Energy, Environment, and Sustainability

SAEED MOAVENI

Second Edition

ENERGY, ENVIRONMENT, AND SUSTAINABILITY

SECOND EDITION

Saeed Moaveni

MINNESOTA STATE UNIVERSITY, MANKATO

CENGAGE

Australia • Brazil • Canada • Mexico • Singapore • United Kingdom • United States

Energy, Environment, and Sustainability
Second Edition
Saeed Moaveni

SVP, Higher Education Product Management: Erin Joyner

VP, Product Management, Learning Experiences: Thais Alencar

Product Director: Mark Santee

Senior Product Manager: Timothy L. Anderson

Product Assistant: Simeon Lloyd-Wingard

Learning Designer: MariCarmen Constable

Content Manager: Alexander Sham

Digital Delivery Quality Partner: Nikkita Kendrick

Director, Product Marketing: Jennifer Fink

Product Marketing Manager: Taylor Shenberger

IP Analyst: Deanna Ettinger

Text and Image Permissions Researcher: Integra

Production Service: RPK Editorial Services, Inc.

Compositor: Straive

Manufacturing Planner: Ron Montgomery

Designer: Nadine Ballard

Cover Image: chinaface/Getty Images

Library of Congress Control Number: 2021946427

Student Edition:
ISBN: 978-0-357-67607-3

Loose-leaf Edition:
ISBN: 978-0-357-67614-1

Cengage
200 Pier 4 Boulevard
Boston, MA 02210
USA

Cengage is a leading provider of customized learning solutions with employees residing in nearly 40 different countries and sales in more than 125 countries around the world. Find your local representative at **www.cengage.com.**

To learn more about Cengage platforms and services, register or access your online learning solution, or purchase materials for your course, visit **www.cengage.com.**

Printed in the United States of America
Print Number: 01 Print Year: 2021

Contents

PART 2

Energy 122

PART 3

Environment 306

PART 4

Sustainability 428

Preface

We all realize the importance of understanding fundamental concepts dealing with energy, environment, sustainability, and their relationships, as they affect the quality of our lives. We also agree that a functioning democracy requires well-educated responsible citizens. Unfortunately, the vast majority of students today graduate from high school and college without developing any understanding of the role energy plays in their daily lives and how energy consumption and waste impact the environment and future generations.

This book is an attempt to lay down the foundation for the development of responsible citizens with a clear understanding of contemporary issues dealing with energy, environment, and sustainability. Great care has been exercised to use real-world examples to get important points across, foster critical thinking, and use evidence-based analyses. The content is designed not only to develop the ability of students to go beyond mere understanding of the concepts but to also quantify their energy and environment footprints in order to determine whether their actions are sustainable. The content is also presented with a simple conversational tone with many visual aids to keep today's students engaged. The level of mathematical requirements is kept low so that the topics can be taught to all students. If students can add, subtract, and multiply, then they will be able to follow the examples presented in this textbook, solve the homework problems, and determine their environmental footprints. Moreover, in order to reach out to as many students as possible, the content is prepared as a general education course that can be taught at a community college or a university by instructors with various backgrounds, including physics, science, or engineering. When it comes to energy, environment, and sustainability, we must realize that *we are all in this together!*

Changes in the Second Edition

The Second Edition, consisting of fourteen chapters, includes several new additions, changes, and features that were incorporated in response to adopters' comments, as well as pedagogical and sustainability advances. The major changes include:

- A new chapter on evidence-based data analysis introducing students to an approach that is based on basic scientific principles and easy-to-understand mathematical and statistical models
- A new chapter on electronic spreadsheets which are commonly used to record, organize, and analyze data using formulas, as well as to present the results of an analysis in graph form
- Over 50 new problems

- Greater focus on global interdependency and global data, critical thinking, complex problem-solving, and application of knowledge in real-world settings
- Greater emphasis on a blended model where collaborative problem-solving and community engagements are encouraged

Organization

This book is organized into four parts and 14 chapters; each chapter begins by stating the **learning objectives** (**LO**) and concludes by summarizing what the student should have gained from studying the chapter. Relevant, everyday examples, with which students can associate easily, are provided throughout the book. Many **hands-on problems** conclude each chapter, asking the student to gather and analyze information. Moreover, these problems require students to make brief reports and presentations so that they learn the importance of good written and oral communication skills. To emphasize the significance of teamwork and to encourage group participation, many of the problems also require group work; some require the participation of the entire class. The main parts of the book are described below.

Part One: Basic Concepts

In Part One, consisting of Chapters 1 through 4, we introduce the students to the importance of understanding basic concepts such as human needs, energy, environment, sustainability, and the fundamental dimensions and units that we use every day in our lives. As good global citizens, it is also important to follow a systematic approach to sort carefully through information that is presented to us when we are confronted with a complex problem. We need to make decisions that are based on sound scientific principles, scientific research, scientific data, and mathematical and statistical models.

Chapter 1 provides an introduction to the current state of our world. It introduces the students to world population and its trends, basic human needs, and why it is important to understand concepts of energy, environment, and sustainability. We explain the traits of good global citizens and the importance of developing good communication skills–all essential for a well-educated democratic society. We also emphasize that responsible citizens must have a good grasp of issues related to energy and environment and take active roles in their communities. We point out that although the activities of good citizens can be quite varied, there are some personality traits and involvement practices that typify them:

- Good citizens are well informed and have a firm grasp of current issues, particularly issues related to energy, environment, and sustainability.
- Good citizens have a desire to be life-long learners. For example, they are well read; they attend community meetings and presentations to stay abreast of new events and innovations in technologies and understand how new developments may affect their lives.
- Good citizens have good written and oral communication skills.
- Good citizens have time management skills that enable them to work productively, take good care of their families, and be active in their communities.
- Good citizens generally work in a team environment where they consult each other to solve complex problems that affect all of us.

Chapter 2 explains the role and importance of fundamental dimensions (e.g., length, time, mass, temperature) and systems of units (e.g., foot, meter, second, pound, kilogram, degree Fahrenheit, degree Celsius) in our daily lives. We emphasize to the students that they have been using these concepts all their lives; we now define them in a formal way, so that students can understand and quantify more intelligently their own environmental impact, water and energy consumption rates, and waste.

In **Chapter 3**, we introduce students to evidence-based analysis, an approach that is based on scientific principles, scientific research, scientific data, and mathematical and statistical models. In recent years, the use of this systematic approach in a wide range of topics, including sustainability, has resulted in more reliable decisions. We also discuss linear models, as they are the simplest form of equations used to describe a range of situations. Basic concepts dealing with probability and statistics are also discussed. Probability deals with the branch of science that attempts to predict the likelihood of an event to occur, and statistics is the area of science that deals with the collection, organization, analysis, and interpretation of data.

Spreadsheets are used to record, organize, and analyze data using formulas. They are also used to present the results of an analysis in chart forms. **Chapter 4** covers Microsoft Excel, which offers a large selection of built-in functions that students can use to analyze data. Excel also offers many choices when it comes to creating charts. We also show how to use Excel to find an equation that best fits a set of data and forecasts future trends.

Part Two: Energy

In Part Two, consisting of Chapters 5 through 9, we introduce students to the importance of understanding the basics of conventional and renewable energy; its sources and production; and consumption rates in homes, buildings, transportation, food production and manufacturing. **Chapter 5** explains the basic concepts related to energy and efficiency. These are concepts that every college graduate, regardless of their area of interest, should know. We need energy to build shelter, to cultivate and process food, to make goods, and to maintain our living places at comfortable settings. To quantify the requirements to build things, move or lift objects, or to heat or cool buildings, energy is defined and classified into different categories. We discuss what we mean by mechanical energy and thermal energy. The units of energy and power, including kilowatt-hour, Btu, kilowatt, and horsepower, are also discussed in this chapter. **Chapter 6** covers the basic concepts of electricity and electric power production. We also cover residential power consumption, particularly lighting systems, because lighting accounts for a major portion of electricity use in buildings; lighting systems have received much attention recently due to the energy and sustainability concerns. **Chapter 7** covers the fundamentals of heat transfer, and heat loss and gain in buildings. Space heating and air conditioning account for nearly fifty percent of energy use in homes in the United States. **Chapter 8** provides a comprehensive coverage of energy sources including gasoline, natural gas, coal, and wood, as well as their consumption rates. We detail how much energy we consume in our homes, buildings, and in the transportation and manufacturing sectors. **Chapter 9** explains renewable energy and its sources as well as the basic concepts related to solar energy, wind energy, and hydro-energy.

Part Three: Environment

In Part Three, consisting of Chapters 10 through 13, we focus on the environment and introduce students to air and water and the anatomy of earth, its natural resources, and rates of consumption and waste. We emphasize that our earth has finite resources. **Chapter 10** provides general information about the atmosphere, weather and climate, along with outdoor and indoor air quality standards. **Chapter 11** covers water resources, quality standards, and consumption rates in our homes, in agriculture, and in the industrial and manufacturing sectors of our society. **Chapter 12** provides a detailed understanding of common materials that are used to make products and structures. **Chapter 13** discusses waste and recycling.

Part Four: Sustainability

In Part Four, consisting of **Chapter 14**, we introduce key sustainability concepts, methods, and tools. Every college graduate must develop a keen understanding of the Earth's finite resources, environmental and socioeconomic issues related to sustainability, ethical aspects of sustainability, and the necessity for sustainable development. Students should also know about life-cycle based analysis, resource and waste management, and environmental impact analysis, and be familiar with sustainable-development indicators such as the U.S. Green Building Council (USGBC) and Leadership in Energy and Environmental Design (LEED) rating systems. Finally, in Chapter 14, we have included several personal and community-based projects to promote responsible citizenship and sustainability.

Active Learning Features

This book includes numerous features intended to promote active learning. These features include: (1) Learning Objectives (LO), (2) Discussion Starters, (3) Before You Go On, (4) Highlighted Key Concepts, (5) Summary, (6) Key Terms, (7) Apply What You Have Learned, and (8) Life-long Learning.

Learning Objectives (LO)

Each chapter begins by stating the learning objectives (**LO**), enabling students to identify the most important concepts to take away from that chapter. These objectives are revisited throughout the chapter and are also highlighted within the chapter summary.

Discussion Starters

Pertinent facts and articles serve as chapter openers to promote meaningful discussion and engage students. They provide a means to understanding the importance of what students are about to learn. A good way for the instructor to use a Discussion Starter is by giving students a few minutes to read it at the beginning of a class and then ask the students about their thoughts.

Before You Go On

This feature encourages students to test their comprehension and understanding of the material discussed in a section by answering questions before they continue to the next section.

Vocabulary

It is essential for students to understand the importance of developing a complete vocabulary to converse correctly about today's pressing issues. This feature promotes understanding of basic terminology by asking students to state the meaning of new terms that are covered in a section.

Key Concepts

Key Concepts are highlighted and defined in special boxes throughout the book.

Summary

Each chapter concludes by summarizing what the student should have gained from the chapter. These summaries are designed to help students comprehend and become proficient with the materials.

Key Terms

At the end of each chapter, key terms are indexed so that students can use them for review or check back in the chapter for their meaning.

Apply What You Have Learned

This feature, designed to highlight practical applications of course concepts, encourages students to apply what they have learned to an interesting problem or a situation. To emphasize the importance of teamwork and to encourage group participation, many of these problems require group work.

Life-Long Learning Problems that depict and apply concepts that are critical for life-long learning are clearly denoted by a key icon to draw attention to their importance.

Supplements

Additional instructor resources for this product are available online. Instructor assets include a Solution Answer Guide, Image Library, and PowerPoint® slides. Sign up or sign in at www.cengage.com to search for and access this product and its online resources.

Acknowledgments

I am thankful to all the reviewers who offered general and specific comments during the conception of this book, including Louis D. Albright, Cornell University; Paul Dawson, Boise State University; John Gardner, Boise State University; Thomas Ortmeyer, Clarkson University; William Rauckhorst, Miami University; Malcolm M. Sanders, The University of Vermont; Chiang Shih, Florida State University; and Sesha Srinivasan, Tuskegee University. I also wish to thank Karen Chou of Northwestern University, Melinda Huff of Harding University, and Ali Razban of Indiana University–Purdue University Indianapolis for their feedback on the first edition.

