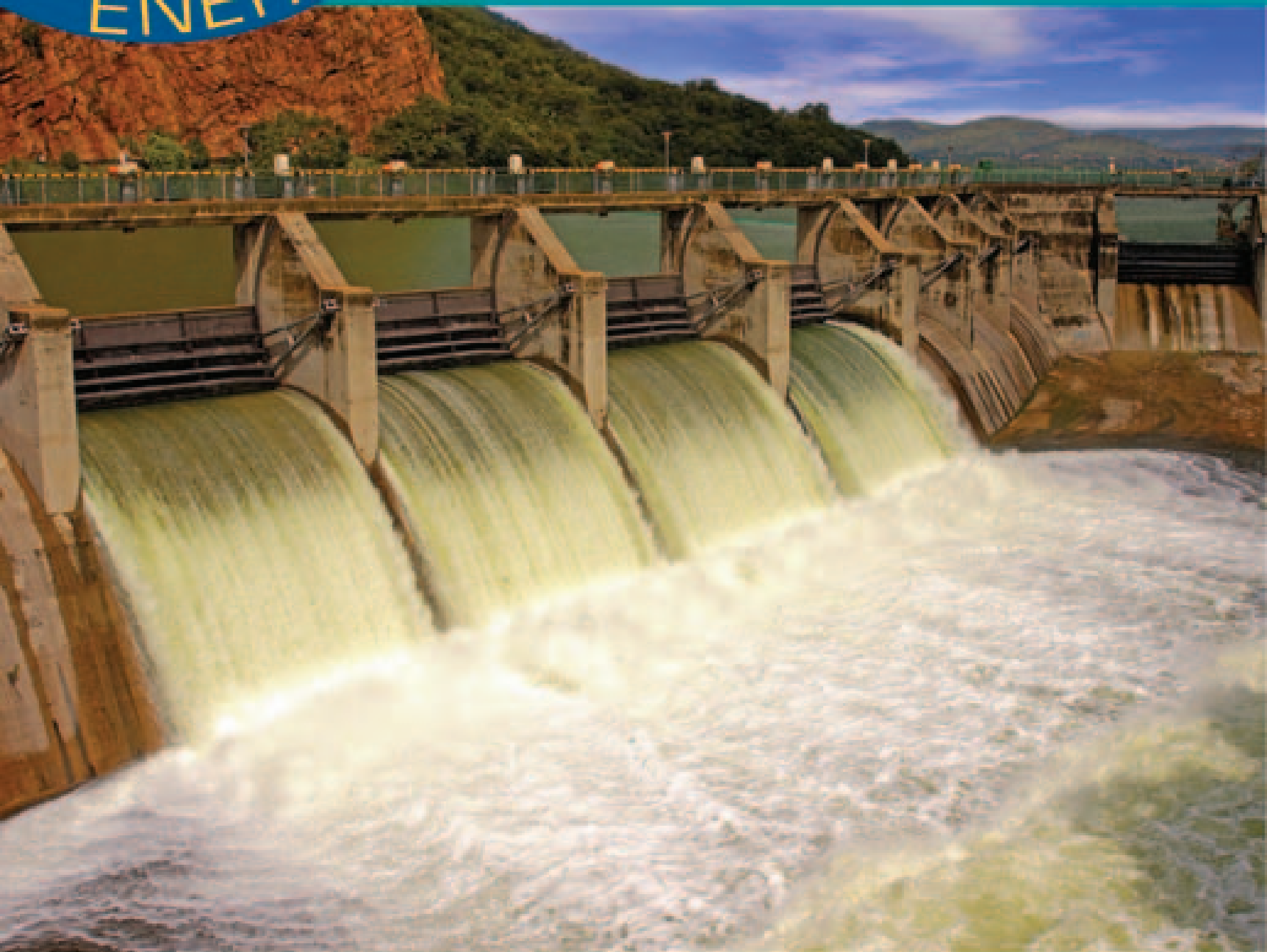
ENERGY TODAY

WATER POWER



Michael Burgan

Series Consultant: Debra Voege, M.A.
Science Curriculum Resource Teacher

ENERGY TODAY

Water Power

by Michael Burgan

Science and Curriculum Consultant:
Debra Voege, M.A.,
Science Curriculum Resource Teacher

