What is the annual operating cost if electricity is $0.15/kWh?
    (A) $2,675/yr
    (B) $3,200/yr
    (C) $4,878/yr
    (D) $1,320/yr

20. Motor slip is proportional to loading.
    (A) True
    (B) False

Answer Key:

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

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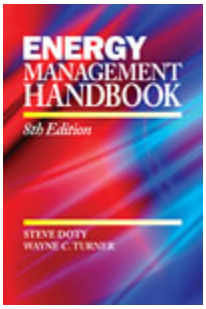

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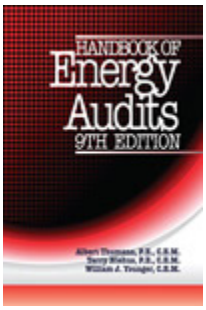
By Albert Thumann, Terry Niehus, and William Younger



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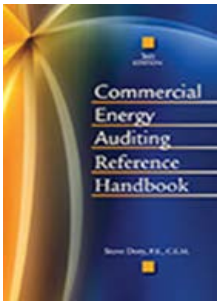

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