I wish to acknowledge and thank the Global Engineering team at Cengage for their dedication to this new book: Timothy Anderson, Senior Product Manager; MariCarmen Constable, Learning Designer; Alexander Sham, Content Manager; and Simeon Lloyd-Wingard, Product Assistant. Thanks are also due to Rose P. Kernan of RPK Editorial Services. They have skillfully guided every aspect of this text's development and production to successful completion.

Thank you for considering this book, and I hope you enjoy it.

—Saeed Moaveni

About the Author

Saeed Moaveni is a successful engineer, author, and educator. Dr. Moaveni is a licensed professional engineer in the State of New York and has over 35 years of experience in practice, teaching, and research. He has held faculty appointments at several universities, including University of South Carolina, Syracuse University, and Minnesota State University, and has served as a graduate program coordinator, department chair, and dean. He is the former Dean of the David Crawford School of Engineering at Norwich University—one of the oldest engineering schools in the country (founded in 1819).

As a well-known educator and researcher, Professor Moaveni has received numerous awards throughout his career, including the Jack Cermak Distinguished Professor Fellowship, the American Society for Engineering Education Outstanding Young Faculty Award, the International Network for Engineering Education & Research Recognition Award, and the Global Citizen Award from Minnesota State University.

Professor Moaveni's various textbooks have been translated into many languages, including traditional Chinese, simplified Chinese, Portuguese, Farsi, and Korean. He has been invited abroad as a visiting scholar at numerous universities, including Kyushu University (Japan), National Chiao Tung University (Taiwan), National Cheng Kung University (Taiwan), the Institute of Theoretical and Applied Mechanics at National Taiwan University, Shanghai University of Engineering Science, and Kwame Nkrumah University of Science and Technology (Ghana).

Digital Resources

CENGAGE | WEBASSIGN

New Digital Solution for Your Classroom

WebAssign is a powerful digital solution designed by educators to enrich the teaching and learning experience. With a robust computational engine at its core, *WebAssign* provides extensive content, instant assessment, and superior support.

WebAssign's powerful question editor allows instructors to create their own questions or modify existing questions. Each question can use any combination of text, mathematical equations and formulas, sound, pictures, video, and interactive HTML elements. Numbers, words, phrases, graphics, and sound or video files can be randomized so that each student receives a different version of the same question.

In addition to common question types such as multiple choice, fill-in-the-blank, essay, and numerical, you can also incorporate robust answer entry palettes (mathPad, chemPad, calcPad, physPad, Graphing Tool) to input and grade symbolic expressions, equations, matrices, and chemical structures using powerful computer algebra systems.

WebAssign Offers Instructors the Following

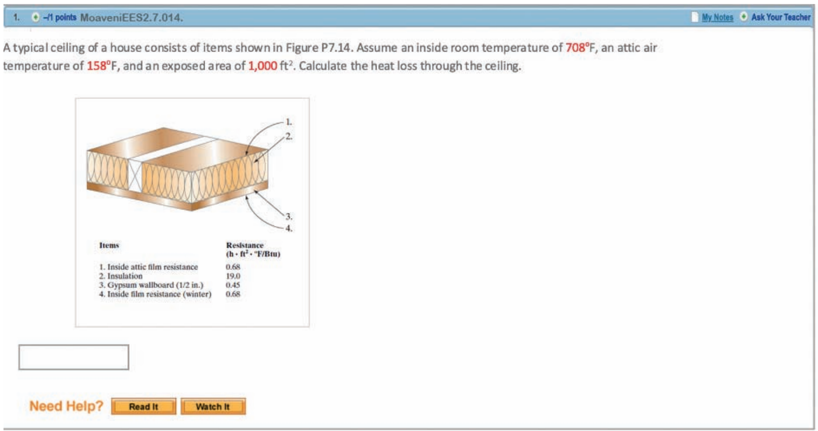
- The ability to create and edit algorithmic and numerical exercises.
- The opportunity to generate randomized iterations of algorithmic and numerical exercises. When instructors assign numerical *WebAssign* homework exercises, the *WebAssign* program offers them the ability to generate and assign their students differing versions of the same exercise. The computational engine extends beyond and provides the luxury of solving for correct solutions/answers.
- The ability to create and customize numerical questions, allowing students to enter units, use a specific number of significant digits, use a specific number of decimal places, respond with a computed answer, or answer within a different tolerance value than the default.

Visit www.webassign.com/instructors/features/ to learn more. To create an account, instructors can go directly to the signup page at www.webassign.net/signup.html.

WebAssign Features for Students

- **Review Concepts at Point of Use**

Within *WebAssign*, a “Read It” button at the bottom of each question links students to corresponding sections of the textbook, enabling access to the MindTap Reader at the precise moment of learning. A “Watch It” button allows a short video to play. These videos help students understand and review the problem they need to complete, enabling support at the precise moment of learning.



- **My Class Insights**

WebAssign’s built-in study feature shows performance across course topics so that students can quickly identify which concepts they have mastered and which areas they may need to spend more time on.

- **Ask Your Teacher**

This powerful feature enables students to contact their instructor with questions about a specific assignment or problem they are working on.

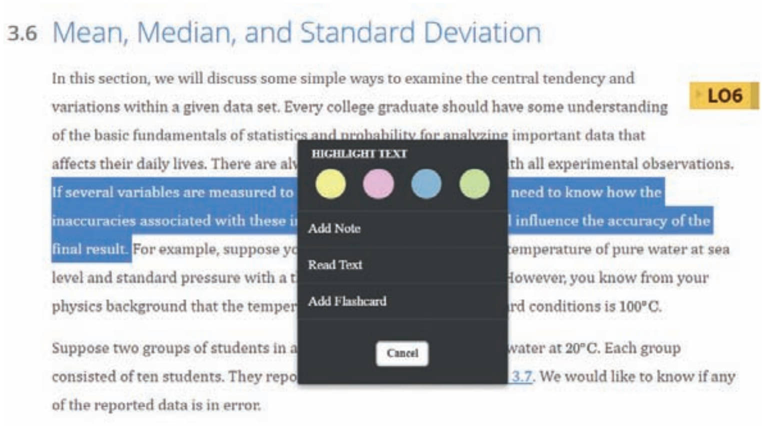
MindTap Reader

Available via *WebAssign* and our digital subscription service, Cengage Unlimited, **MindTap Reader** is Cengage’s next-generation eTextbook for students.

The MindTap Reader provides more than just text learning for the student. It offers a variety of tools to help our future good global citizens learn chapter concepts in a way that resonates with their workflow and learning styles.

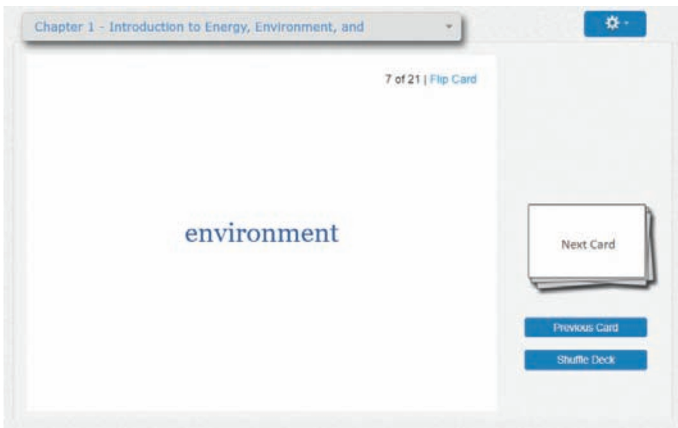
- **Personalize their experience**

Within the MindTap Reader, students can highlight key concepts, add notes, and bookmark pages. These are collected in My Notes, ensuring they will have their own study guide when it comes time to study for exams.



- **Flexibility at their fingertips**

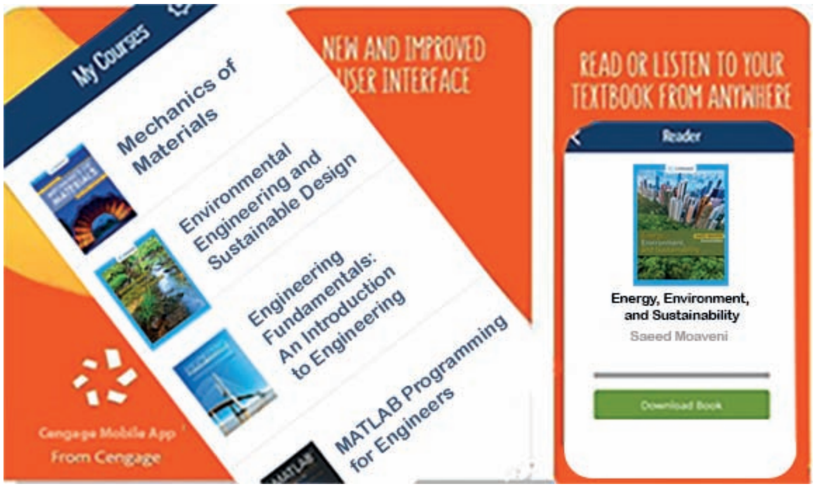
With access to the book's internal glossary, students can personalize their study experience by creating and collating their own custom flashcards. The ReadSpeaker feature reads text aloud to students so they can learn on the go—wherever they are.



The Cengage Mobile App

Available on iOS and Android smartphones, the Cengage Mobile App provides convenience. Students can access their entire textbook anyplace and anytime. They can take notes, highlight important passages, and have their text read aloud whether they are online or off.

To learn more and download the mobile app, visit www.cengage.com/mobile-app/.



CENGAGE UNLIMITED

All-You-Can-Learn Access with Cengage Unlimited

Cengage Unlimited is the cost-saving student plan that includes access to our entire library of eTextbooks, online platforms and more—in one place, for one price. For just $119.99 for four months, a student gets online and offline access to Cengage course materials across disciplines, plus hundreds of student success and career readiness skill-building activities. To learn more, visit www.cengage.com/unlimited.

ENERGY, ENVIRONMENT, AND SUSTAINABILITY

SECOND EDITION

Basic Concepts

PART 1

In Part One of this book, we introduce you to the importance of understanding basic concepts such as human needs, energy, environment, and sustainability. Good citizens are well informed and have a firm grasp of current issues, particularly those related to population trends, energy, environment, and sustainability; these are all essential for a well-educated democratic society. Responsible citizens also take active roles in their communities; have a desire to be life-long learners; stay abreast of innovations in technologies and understand how new developments affect their lives; have time management skills that enable them to work productively, take good care of their families, and be active in their communities; and work in a team environment where they consult each other to solve problems that affect all of us.

In Part One, we also explain the role of fundamental dimensions such as length, time, mass, and temperature and systems of units such as the foot (or meter), second, pound (kilogram), and degree Fahrenheit (Celsius) in our daily lives. You have been using these concepts all your lives; however, here we define them in a formal way so that you can use them to quantify your own environmental impact, water and energy consumption rates, and waste.

As a good global citizen, it is also important to follow a systematic approach to sort carefully through information presented to you when you are confronted with a complex problem. In Part One, you will also be introduced to concepts related to evidence-based analysis: an approach that is based on scientific principles, scientific research, scientific data, and mathematical and statistical models. In recent years, the use of this systematic approach in a wide range of topics including sustainability has resulted in more reliable decisions.

Spreadsheets are commonly used to record, organize, and analyze data using formulas, and to present the results of an analysis in graph form. In this part of the book, we will also discuss the use of spreadsheets in solving problems.