CHELSEA CLUBHOUSE
An Imprint of Chelsea House Publishers

Energy Today: Water Power

Copyright © 2010 by Infobase Publishing

All rights reserved. No part of this book may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage or retrieval systems, without permission in writing from the publisher. For information contact:

Chelsea Clubhouse
An imprint of Chelsea House Publishers
132 West 31st Street
New York NY 10001

Library of Congress Cataloging-in-Publication Data
Burgan, Michael.
Water power / by Michael Burgan; science and curriculum consultant, Debra Voege.
p. cm. — (Energy today)
Includes index.
ISBN 978-1-60413-781-1 (hardcover)
ISBN 978-1-4381-3223-5 (e-book)
1. Water-power—Juvenile literature. I. Title. II. Series.
TC147.B87 2010
333.91'4—dc22 2009043267

Chelsea Clubhouse books are available at special discounts when purchased in bulk quantities for businesses, associations, institutions, or sales promotions. Please call our Special Sales Department in New York at (212) 967-8800 or (800) 322-8755.

You can find Chelsea Clubhouse on the World Wide Web at http://www.chelseahouse.com

Developed for Chelsea House by RJF Publishing LLC (www.RJFpublishing.com)
Project Editor: Jacqueline Laks Gorman
Text and cover design by Tammy West/Westgraphix LLC
Illustrations by Spectrum Creative Inc.
Photo research by Edward A. Thomas
Index by Nila Glikin
Composition by Westgraphix LLC
Cover printed by Bang Printing, Brainerd, MN
Book printed and bound by Bang Printing, Brainerd, MN
Date printed: May 2010
Printed in the United States of America

Photo Credits: 5: iStockphoto; 6: iStockphoto; 9: AP Images; 10: Practical Action/Ana Castāned; 15: Kris Unger/Verdant Power Inc.; 17: Ocean Power Technologies, Inc. PowerBuoy®; 24: © Lars Johansson/Alamy; 25: iStockphoto; 26: Pelamis Wave Power Limited; 27: © David Wall/Alamy; 29: © FogStock/Alamy; 30: © Emmanuel LATTES/Alamy; 32: AP Images; 33: © dmac/Alamy; 34: Getty Images; 37: © Press Association via AP Images; 38: © Greenshoots Communications/Alamy; 39: © Bill Brooks/Alamy; 41: Oregon State University, School of Engineering and Computer Sciences; 42: Lockheed Martin.

10 9 8 7 6 5 4 3 2 1

This book is printed on acid-free paper.

All links and Web addresses were checked and verified to be correct at the time of publication. Because of the dynamic nature of the Web, some addresses and links may have changed since publication and may no longer be valid.

TABLE OF CONTENTS

CHAPTER 1:
What Is Water Power? 4

CHAPTER 2:
The Many Forms of Water Power 12

CHAPTER 3:
Why Use Water Power? 22

CHAPTER 4:
Problems with Water Power 28

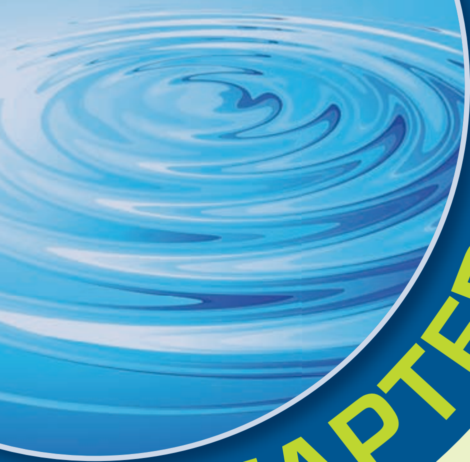
CHAPTER 5:
Looking Ahead 36

Glossary 44

To Learn More 46

Index 47

Words that are defined in the Glossary are in **bold** type the first time they appear in the text.



CHAPTER 1

What Is Water Power?

A river rushes over rocks and its waters fall hundreds of feet. At the seashore, the ocean's waters come up high on the shore. Hours later, the **tide** falls back again. Farther out in the ocean, wind whips the water's surface. Great waves rise and fall.

