

## 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)

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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, 9<sup>th</sup> Edition, by Albert Thumann, Terry Niehus, and William J. Younger, the Commercial Energy Auditing Reference Handbook, 2<sup>nd</sup> Edition by Steve Doty, and the Energy Management Handbook, 8<sup>th</sup> 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

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#### **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.*

- Which of the following is not always correct?
  - 10 kWh = 34,120 Btus
  - 5 therms = 500,000 Btus
  - 3 tons = 36,000 Btu/hr
  - 1 MCF = 1 MMbtu
- 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 for this rate class are \$0.06/kWh and \$15/kW-month for demand.
  - \$33,000
  - \$60,000
  - \$78,000
  - \$45,000
- The lighting efficacy term is lumens per watt.
  - True
  - False
- 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?
  - 286
  - 140
  - 900
  - 75
- 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.
  - 6.67 years
  - 8.67 years
  - 0.15 years
  - 4.25 years
- 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?
  - 0.47 years
  - 3.63 years
  - 0.90 years
  - 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:

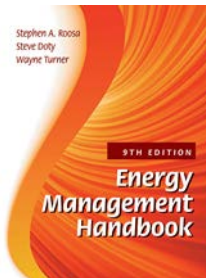
- 1- D
- 2- C
- 3- A
- 4- B
- 5- A
- 6- D
- 7- A
- 8- B
- 9- C
- 10- D
- 11- C
- 12- B
- 13- B
- 14- C
- 15- D
- 16- B
- 17- C
- 18- D
- 19- A
- 20- A

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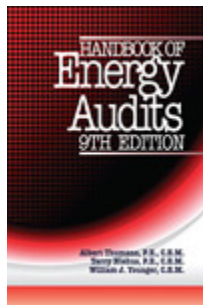


### **ENERGY MANAGEMENT HANDBOOK, 9<sup>th</sup> Edition**

*By Steve Doty, Stephen Roosa, and Wayne C. Turner*

Newly revised and edited, This comprehensive handbook is recognized as the definitive stand-alone energy manager's desk reference, used by tens of thousands of professionals throughout the energy management industry. This new ninth edition includes new chapters on energy management controls systems, compressed air systems, renewable energy, and carbon reduction.

*ISBN: 0-88173-785-2, 8½ x 11, 893 pp., Illus., Hardcover, Order Code 7364 Price: \$260.00*

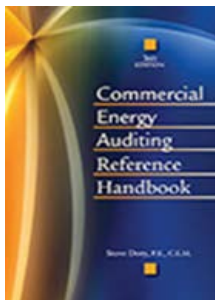


### **HANDBOOK OF ENERGY AUDITS, 9<sup>th</sup> Edition**

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This best-selling handbook is the most comprehensive and practical reference available on energy auditing in buildings and industry. Completely edited throughout, this latest edition includes new chapters on investment grade energy audits and retro-commissioning audits, as well as new information on ISO 50001 and the Superior Energy Performance program.

*ISBN: 0-88173-685-6, 6 x 9, 495 pp., Illus., Hardcover, Order Code 675 Price: \$130.00*



### **COMMERCIAL ENERGY AUDITING REFERENCE HANDBOOK, 3<sup>rd</sup> Edition**

*By Steve Doty*

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*ISBN: 0-88173-756-9, 6 x 9, Illus. 1075 pp., Hardcover, Order Code: 0716 Price: \$135.00*

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