CHAPTER

1

Introduction to Energy, Environment, and Sustainability

LEARNING OBJECTIVES

LO¹ Basic Human Needs: understand the basic human needs, including clean air, clean water, food, and shelter

LO² Energy: understand that it takes energy to address basic human needs and be familiar with energy consumption rates and sources in your daily life

LO³ Environment: explain what we mean by environment and be familiar with its main components

LO⁴ Sustainability: define sustainability and its role in your daily life

Chuyuss/Shutterstock.com, Hung Chung Chih/Shutterstock.com, Thomas La Mela/Shutterstock.com, Adisa/Shutterstock.com, siraphat/Shutterstock.com, Riccardo Mayer/Shutterstock.com

Discussion Starter

We all want to make the world a better place, but how do we do it, and where do we start? Leo Tolstoy, a Russian novelist and philosopher, once said:

> *"Everyone thinks of changing the world, but no one thinks of changing oneself."*

Increasingly, because of worldwide socioeconomic trends, environmental concerns, and the Earth's finite resources, more is expected of all of us. As responsible global citizens, we are expected to consider the link among the Earth's finite resources and environmental, social, ethical, technical, and economical factors as we make decisions regarding the services that we use and the products we consume. This book is designed to introduce you—a college student—regardless of your area of study, personal interests, and future career path, to important issues such as energy, environment, and sustainability that affect all of us. A quote often attributed to Chief Seattle of the Dkhw'Duw'Absh (1786–1866) says it best:

> *"What befalls the Earth befalls all the sons (and daughters) of the Earth. This we know: the Earth does not belong to man, man belongs to the Earth. All things are connected like the blood that unites us all. Man does not weave this web of life. He is merely a strand of it. Whatever he does to the web, he does to himself."*

To the Students: What does all this mean to you? Have you thought about changing the world (or yourself)? Where do you start?

LO[1] 1.1 Basic Human Needs

During the past decades, much has been said about vital issues related to *energy, the environment*, and *sustainability*. What are these issues, and why is it important for you to understand them? Increasingly, because of worldwide socioeconomic trends, environmental concerns, and the Earth's finite resources, more is expected of all of us. As responsible global citizens, we are expected to consider the link among the Earth's finite resources and environmental, social, ethical, technical, and economical factors as we make decisions in our daily lives. In our decision-making process, we are expected to consider our energy and environment footprints and take into account factors such as the natural resources that were consumed to make a product. We also need to consider how much energy it takes to manufacture, transport, use, and finally dispose of the product.

This book is an attempt to introduce you to these important issues that affect all of us. Currently, there is great international competition for Earth's finite resources as each nation works to address their own energy, water, and food security needs. However, it is important to develop a global view of our needs. A human body is made of many interacting parts that work well together and share resources effectively. Furthermore, when a part of our body—even as small as a tooth—is in pain, the body as a whole is uncomfortable until the pain is gone. We should develop a similar, holistic view of our societies: one that increases commonality of human purpose, and one that gives a greater meaning to life beyond the walls of our homes, beyond the boundaries of our cities, and beyond our own countries. It is imperative that we all understand that *we are all in this together*, and in order to address our energy, clean air and water, and food security needs intelligently, we must work together and be well educated in topics such as energy, environment, and sustainability. *It is only then that we can consume resources in such a way that meets our present needs without compromising the ability of future generations to meet their needs.*

We as people, regardless of where we live, need the following things: clean air, clean water, food, and shelter. In our modern society, we also need various modes of transportation to get to different places. We also like to have some sense of security, to be able to relax, and to be entertained. We desire to be liked and appreciated by our friends and family as well. Some people have a good standard of living, while many (especially those who live in developing countries) do not. You will probably agree that our world would be a better place if every one of us had clean air and water; enough food to eat; a comfortable and safe place to live; meaningful work to do; and some time for relaxation, family, and friends.

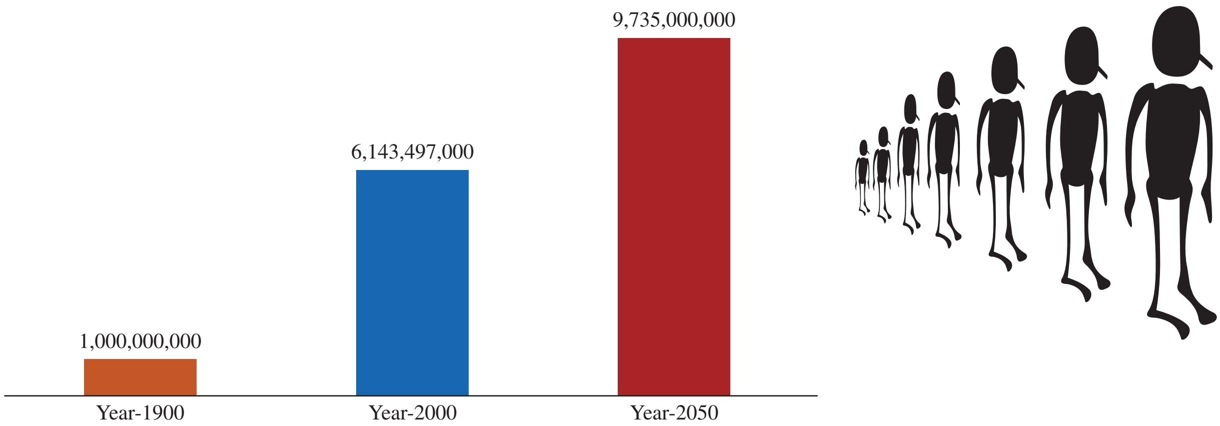
Rawpixel.com/Shutterstock.com

At the turn of the 21st century, there were approximately six billion of us inhabiting the Earth; as a means of comparison, the world population about 100 years ago, at the turn of the 20th century, was one billion. Think about this! It took us since the beginning of human existence to year 1900 CE to reach a population of one billion. Then it only took 100 years to increase the population fivefold.

According to the latest estimates and projections of the United Nations, the world population will reach 9.7 billion people by the year 2050. Not only will the number of people inhabiting the Earth continue to rise, but the age structure of the world population will also change. The world's senior population—people at least 65 years of age—will more than double in the next 30 years (see Figure 1.1).

It is expected that the world population will reach 9.7 billion people by the year 2050.

How is this information relevant? Well, let's start with our most essential need, clean air; without it, we cannot live.



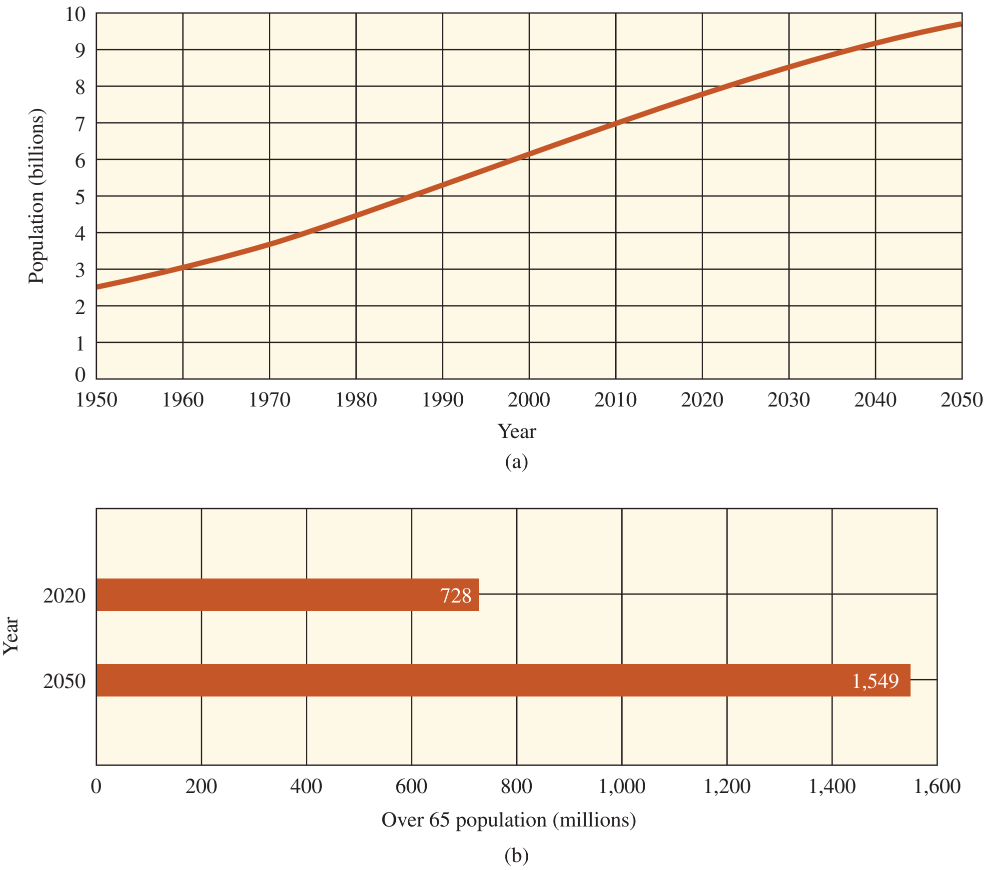
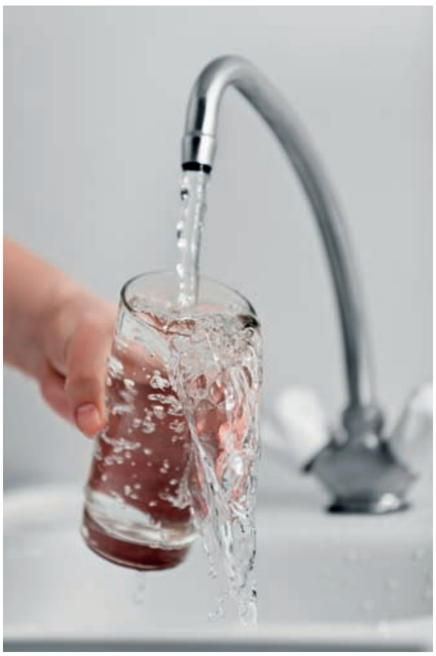


FIGURE 1.1 (a) The latest projection of world population growth. (b) The latest estimate of U.S. senior population growth.
Source: United Nations, Department of Economic and Social Affairs, Population Division (2019)

We Need Clean Air Every day, human activities through *stationary* and *mobile* sources contribute to the pollution of outdoor air. Power plants, factories, and dry cleaners are examples of stationary sources that create outdoor air pollution. Mobile sources of air pollution, such as cars, buses, trucks, planes, and trains, also add to the level of outdoor air pollution. In addition to these human-made sources, *natural* air pollution also occurs due to forest fires, windblown dust, and volcanic eruptions. Moreover, because most of us spend approximately 90 percent of our time indoors, indoor air quality is also very important to our short-term and long-term health. In recent years, we have used more synthetic materials in newly built homes that can give off harmful vapors. We also use more chemical pollutants, such as pesticides and household cleaners.

Liukov/Shutterstock.com



Ilya Andriyanov/Shutterstock.com

We Need Clean Water Our next essential need is water. Droughts are good reminders of how significant water is to our daily lives. In addition to quantity, quality is also a concern. As you would expect, human activities and naturally occurring microorganisms contribute to the contaminant level in our water supply. In agriculture, for example, pollutants such as fertilizers, pesticides, and animal waste from large cattle, pig, or poultry farms contribute to water pollution. Other human activities such as mining, construction, manufacturing goods, landfills, and waste water treatment plants are also major contributors to water pollution.

We Need Food To lead a normal active life, we need to consume a certain number of calories that come from eating meat, fish, eggs, dairy products, fruits, bread, vegetables, and the like. In the American diet, carbohydrates, protein, and fat are the main sources of calories.

The total number of food calories a person needs each day to lead an active and healthy life depends on factors such as gender, age, height, weight, and level of physical activity. Moreover, in order to maintain a healthy body weight, calories consumed from food and drinks must equal calories expended through daily activities. Therefore, if you

monticello/Shutterstock.com

consume more calories than you expend, you will gain weight. As we later explain in Chapter 2, the energy content of food is typically expressed in Calories (with an uppercase C). For example, a banana has about 100 Calories, whereas a medium serving of French fries has around 400 Calories. One Calorie is equal to 1,000 calories (with a lowercase c), and one calorie is formally defined as the amount of energy required to raise the temperature of one gram (1 g) of water by one degree Celsius (1°C). For now, don't worry if you don't fully understand what one calorie represents; this and other important concepts will be explained in greater detail in Chapters 2 and 5.

To maintain a healthy body weight, calories consumed from food and drinks must equal calories expended through daily activities.

In the United States, by law, dietary guidelines for Americans are reviewed and published every five years by the U.S. Department of Agriculture (USDA) and the U.S. Department of Health and Human Services (HHS).