Moving water in rivers or the seas can create a beautiful picture. Many people enjoy watching these natural sights. Moving water can be more than beautiful, however. It can also be a great source of power. Thousands of years ago, humans first learned that moving water could turn wheels that were made of wood. The turning wheels could then be connected to large round stones. As the wheels moved, so did the stones. The stones were used to grind corn or wheat into flour. Over time, people found other ways to use water power. The energy created by water has made life easier for many people around the world.

Forms of Water Power

Water power comes in different forms. The most common type, called **hydropower**, uses the energy created by moving water. (*Hydro* comes from a Greek word meaning "water.") Often, dams are built across large rivers. Water flows from a high point on one side of the dam to a lower point on the other side. The water has what is called **kinetic**, or moving, energy. The falling

The power of moving water can be used for many purposes.

water turns the blades of a machine called a **turbine**. The water's kinetic energy is passed on to the turbine. The turbine is connected to a metal **shaft**. The shaft turns when the turbine does. The turning shaft is part of a machine called a generator. The generator creates electricity that is sent through cables to homes and businesses. Electricity that is created by water power is called hydroelectricity.

Other forms of water power include wave power and tidal power. Most of these types of water power work in essentially the same way as hydropower from river dams.

Today, people are trying to find new ways to create hydroelectricity. One way is to capture more of the kinetic

In a hydroelectric dam, the movement of water through the dam helps to create electricity.

energy found in ocean water. This can be done in several ways. Close to shore, the tides move in and out twice a day. Some areas have large differences between the height of the highest and the lowest tides. The rising and falling of these tides can be used to power turbines and create electricity.

Ocean waves also contain energy, called wave energy. Different systems are being tested to capture this energy. In some areas, the waves are strong near the shore, and turbines can be built close to land. Other systems try to use the water's kinetic energy far from shore.

Ocean waters can be very warm near the surface. They take in the heat from the Sun. Far below the surface, however, the temperature falls rapidly. In some hot

PEOPLE TO KNOW

NIKOLA TESLA

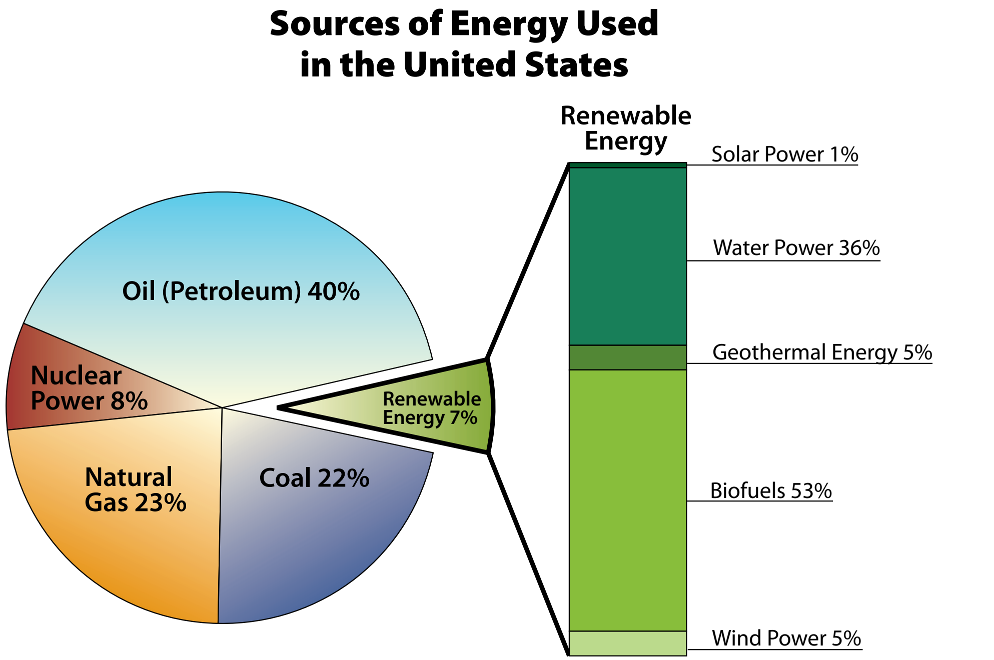
Nikola Tesla was born in what is now Croatia in 1856. His mother was an inventor who created household appliances. As a boy, Tesla dreamed about using the energy in waterfalls to power large wheels. As a young man, he worked as an engineer. He perfected a system for generating and sending a form of electricity called alternating current. Tesla brought his system to the United States in 1884. He found it hard to win support for his system. The brilliant inventor Thomas Edison had already begun producing electricity with a different system.