ODPHP, 2020–2025 Dietary Guidelines for Americans, www.dietaryguidelines.gov/resources/2020-2025-dietary-guidelines-online-materials

Table 1.1 shows the estimated total Calorie needs for weight maintenance based on age, gender, and physical activity level. This data is from the *Dietary Guidelines for Americans 2015* USDA and HHS report. As shown in Table 1.1, adult women

TABLE 1.1 Estimated Calorie Needs per Day by Age, Gender, and Physical Activity Level

Estimated amounts of Calories[a] needed to maintain Calorie balance for various gender and age groups at three different levels of physical activity. The estimates are rounded to the nearest 200 Calories for assignment to a USDA food pattern. An individual's Calorie needs may be higher or lower than these average estimates.

	Male			Female[c]		
Activity Level[b] (Age)	**Sedentary**	**Moderately Active**	**Active**	**Sedentary**	**Moderately Active**	**Active**
2	1,000	1,000	1,000	1,000	1,000	1,000
3	1,200	1,400	1,400	1,000	1,200	1,400
4	1,200	1,400	1,600	1,200	1,400	1,400
5	1,200	1,400	1,600	1,200	1,400	1,600
6	1,400	1,600	1,800	1,200	1,400	1,600
7	1,400	1,600	1,800	1,200	1,600	1,800
8	1,400	1,600	2,000	1,400	1,600	1,800
9	1,600	1,800	2,000	1,400	1,600	1,800
10	1,600	1,800	2,200	1,400	1,800	2,000
11	1,800	2,000	2,200	1,600	1,800	2,000
12	1,800	2,200	2,400	1,600	2,000	2,200
13	2,000	2,200	2,600	1,600	2,000	2,200
14	2,000	2,400	2,800	1,800	2,000	2,400
15	2,200	2,600	3,000	1,800	2,000	2,400
16	2,400	2,800	3,200	1,800	2,000	2,400
17	2,400	2,800	3,200	1,800	2,000	2,400
18	2,400	2,800	3,200	1,800	2,000	2,400
19–20	2,600	2,800	3,000	2,000	2,200	2,400
21–25	2,400	2,800	3,000	2,000	2,200	2,400
26–30	2,400	2,600	3,000	1,800	2,000	2,400
31–35	2,400	2,600	3,000	1,800	2,000	2,200
36–40	2,400	2,600	2,800	1,800	2,000	2,200
41–45	2,200	2,600	2,800	1,800	2,000	2,200
46–50	2,200	2,400	2,800	1,800	2,000	2,200
51–55	2,200	2,400	2,800	1,600	1,800	2,200
56–60	2,200	2,400	2,600	1,600	1,800	2,200
61–65	2,000	2,400	2,600	1,600	1,800	2,000
66–70	2,000	2,200	2,600	1,600	1,800	2,000
71–75	2,000	2,200	2,600	1,600	1,800	2,000
76+	2,000	2,200	2,400	1,600	1,800	2,000

[a]Based on Estimated Energy Requirements (EER) equations, using reference heights (average) and reference weights (healthy) for each age-gender group. For children and adolescents, reference height and weight vary. For adults, the reference man is 5 feet 10 inches tall and weighs 154 pounds. The reference woman is 5 feet 4 inches tall and weighs 126 pounds. EER equations are from the Institute of Medicine, *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*, Washington D.C.: The National Academies Press, 2002.

[b]Sedentary means a lifestyle that includes only the light physical activity associated with typical day-to-day life. Moderately active means a lifestyle that includes physical activity equivalent to walking about 1.5 to 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life. Active means a lifestyle that includes physical activity equivalent to walking more than 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life.

[c]Estimates for females do not include women who are pregnant or breastfeeding.

Source: Based on the Institute of Medicine, *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*, Washington D.C.: The National Academies Press, 2002 need to consume between 1,800 and 2,400 Calories per day, while adult men may require 2,400 to 3,200 Calories. The low values represent caloric intake for sedentary conditions, whereas the higher values are for active individuals.

Not all Americans are able to follow the dietary guidelines. Here are some facts about American caloric imbalance that are worth noting:

- According to the USDA Economic Research Service, in recent years nearly 15 percent of American households have been unable to get enough food to meet their daily Calorie needs.
- At the other end of the spectrum, many Americans (among all subgroups of the population) are overweight or obese because their daily Calorie intake exceeds their activity level needs.
- In an article entitled "U.S. Lets 141 Trillion Calories of Food Go to Waste Each Year," Eliza Barclay writes that "The sheer volume of food wasted in the U.S. each year should cause us some shame, given how many people are hungry both in our own backyard and abroad." This is happening in America, while 1 in 9 people in the world (data from the World Food Programme Organization) do not have enough food to lead a normal life. The 141 trillion Calories that represent approximately 1,250 Calories per person per day in the United States are the result of nearly 130 billion pounds of food that is lost. Moreover, it is important to understand that the wasted food is worth over $100 billion. According to USDA, the top three food groups lost (in a recent year) were dairy products (25 billion pounds, or 19 percent of all the lost food); vegetables (25 billion pounds, or 19 percent); and grain products (18.5 billion pounds, or 14 percent). The USDA's Economic Research Service also points out that, if we were to reduce this waste, the price of food worldwide might go down. In addition, most of us do not realize that a vast amount of energy is spent in the food supply chain, and when food is wasted, valuable resources such as water and fossil fuels (that go into growing, processing, and transporting the food) are also wasted.

Have you ever thought about how much energy it takes to feed you every day? Let's start with a simple example and assume that you had some cereal for breakfast this morning. Now think about what it takes to grow a cereal crop such as corn and wheat (incidentally, corn, wheat, and soybeans make up the majority of field crop inputs to the U.S. food supply). Think about the energy that needs to be spent to plant the seeds, make and apply fertilizers, irrigate the field, harvest the crop, and finally transport it to a processing plant. Next consider how much energy it takes to process the corn into the cereal, make plastic bags and attractive boxes to contain it, and deliver the cereal boxes to the supermarkets. Moreover, we like to have some milk with our cereal; this requires additional energy to make the cattle feed, run the milking machines, produce milk containers, and build and operate refrigerated trucks. After the milk gets to the supermarket, it needs to be placed in cold storage, requiring energy to maintain its low temperature. Once you bring the milk home, you need to store it in a refrigerator, which also consumes energy. You get the picture! Now, think about all of the other food and drinks that you consume in a single day. In Chapters 2 and 5 through 9, we explain important concepts related to energy and power that every good global citizen should understand.

Now let us consider what happens to a dollar spent on food. According to the USDA, for a typical dollar spent (in a recent year) by U.S. consumers on domestically produced food (including both grocery store and eating-out purchases), 7.6 cents went to farm production, 14.7 cents to food processing, 2.3 cents to packaging, 3.4 cents to transportation, 8.4 cents to a wholesale trader, 12.1 cents to the food retailer, 38.5 cents to services provided by food service establishments, 4.1 cents to energy costs, 3 cents to finance and insurance costs, and 5.9 cents to pay for activities such as advertising, legal, and accounting services (see Figure 1.2).

As you can see, if you were to buy a loaf of bread in the United States, say for $1, approximately 14 cents goes to the actual cost of the flour and the remaining 86 cents goes to paying for processing, packaging, transportation, advertising, and so on. But if the price of wheat doubles from 14 cents to 28 cents, assuming no changes in other costs, the bread will cost only an additional 14 cents, which is an increase of 14 percent in total cost. The share of U.S. household consumer expenditures by major categories for 2019 is shown in Figure 1.3. In contrast, in developing countries, some people may spend as much as 80 percent of their income on food.

Consequently, many people in developing countries cannot afford to buy processed, cooked, or packaged food. For example, instead of buying already-baked bread, they buy flour and make the bread themselves. So for these people, when the price of wheat doubles, the cost of bread is also doubled—an increase of 100 percent! The 2020 world hunger map is shown in Figure 1.4. The next time you are about to waste food, think carefully!

FIGURE 1.2 The food dollar.
Note: "Other" includes two industry groups: Advertising plus Legal & Accounting
Source: U.S. Department of Agriculture

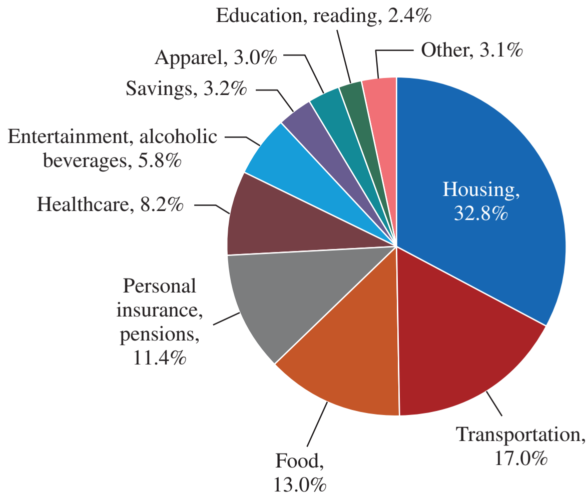


FIGURE 1.3 The share of U.S. household consumption expenditures by major categories, 2019.

Note: "Other" includes personal care products, tobacco, and miscellaneous expenditures

Source: U.S. Bureau of Labor Statistics, Consumer Expenditures Report 2019

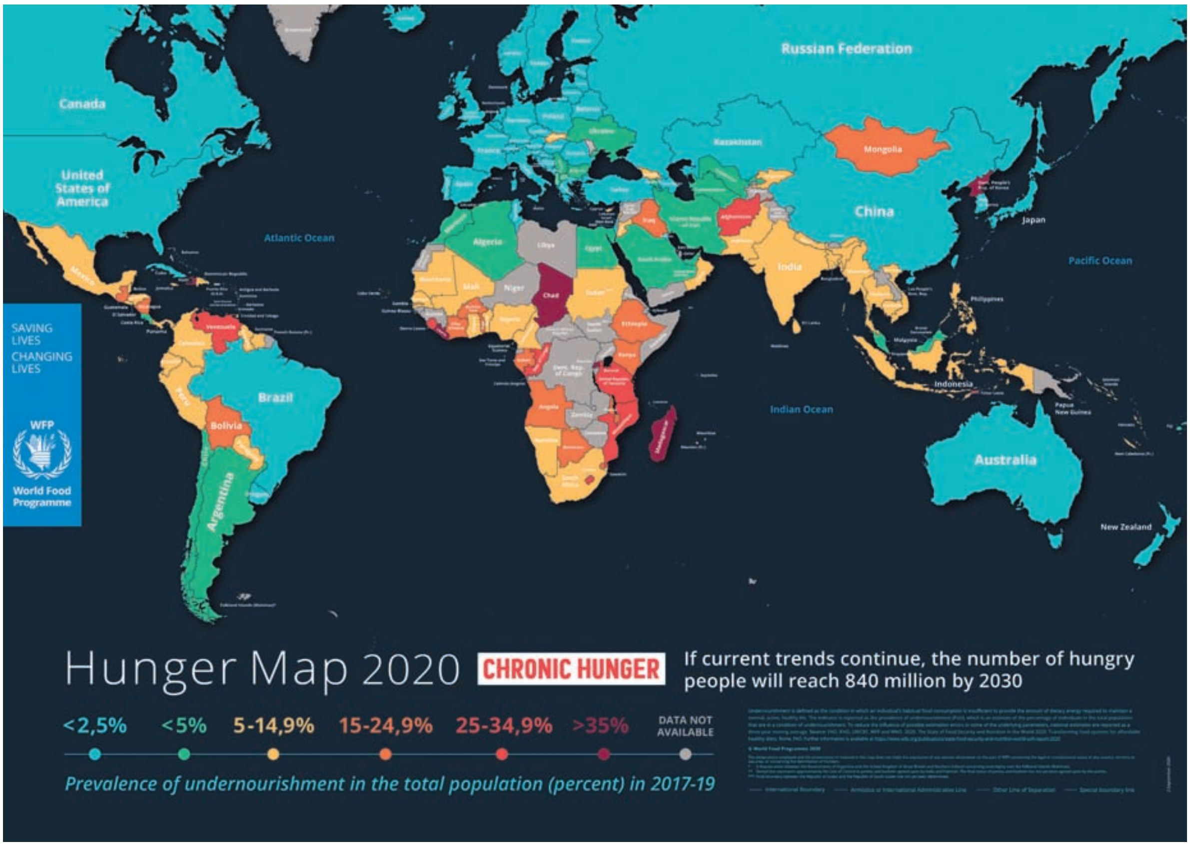
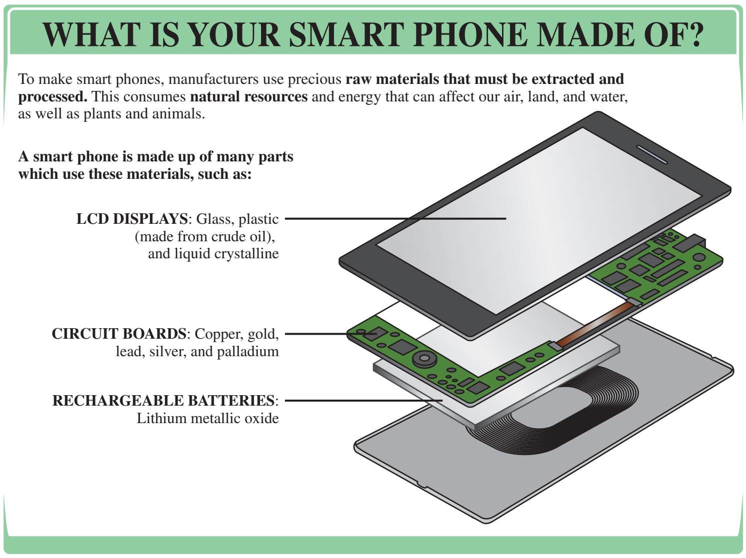


FIGURE 1.4 The 2020 World Hunger Map.

Source: United Nations, World Food Programme, Hunger Map 2020

We Need Natural Resources to Make Goods and Provide Services In addition to our need for clean air, water, and food, we as a society create and use products and services that make our lives better (Figure 1.5). Think about all the products that we use in our everyday lives, such as cars, computers, smart phones, clothing, home appliances, heating and cooling equipment, healthcare devices, and the tools and machines used to make these products. Also think about our infrastructure; for example, homes, malls, commercial buildings, highways, airports, communication systems, mass-transit systems, and the power plants that supply the power to maintain this framework. We often forget that there are many people behind the scenes who are responsible for finding suitable ways and designing the necessary equipment to extract raw materials, petroleum, and natural gas from the Earth.

When we use a product, such as a smart phone, electronic tablet, car, washing machine, oven, or refrigerator, we need to be mindful of what type of materials went into making the product, where the materials came from, how much energy it took to produce the product, and eventually, what it would take to recycle or dispose of it. We will discuss common materials used in making products and infrastructure in Chapter 12.



Source: Based on EPA

arka38/Shutterstock.com vovan/Shutterstock.com Alexandru Nika/Shutterstock.com Oleksandr Delyk/Shutterstock.com

FIGURE 1.5 Examples of products used in our daily lives.

What Happens to Products When They Are Disposed? As a good global citizen, it is also important to understand what happens to products when we discard them. Each year, the U.S. Environmental Protection Agency collects and reports data on the generation and disposal of waste in the United States. According to the latest available data, in 2018, people in the United States generated 292 million tons of trash (approximately 4.9 pounds per person per day) of which only 93.9 million tons were recycled or composted. We will discuss municipal and industrial waste and recycling in Chapter 13.

kanvag/Shutterstock.com

Evan Lorne/Shutterstock.com

Before You Go On

Answer the following questions to test your understanding of the preceding section:

1. What are the basic human needs?
2. In your own words, describe energy, environment, and sustainability.
3. What are some of the consequences of an increasing world population?

LO[2] 1.2 Energy

Without energy, we cannot do anything! Therefore, **energy** should be the starting point for a better understanding of our environmental footprint. We need energy to keep our homes comfortable, to make goods, and to provide services that allow us to enjoy a high standard of living. We use energy in our homes for space heating and cooling, hot water, lighting, appliances, and electronics. We also use energy in our cars for personal and business travel. In addition to our personal energy requirements, we need energy for businesses and industry to make and transport all kinds of products and food; to make materials for and to erect buildings; and to build and maintain our infrastructure (roads, bridges, railroad systems, airports, etc.). To understand your daily energy needs, tomorrow morning when you get up, just look around you and think carefully. During the night, your bedroom was kept at the right temperature thanks to the heating or cooling system in your place of residence. When you turn on the lights or your TV, be assured that thousands of people at power plants around the country are making certain the flow of electricity remains uninterrupted. When you are

hans engbers/Shutterstock.com

getting ready to take your morning shower, think about the clean water you are about to use: Where did it come from, and how is it heated? That water could be coming to your place thanks to a network of piping systems and water treatment facilities. Moreover, the water could be heated by natural gas, electricity, or fuel oil that is brought to your home thanks to the work and effort of many people behind the scenes. When you dry yourself with a towel, think about what types of machines were used and how much energy was consumed to produce the towel. Think about the machines used to plant and pick the cotton, transport it to a factory, clean it, and dye it a color that is pleasing to your eyes. Think about other machines that were used to weave the fabric and send it to sewing machines. Also, think about where the towel was made and all of the energy consumed to transport it to the store from which you purchased it. The same is true of the clothing you are about to put on. Next, let's say you are about to have some cereal. As mentioned previously, the milk was kept fresh in your refrigerator and the cereal was made available due to the efforts of farmers and people in a food processing plant; each requires energy to produce and transport to grocery stores. Now you are ready to get into your car, take a bus, or ride the subway. Think about the amount of materials and energy needed to make your transportation system and to move it along. Clearly, *there is nothing that you do in your daily life that does not involve energy*. As we have been emphasizing, there are certain concepts that every citizen, regardless of their area of interest, should know. As a good global citizen, you need to have a firm grasp of energy, including its sources, generation, and consumption rates.

The world energy consumption by fuel type is shown in Figure 1.6. In 2018 (the most recent available data), 599 quadrillion Btu of energy was consumed worldwide, and as shown in Figure 1.6, petroleum, coal, and natural gas made up nearly 85 percent of all the fuel used to generate energy. One quadrillion is equal to 10^{15} or 1,000,000,000,000,000, and Btu denotes British thermal units. One Btu represents the amount of energy needed to raise the temperature of one pound of water by 1 degree Fahrenheit (1°F). For example, to take a nice long shower, you need to raise the temperature of 20 gallons of water (approximately 170 pounds of water) from 70 to 120°F (a temperature increase of 50°F). The amount of energy required to achieve this task is about 8,500 Btu.

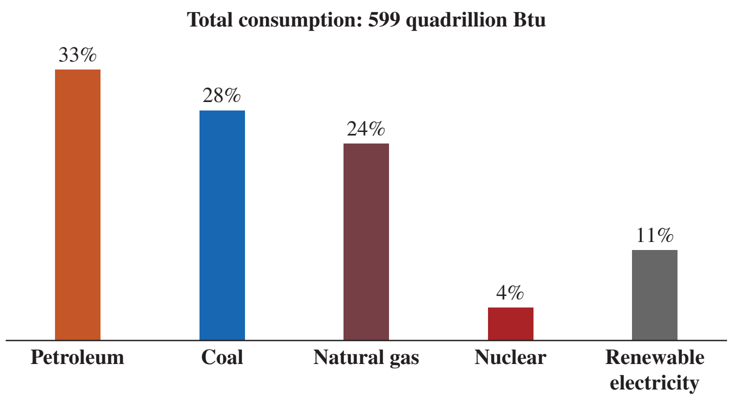


FIGURE 1.6 World energy consumption by fuel type (the most recent available data).
Source: U.S. Energy Information Administration (2018)

If you were to multiply this number by 365 days, you would obtain the annual amount of energy used for showering, which is nearly 3.13 million Btu. This example gives you a sense of how much energy it takes for just one of your daily activities and a better understanding of the relative magnitude of the Btu value shown in Figure 1.6. As is the case with any new concepts you learn, energy has its own terminology that you should familiarize yourself with. We will explain energy and power-related concepts in detail in Chapter 5.

In 2018, the five countries with the largest energy consumptions were China, the United States, Russia, India, and Japan, as shown in Figure 1.7. The per capita consumption for these countries is shown in Figure 1.8. Note that the United States has the largest per capita energy consumption in the world with a value of 310 million Btu.

The United States Energy Information Administration (EIA) classifies the energy consumption rates by major sectors of our economy: Industrial, Transportation, Residential, and Commercial.

In the United States, to keep track of how we consume energy in our society, the Energy Information Administration (EIA) classifies the energy consumption rates by major sectors of our economy. These sectors are organized into industrial, transportation, residential, and commercial. The percentage of energy consumed by major sectors of the economy is depicted in Figure 1.9.

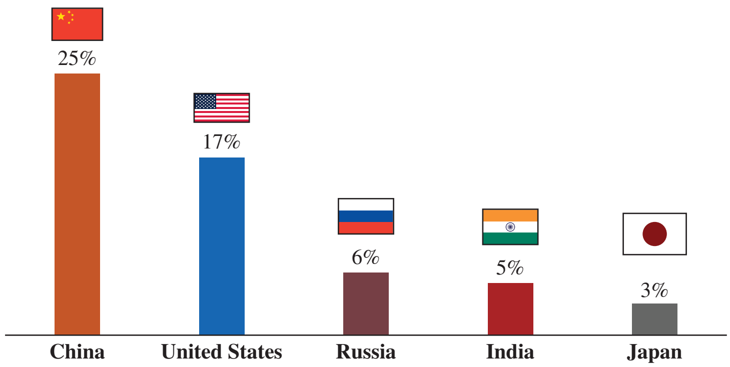


FIGURE 1.7 World energy consumption by the top five countries.
Source: U.S. Energy Information Administration (2018)

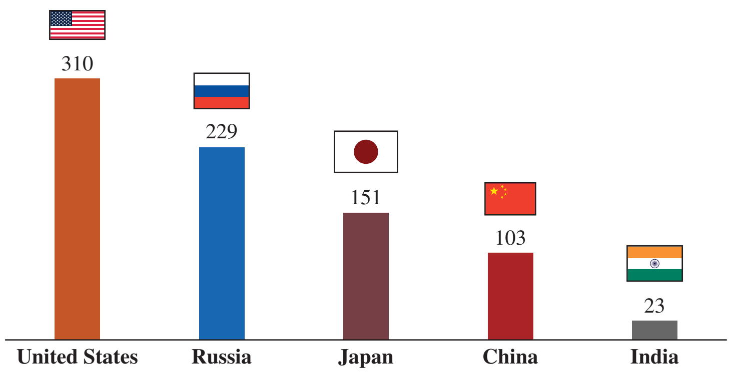


FIGURE 1.8 Per capita consumption of selected countries. Unit: million Btu.
Source: U.S. Energy Information Administration (2018)

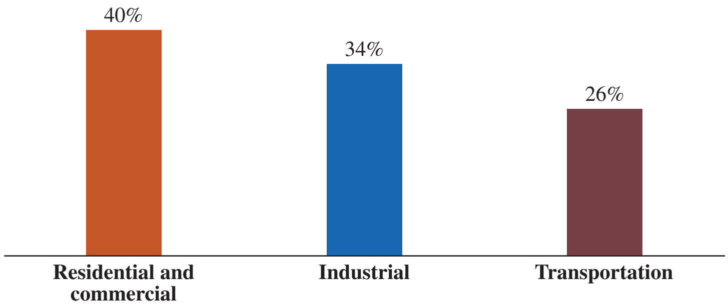


FIGURE 1.9 Share of energy consumed by major sectors of the economy.
Source: U.S. Energy Information Administration, Monthly Energy Review (March 2021)

- The **residential sector** accounts for energy use in homes and apartments. Think about the space heating and cooling equipment; lighting systems; electronic devices; and appliances, such as refrigerators, freezers, ovens, washers, and dryers that are used in our homes every day.
- The **commercial sector** keeps track of energy use in schools, municipal buildings, hospitals, hotels, shopping malls, restaurants, police stations, places of worship, and warehouses. As shown in Figure 1.9, in 2020, the residential and commercial sectors accounted for 40 percent of total energy used in the United States.
- The **industrial sector** accounted for 34 percent of the total energy used in the United States. This value represents the share of total energy needed for all of the facilities and equipment for construction, mining, agriculture, and manufacturing.
- The **transportation sector**, which includes energy use by all types of vehicles (motorcycles, cars, trucks, buses, trains, subways, aircraft, boats, barges, ships, etc.) to transport people and goods, accounted for 26 percent of the total energy used in 2020. Think about all of the cars, buses, trains, planes, and subway systems that are used to transport people. Also, consider all of the trucks, trains, barges, and planes that are used every day to carry goods. According to the EIA, most of our transportation energy is consumed by automobiles and light trucks; gasoline and diesel fuel account for nearly 75 percent of energy consumed by vehicles.

Now that you have a good idea about the share of energy use in the industrial, transportation, residential, and commercial sectors of our economy, let us look at the types of fuel, such as petroleum, natural gas, and coal, that are used to generate energy. Figure 1.10 shows the total energy consumption in the United States by fuel/energy source. As shown in Figure 1.10, fossil fuels (petroleum, natural gas, and coal) make up 79 percent of the total fuel/energy source.

In Chapter 8, we discuss in greater detail energy sources, such as gasoline, natural gas, coal, and wood, along with their consumption rates. We will also explain in more detail how much energy we consume in our homes and buildings as well as for transportation and manufacturing.

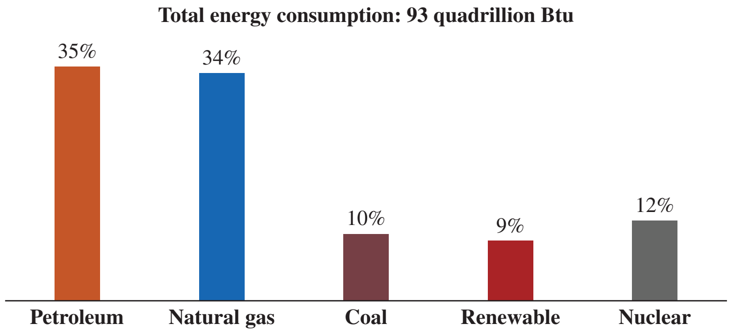


FIGURE 1.10 Total energy consumption in the U.S. by fuel/energy source (the most recent available data).
Source: U.S. Energy Information Administration, Monthly Energy Review (March 2021)

Before You Go On

Answer the following questions to test your understanding of the preceding section:

1. Why do we need energy?
2. According to the Energy Information Administration, what are the major sectors of the economy that consume energy?
3. How do we consume energy at home?
4. What types of fuel are used in the residential sector?

Vocabulary—It is important for you (as a good global citizen) to understand that you need to develop a comprehensive vocabulary to communicate effectively. Throughout this book, we ask you to define the meaning of new words. This feature promotes your vocabulary growth. State the meaning of the following terms:

Btu

Quadrillion

LO³ 1.3 Environment

Environment is one of those terms that mean different things to different people. For example, as a computer user, we may talk about the *desktop environment*, which means the user interface of the computer: icons, windows, folders, toolbars, etc. On the other hand, to a civil engineer or a construction manager, the *built environment* refers to human-made structures, such as roads, water piping networks, fuel distribution piping networks, buildings, or electric power networks. Often when we talk about **environment**, we mean the *natural environment*, which includes all living (plants, animals) and non-living (air, water, rocks) things that exist on or within the Earth. It is also important to realize that

robert_s/Shutterstock.com

each one of these categories could be further subdivided. For example, water could be grouped as above ground (rivers, ponds, lakes, seas, oceans) or below ground (aquifers).

As you learned in school, our home, the Earth, is the third planet from the Sun. As you also know, over 70 percent of the Earth's surface is covered with bodies of water: the oceans, seas, lakes, and rivers. Oceans play an important role in moderating the Earth's surface temperature. Because of the abundance of water on its surface, the Earth appears blue when viewed from space; hence, it is called the blue planet. Moreover, to better represent the Earth's structure, it is divided into major layers that are located above and below its surface. **Atmosphere** represents the air that covers the surface of the Earth. The air extends approximately 90 miles from the surface of the Earth to a point called "the edge of space." The solid portion of the Earth itself is made up of different layers with different characteristics. Its mass is composed mostly of iron, oxygen, and silicon (approximately 32 percent iron, 30 percent oxygen, and 15 percent silicon). The Earth also contains other elements, such as sulfur, nickel, magnesium, and aluminum. The structure below the Earth's surface is generally grouped into four layers: **crust**, **mantle**, **outer core**, and **inner core** (see Figure 1.11). This classification is

Above the surface of the Earth

Atmosphere: 0–90 miles (0–140 km)

Thickness of different layers (approximate values)

Crust: 0–25 miles (0–40 km)
Mantle: 25–1,800 miles (40–2,900 km)
Outer core: 1,800–3,200 miles (2,900–5,200 km)
Inner core: 3,200–4,000 miles (5,200–6,400 km)

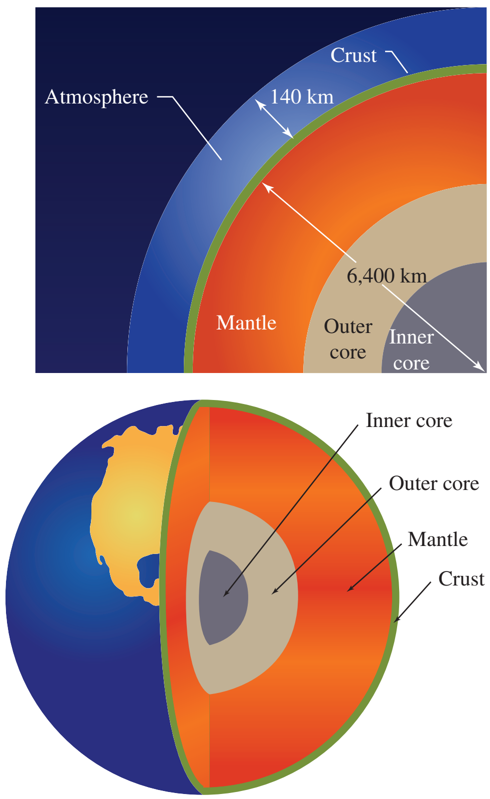


FIGURE 1.11 The structure of the Earth.

based on the properties of materials and the manner by which the materials move or flow in each layer. We explain the Earth's structure in greater detail in Chapter 12. However, at this point, it is important for you to understand that the raw materials that make up the products that we use in our daily lives come from the Earth's crust. The crust makes up about 0.5 percent of the Earth's total mass and 1 percent of its volume. We also discuss common materials used in making products and building our infrastructure in Chapter 12.

Air

We all need air to sustain life. The Earth's atmosphere, which we refer to as **air**, is a mixture of approximately 78 percent nitrogen, 21 percent oxygen, and a very small amount of argon and other gases, such as carbon dioxide, sulfur dioxide, and nitrogen oxide. The atmosphere also contains water vapor in the form of clouds, which allow for the transport of water from the oceans to land by way of rain and snow. At higher altitudes, the Earth's atmosphere also contains ozone.

Even though gases such as carbon dioxide make up only a small percentage of the Earth's atmosphere, they play a significant role in maintaining a thermally comfortable environment for us and other living species. For example, the ozone absorbs most of the ultraviolet radiation arriving from the sun that can harm us. Carbon dioxide plays an important role in sustaining plant life; however, if the atmosphere contains too much carbon dioxide, it will not allow the Earth to cool down effectively.

Ciprian Stremtan/Shutterstock.com

Air is a mixture of mostly nitrogen, oxygen, and small amounts of other gases, such as argon, carbon dioxide, sulfur dioxide, and nitrogen oxide. Carbon dioxide plays an important role in sustaining plant life; however, if the atmosphere contains too much carbon dioxide, it will not allow the Earth to cool down effectively.

Greenhouse Gases

When solar energy passes through the Earth's atmosphere, some of it is absorbed; some of it is scattered; and some of it is reflected by clouds, dust, pollutants, and different types of gases or water vapor in the atmosphere. The solar energy that reaches the Earth's surface warms the Earth, and eventually, some of the absorbed energy is radiated back toward space as the Earth's surface cools down in the evenings. Many gases present in the atmosphere trap some of this heat and consequently prevent the Earth's surface and its atmosphere from cooling (Figure 1.12). The gradual warming of the Earth's atmosphere is commonly referred to as the *greenhouse effect*, and the gases that cause the warming are called **greenhouse gases** (Figure 1.12).

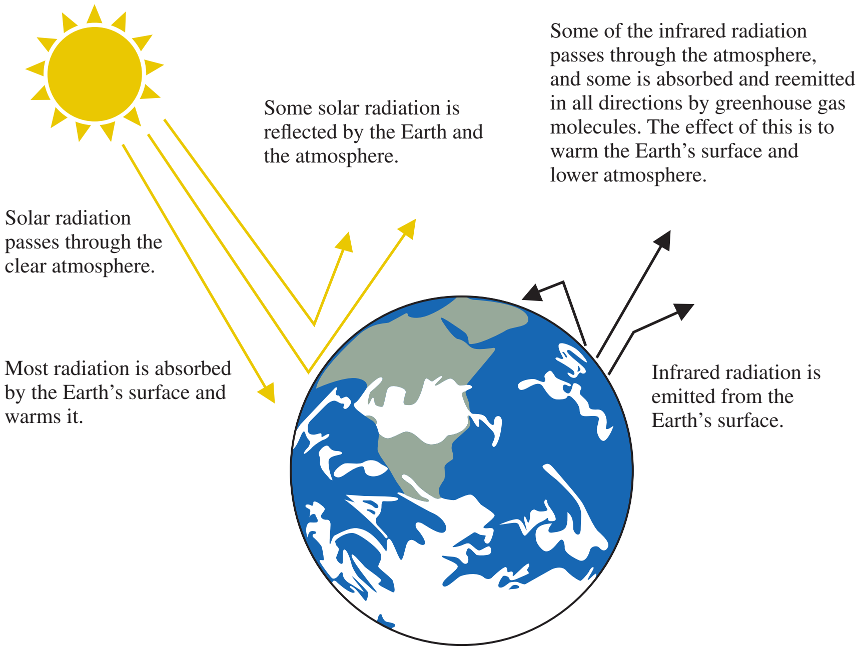


FIGURE 1.12 The greenhouse gas effect.
Source: Based on U.S. Energy Information Administration

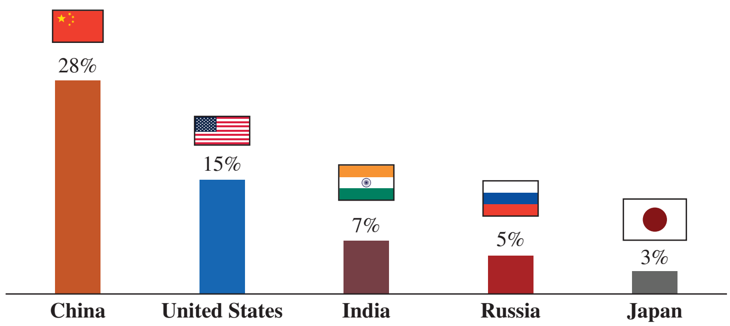


FIGURE 1.13 Carbon dioxide emissions of the top five emitters.
Source: Global Carbon Project (2020)

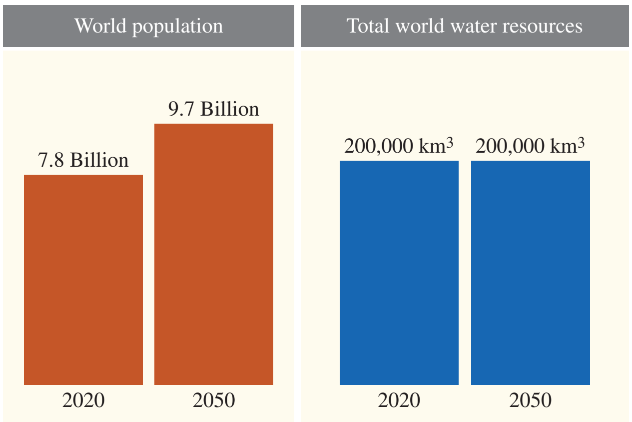
The five countries with the largest carbon dioxide emissions are shown in Figure 1.13. At present, China is the largest emitter, followed by the United States. We discuss air, air quality standards, and our individual roles in contributing to indoor and outdoor air pollution in Chapter 10.

Water

Every living thing also needs water to sustain life. In addition to drinking water, we need water for many of our daily activities, including cooking, grooming, and washing. It is also a key resource when fighting fires. Water is not only

Dmitry Naumov/Shutterstock.com

transported to homes for our domestic use, but it also has many other applications. We need water to grow fruits, vegetables, nuts, cotton, trees, and so on. Water is commonly used in the mining industry, as a cooling or cleaning agent in a number of food processing plants, and in many other industrial operations. Water also is used in all steam power-generating (thermoelectric) plants to produce electricity. Here are some important data related to water, agriculture, and food security as reported by the United Nations.



- The daily drinking water requirement per person is 2 to 4 liters, but it takes 2,000 to 5,000 liters of water to produce one person's daily supply of food.
- It takes 1,000 to 3,000 liters of water to produce just one kilogram of rice and 13,000 to 15,000 liters to produce one kilogram of grain-fed beef.
- In 2019, the estimated number of undernourished people worldwide was 690 million.
- By 2050, the world's water will have to support the agricultural systems that will feed and create livelihoods for an additional 1.9 billion people.

- The extent of land under irrigation in the world is 275 million hectares, about 20 percent of which is cropland. Rain-fed agriculture is practiced on the remaining 80 percent of the arable land.
- Irregular or inadequate rainfall affects crops and food supply. From 2006 to 2016, nearly 65 percent of crop production and 44 percent of fisheries and aquaculture production were damaged by floods; 86 percent of livestock was negatively affected by drought.

In the data mentioned previously, one liter is approximately equal to a quarter of a gallon (1 liter $\approx$ $\frac{1}{4}$ gallon), and one kilogram is equal to 2.2 pounds. We will explain systems of units in greater detail in Chapter 2.

To better understand the **water cycle**, see Figure 1.14. Radiation from the sun evaporates water, water vapors form into clouds, and eventually, under favorable conditions, water vapor turns into liquid water or snow and falls back on the land and into the ocean. On land, depending on the amount of precipitation, part of the water infiltrates the soil, part of it may be absorbed by vegetation, and part of it runs as streams or rivers and collects into natural reservoirs called lakes. **Surface water** refers to water in reservoirs, lakes, rivers, and streams. **Groundwater**, on the other hand, refers to the water that has infiltrated the ground; surface water and groundwater eventually return to the ocean, and the water cycle is

The total amount of water on the Earth is constant—we don't lose or gain water on the Earth.

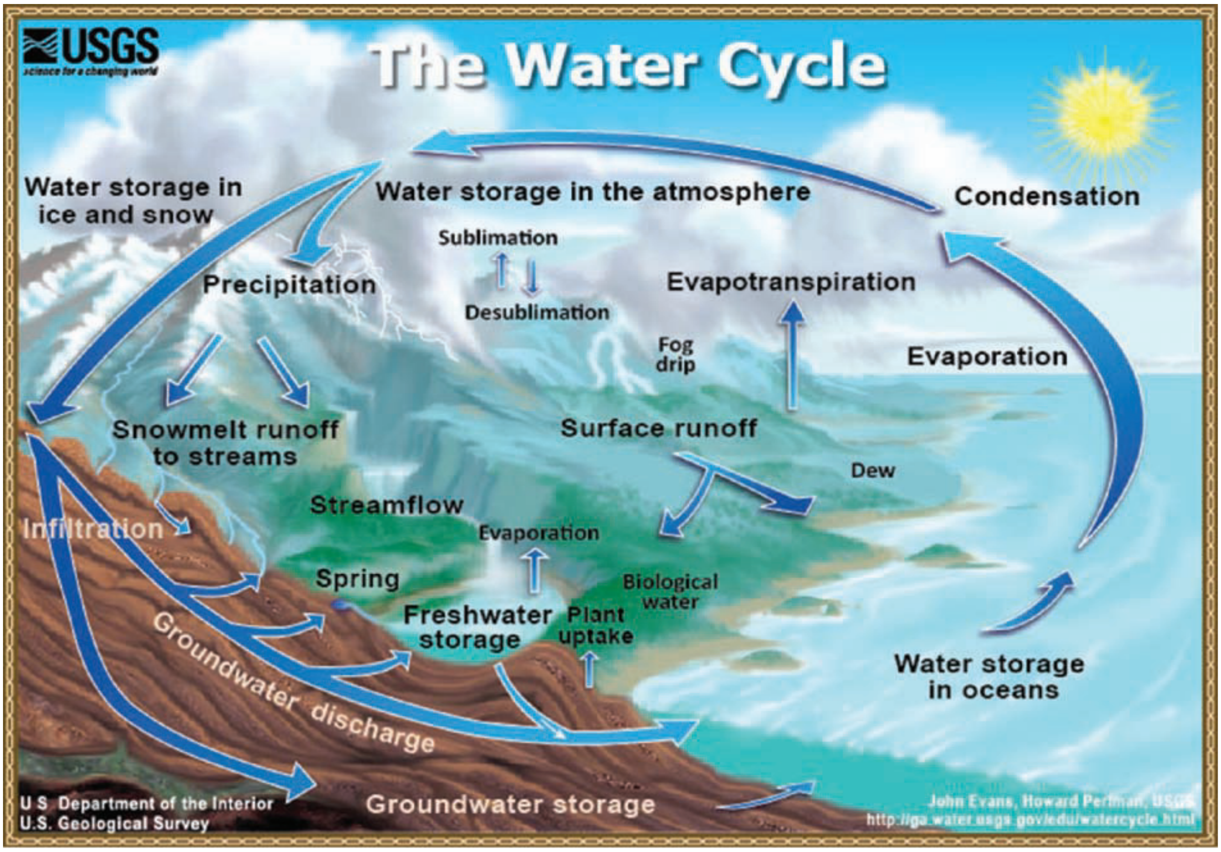


FIGURE 1.14 The water cycle.
Source: U.S. Department of the Interior

completed. In addition to understanding the water cycle, *it is also important to realize that the amount of water that is available to us on the Earth is constant.* Even though water can change phase from liquid to vapor or from liquid to ice, the total amount remains constant—we don't lose or gain water on the Earth. For example, when you take a shower, the water you used could end up elsewhere and be used for an entirely different purpose, such as cooking (of course, after it has been treated and filtered). We discuss water resources, consumption rates, and quality standards in Chapter 11.

Before You Go On

Answer the following questions to test your understanding of the preceding section:

1. What does the word environment mean to you?
2. What are the major layers of the Earth?
3. What are the main gases that make up air?
4. In your own words, describe the greenhouse gas effect.
5. In your own words, describe the water cycle.

Vocabulary—State the meaning of the following terms:

Air

Greenhouse gases

LO[4] 1.4 Sustainability

Sustainability could be defined as consuming resources in such a way that meets our present needs without compromising the ability of future generations to meet their needs.

As we mentioned previously, much has been written or said about "sustainability." But what does it mean to you, and why is it important for you to have a good grasp of this concept? To start with, it is important to know that there is no universal definition for **sustainability**. It means different things to different professions. However, one of the generally accepted definitions is "*design and development that meets the needs of the present without compromising the ability of future generations to meet their own needs*." This statement originates from the 1987 United Nations Brundtland Commission Report.

We all agree that we need to design and produce goods and services to enjoy a high standard of living and to advance health care. We also need to address our infrastructure and energy needs and food security. However, as a global community, we are expected to address our needs while also addressing serious environmental and sustainability concerns. Because of this fact, we need good global citizens who understand the link among the Earth's finite resources and our environmental, social, ethical, technical, and economical factors. The shortage of citizens who understand the concept of sustainability—people who can apply the sustainability concepts, methods, and tools to their problem-solving and decision-making processes—could have serious negative consequences for our future. To address this concern, many institutions of higher education and organizations have recently come out in support of sustainability education. As you study this book, you will gradually learn more details about sustainability concepts, methods, and tools. Hopefully, you will apply them to your decision-making process to make the world a better place for all of us!

Attributes of Good Global Citizens

Now that you have a general sense of why you need to know about energy, environment, and sustainability, you may be wondering about how to get involved and how to become a good global citizen. *As good global citizens, we need to realize that the choices we make in our everyday lives affect all of us*. We need to change our behaviors, especially with respect to the way we consume energy and use the finite resources available to us. Computers, smart electronic devices, and computer-controlled machines are continuously reshaping our way of life. Such tools influence the way we do things and help provide us with the necessities of our lives—clean water, food, and shelter. We need to become lifelong learners so that we can make informed decisions and anticipate and react to the global changes caused by technological innovations as well as population and environmental changes. Although the activities of good citizens may be varied,

ESB Professional/Shutterstock.com

there are some personality traits and practices that typify most of today's good global citizens.

- Good citizens are well informed and have a firm grasp of basic concepts and current issues, particularly issues related to energy, the environment, and sustainability.
- Good citizens have a desire to be life-long learners. For example, they are well read, attend community and town meetings to stay abreast of new events, and learn about how innovations and new technologies may affect their lives.
- Good citizens have good written and oral communication skills.
- Good citizens have time management skills that enable them to work productively, take good care of their families, and be active in their communities.
- Good citizens generally work well in a team environment where they consult each other to solve complex problems that affect all of us.

Communication

As good global citizens, you need to develop good written and oral communication skills in order to express your thoughts, present concepts, provide analyses of problems and their solutions, and show your findings from a research project. Starting right now, it is important to understand that *the ability to communicate your solution to a problem is as important as the solution itself*. You may spend weeks on a project, but if you cannot effectively communicate to others, the results of all your efforts may not be understood and appreciated. *In this book, to emphasize that a good global citizen should have good communication skills, we ask you to write reports and give presentations*. These reports might be lengthy and contain charts and graphs, or they

Fizkes/Shutterstock.com

may take the form of a brief memorandum. These forms of communication are explained next.

Written Reports One type of written report is a progress report. *Progress reports* are a means of communicating to others in an organization or to the sponsors of a project how much progress has been made and which of the main objectives of the project have been achieved to date. Based on the total time period required for a project, progress reports may be written for a period of a week, a month, several months, or a year. The format of the progress report may be dictated by a manager in an organization or by the project's sponsors. In your case, your instructor will specify how often you need to write a progress report for say, a term project.

Short memos are yet another way of conveying information in a brief way to interested individuals. Generally, short memos are under two pages in length. A general format for a short memo header is shown below. The header of the memo contains information such as the date, who the memo is from, to whom it is being sent, and a subject line. This is followed by the main body of the memo.

Date: *May 3, 2015*
From: *Mr. John Doe*
To: *Members of Project X*
Re: *Proposed Wind Energy Farm*

As the name implies, *detailed reports* are comprehensive and provide a great deal of information. These reports generally contain the following items: title, abstract, objectives, analysis, data and results, a discussion of results, conclusions and recommendations, and references. Whenever you write a report, you must include a list of references that show the reader where you obtained some of the information. For the references, you may want to use the following format styles:

For Books: Author, *title* (italicized), publisher, place of publication, date (year), and page(s).
For Journal Articles: Author, "title of article" (enclosed in quotation marks), name of journal, volume number, issue number, year, and page(s).
For Internet Materials: Author (or company), title (or page tab), date accessed, and URL address.

Oral Presentations Some of the problems in this book require you to give oral presentations. You already communicate orally with others all the time. Informal communication is part of our daily life. We may talk about sports, the weather, what is happening around the world, or a homework assignment. However, when it comes to formal presentations, there are certain rules and strategies that you need to follow. Your oral presentation may show the results of all your efforts regarding a project that you may have spent weeks or months to develop. If the listener cannot follow you, then all of your efforts will go to waste. It is very important, therefore, that all information be conveyed in a manner easily understood by the listener.

lightpoet/Shutterstock.com

An oral technical presentation in many ways is similar to a written one, as you need to be well organized and have an outline of your presentation ready. It may be a good idea to write down what you are planning to present. Remember, it is harder to erase or correct what you say after you have said it than to write it down on a piece of paper and correct it before you say it. You want to make every effort to ensure that what is said (or sent) is what is understood (or received) by the listener.

Rehearse your presentation before you deliver it formally. You may want to ask a friend to listen and provide helpful suggestions about your style of presentation, delivery, content, and so on. Present the information in a way that will be understood easily by your audience. Avoid using terminology or phrases that may be unfamiliar to listeners. If you have to give a longer talk, then you may want to add some humor or tell some interesting, relevant stories to keep your audience's attention. Maintain eye contact with everyone in your audience, not just one or two people. Use good visual aids. When possible, incorporate charts, graphs, animated drawings, short videos, and models. You may also want to have copies of the outline, along with notes on the important concepts and findings, ready to hand out to interested audience members. In summary, when giving an oral presentation, be organized, be well prepared, get right to the point, and consider the needs and expectations of your listeners.

Teamwork

Some of the projects in this book require teamwork. Therefore, it is important to say a few words about teamwork and conflict resolution. A **team** may be defined as a group of individuals with complementary expertise, problem-solving skills, and talents who work together to solve a problem or achieve a common goal. A good team is one that gets the best out of each other. The individuals making up a good team know when to compromise for the good of the team and its common goal. Communication is an essential part of successful teamwork. The individuals making up the team need to clearly understand the role of each team member and how each task fits together.

Common Traits of Good Teams More and more, employers are looking for individuals who not only have a good grasp of contemporary issues but can also work well with others in a team environment. Successful teams have the following components:

- The team members should all understand and accept the goals of the project, which should be clear and realistic.
- The team should be made up of individuals with complementary expertise, problem-solving skills, backgrounds, and talents.
- The team should have a good leader.
- The team leadership and the environment in which discussions take place should promote openness, respect, and honesty.
- Team needs and goals should come before individual needs and goals.

Conflict Resolution When a group of people work together, conflicts sometimes arise. Conflicts can be the result of miscommunication, personality differences, or the way events and actions are interpreted by a member of a team. Managing conflicts is an important part of a team dynamic. When it comes to conflict management, a person's response may be categorized in one of the following ways.

- There are those in a team environment who try to avoid conflicts. Although this may seem like a good approach, it demonstrates low assertiveness and a low level of cooperation. Under these conditions, the person who is most assertive will dominate the team, making progress as a whole difficult. *Accommodating team members* are highly cooperative, but their low assertiveness could result in poor team decisions. This is because the ideas of the most assertive person in the group may not necessarily reflect the best solution.
- *Compromising team members* demonstrate a moderate level of assertiveness and cooperation. Compromised solutions should be considered as a last resort. Again, by compromising, the team may have sacrificed the best solution for the sake of group unity.
- A better approach is the *collaborative* "conflict resolution" approach, which demonstrates a high level of assertiveness and cooperation by the team. With this approach, instead of pointing a finger at someone and blaming an individual for the problem, the conflict is treated as a problem to be solved by the entire team. The team proposes solutions, means of evaluation, and (when appropriate) combines solutions to reach an ideal solution. Furthermore, in order to reach a resolution to a problem, a plan with clear steps must be laid out.

Good communication is an integral part of any conflict resolution. One of the most important rules in communication is to make sure that the message sent is the message received—without any misunderstanding. *Team members must listen to each other*. Good listeners do not interrupt; they allow the speaker to feel at ease, do not get angry, and do not criticize. You also may want to ask relevant questions to let the speaker know that you really are listening.

Before You Go On

Answer the following questions to test your understanding of the preceding section:

1. Why is it important for all of us to understand and apply sustainable practices to our everyday lives?
2. What are common traits of good global citizens?
3. State the differences between these written communications: progress report, short memo, and detailed technical report.
4. What do we mean by team and teamwork?
5. Explain how you would resolve a conflict that may arise when working in a team environment.

SUMMARY

LO1 Basic Human Needs

You should have a good understanding of basic human needs and the growing world population. At the turn of the 21st century, there were approximately six billion of us inhabiting the Earth. According to the latest estimates, the world population will reach 9.7 billion people by the year 2050. We need clean air, clean water, food, and shelter. As a society, we create and consume many different products and services. Think about all the products and services that you used yesterday.

We need energy to address our needs, such as building structures, growing food, and accessing clean water. The energy use per capita in the world has been increasing steadily as the economies of the world grow. Added to these concerns is the expected rise in the world population from the current 7.8 billion to about 9.7 billion people by the mid-21st century! Stationary, mobile, and natural sources contribute to outdoor air pollution. Human activities, such as mining, construction, manufacturing goods, and agriculture, contribute to water pollution. In order to address our needs and maintain a good standard of living, we as a society are faced with the problems of finding energy sources and reducing pollution and waste.

LO2 Energy

You should have a good understanding of the significant role energy plays in our daily lives and realize that without energy we cannot keep our homes warm and well lit; move our cars; make products and structures; grow food; or have easy access to water, shelter, and other essential needs. You should be familiar with energy consumption rates in our society. You should also know that coal, natural gas, and petroleum still provide the majority of our energy needs, and realize that the majority of the coal mined in the United States is used for generating electricity. So don't waste electricity!

LO3 Environment

By environment we mean *our natural environment,* which includes all living (plants, animals) and nonliving (air, water, rocks) things that exist on or within the Earth. It is also important to realize that each one of these categories can be subdivided further. For example, water can be grouped as above ground (rivers, ponds, lakes, seas, oceans) or below ground (aquifers). You should understand what we mean by greenhouse gases and how you can reduce the amount of greenhouse gases that are produced due to your everyday activities.

LO[4] Sustainability

It is very important for us to understand that, because of worldwide socioeconomic trends, environmental concerns, and Earth's finite resources, more is expected of each one of us. As a society, we are expected to design and provide goods and services that increase the standard of living and advance health care while considering the links between the Earth's finite resources and environmental, social, ethical, technical, and economical factors. One of the generally accepted definitions of sustainability is "*design and development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*"

KEY TERMS

Apply What You Have Learned

This is a possible term project for your class. Prepare a website for waste reduction, greenhouse gas reduction, and energy-saving measures that could be used on your campus. Elect a group leader, and then divide up the tasks among yourselves. Think about ways to measure the success of the project. As you work on the project, also take note of both the pleasures and problems that arise from working in a team environment. Write a brief report about your experiences working as a team on this project. What are your recommendations for others who may work collaboratively on similar projects?

PROBLEMS

Problems that promote life-long learning are denoted by 🔑

1.1 🔑 Each of you is to ask an older adult (for example, your grandparents) to think back to when they graduated from high school or college and to create a list of products and services that are available in their everyday lives now that were not available to them then. Ask them if they ever imagined that these products and services would be available today. To get your conversation started, here are a few examples: smart phones, online banking, electronic tablets, self-checkout scanners at the supermarket, and so on. Ask them to explain how these products have made their lives better (or worse).

wavebreakmedia/Shutterstock.com

Dmitry Kalinovsky/Shutterstock.com

1.2 Use your imagination to compile a list of products and services that are not available now that you think will be readily available in the next 20 years. Present the list to the class and explain which products and services you most look forward to using.

1.3 Record how much trash you generate each week. For a period of one week, maintain a daily logbook to keep track of what and how much you throw away and recycle each day. Suggest ways you can reduce waste and increase your own recycling. Compile your findings into a report and present it to the class.

1.4 Estimate how many cans of soda or other beverages you drink each year and calculate the amount of aluminum (in pounds or kilograms) that was used to make the cans. A 12-ounce (355 milliliters) empty aluminum can has a mass of 0.0445 pound (20.18 grams). State your assumptions, and explain your calculations.

1.5 Estimate the amount of copy or printing paper that you use every year. A 500-sheet ream of copy paper has an approximate mass of 5 pounds (2.27 kg). How much of this consumption is truly necessary, and how much of your own paper consumption could be avoided? State your assumptions.

1.6 Estimate how much water you consume each year when showering. To determine your shower water consumption:

a. Obtain a container of a known volume (for example, an empty gallon-size water or milk container) and then time how long it takes to fill the container.

b. Calculate the volumetric flow rate in gallons or liters per minute.

c. Measure the time that you spend on average when taking showers. Calculate the volume of the water consumed taking a shower on a daily basis.

d. Multiply the daily value by 365 to get the yearly value.

1.7 Estimate how much gasoline you consume each year for driving around town, doing errands, going to school, traveling to and from work, or just traveling from place to place.

1.8 Estimate how much food you consume annually for breakfast, lunch, dinner, and snacks. For a period of one week, maintain a daily log to keep track of what and how much you eat each day. Based on this analysis, estimate your annual food consumption. State all your assumptions.

1.9 Electric motors, which are found in many appliances and devices around your home, consume lots of energy. Identify at least five products at home that use electric motors. Could you get by without using any of them as often as you do now?

1.10 Identify at least five different energy-consuming products or practices at home and suggest ways to reduce consumption, such as turning off the light when you leave a room.

1.11 Electronic communication is becoming increasingly important. In your own words, identify the various situations under which you should write a letter, send an e-mail, send a text message, make a telephone call, or talk to someone in person. Explain why one particular form of communication is preferable to the others available.

1.12 In a brief report, discuss why we need various modes of transportation. How did they evolve? Discuss the roles of public transportation, water transportation, highway transportation, railroad transportation, and air transportation.

1.13 Visit the U.S. Department of Energy website and collect energy consumption data for each sector of the economy for the most recent year. Prepare a brief report discussing your findings.

1.14 In order to increase public awareness about the importance of energy, the environment, and sustainability and to promote global citizenship education among the younger generation, prepare and give a 15-minute presentation for a middle or high school class.

1.15 If this class has a term project, present your final work, on the date set by your instructor, at your school dining hall or during half-time of a sporting event. If the project has a competitive component, hold the design competition at the suggested locations as well.

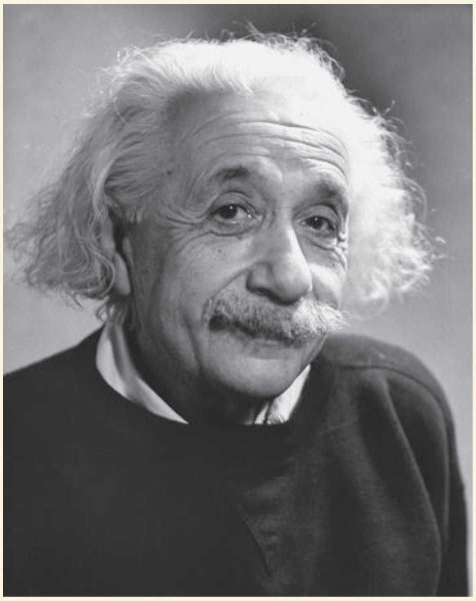
1.16 Prepare a 15-minute oral presentation about energy and its use in our everyday lives. The next time you go home, present it to the juniors at your old high school.

1.17 Investigate how much trash is generated on your campus each week. Suggest ways to reduce waste and increase recycling. Compile your findings in a brief report and present it to the class. State all your assumptions.

1.18 A gallon (3.8 liters) of gasoline that weighs 6.3 pounds (2.85 kg) can produce 20 pounds (9.1 kg) of carbon dioxide. Yes, 20 pounds (9.1 kg) of carbon dioxide! Assume 100 million people with cars (with 20 miles/gallon (10.6 km/liter) gasoline consumption rates) decide to walk 3 miles (4.8 km) a day (for approximately an hour) instead of driving their cars. What would be the reduction in pounds of carbon dioxide released into the atmosphere on a yearly basis?

1.19 Make a list of clothing, shoes, and accessories that you purchased last year. List the materials that you think were used to make these items. Discuss the origin of the materials.

1.20 Look around your home and estimate how many feet (or meters) of visible copper wire are in use for extension and power cords for common items such as a hairdryer, TV, phone charger, laptop computer, or lamp. Write a brief report and discuss your findings.



Fred Stein Archive/Contributor/Archive Photos/Getty Images

"Education is what remains after one has forgotten everything he learned in school." —ALBERT EINSTEIN (1879–1955)