Tesla worked for Edison for several months until they had a disagreement. Then, Tesla had a great success during the 1890s, when he put his electric system in place at Niagara Falls, New York. Soon, the waters from the Falls turned turbines connected to generators. Each generator was close to 12 feet (3.7 meters) tall and almost as wide. The **power plant** at Niagara Falls sent electricity to homes that were hundreds of miles away. Tesla's work created the first large hydroelectric plant in the world. Within 25 years, about 25 percent of all U.S. electricity came from hydropower. Tesla went on to create new kinds of light bulbs and make important discoveries in radio, among other inventions. He died in 1943 in New York City. There is a monument honoring him in Niagara Falls State Park.

climates, the difference in temperature can be huge. Scientists have found ways to use the warm and colder water to power turbines. This source of power is called ocean **thermal** energy conversion, or OTEC.

The Benefits of Using Water Power

People often generate energy by burning coal, oil, and natural gas. These three **natural resources** are called **fossil fuels**. They were formed millions of years ago from the remains of ancient plants and animals. They are found deep in the ground



Note: Figures are for the year 2007. No information is included for hydrogen fuel because it was not yet being used in large enough quantities.
Source: U.S. Energy Information Administration

or below the oceans. Once these resources are found, they can be used to generate electricity. There is a problem with fossil fuels, however. The world has only a limited supply of them. Once they are used, they cannot be replaced with other fossil fuels. They are being used up. Since the people of the world rely heavily on coal, oil, and natural gas for their power, new sources of power are needed.

Nuclear power is another common source of energy in the world today. Most nuclear power comes from a **radioactive** substance called uranium. A complicated process is used to make energy from uranium.

Did You Know?

The Words and Numbers of Electricity

Today, five power plants on the Niagara River generate almost 5 million kilowatts of electricity. **Watts** are units of measurement that are used to express the rate at which electric energy is used. *Kilo* comes from the Latin word for 1,000, so the Niagara plants create 5 billion, or 5,000,0000,000, watts (5,000,000 x 1,000).

Electricity can also be measured in larger units, such as megawatts (one million watts) or gigawatts (one billion watts). In homes, electric use is measured in kilowatt-hours (kWh). To figure out how much electricity a house uses, you can multiply the watts used by the hours of use. In the United States, the average home uses almost 1,000 kWh every month. In 2008, the entire United States used 4.18 million gigawatt-hours of electricity.

Part of one of the power plants on the Niagara River.

Did You Know?

Hydropower Goes Small

Not all hydroelectric power plants are big. Some parts of the world do not have rivers that are large enough for big dams, or people live far from where these dams could be built. Smaller hydropower plants are built instead. In the Andes Mountains of Peru, a British group has helped poor residents build 47 small hydropower plants. Each produces an average of 33 kilowatts of electricity. Together, these plants provide electricity for about 5,000 families. Without this water power, the families would have no electricity at all.

A worker adjusts part of a small hydropower plant in Peru.

Water is much easier to find than uranium, coal, oil, and natural gas. Water also creates much safer energy than the other sources. Removing coal and uranium from the ground can hurt the **environment**. The power plants fueled by coal and oil create pollution that can harm the air or nearby water. The power plants also release substances that many scientists say are causing **global warming**, which can hurt the planet. In addition, the radiation from uranium can harm people. Great steps must be taken to make sure that nuclear power plants are safe. The radioactive waste created by nuclear plants is also dangerous. So far, no long-term solution has been found to the problem of how to store radioactive waste safely.

In Their Own Words

"Throughout our nation, water is the lifeblood of our bodies, our economies, and our well-being. You see, we don't just use water for drinking."

Stephen L. Johnson, former head of the Environmental Protection Agency, 2007

Water power is not a perfect source of energy. It can be expensive to build and place turbines that use water power. In addition, only some areas have the right kinds of rivers or ocean waves to create hydroelectricity. Scientists are still working to improve the systems to create power from water, but they hope that water power will become cheaper and more common in the years to come. Then people can use less of the other natural resources that create electricity—resources that may run out or may harm the planet.

CHAPTER 2

The Many Forms of Water Power

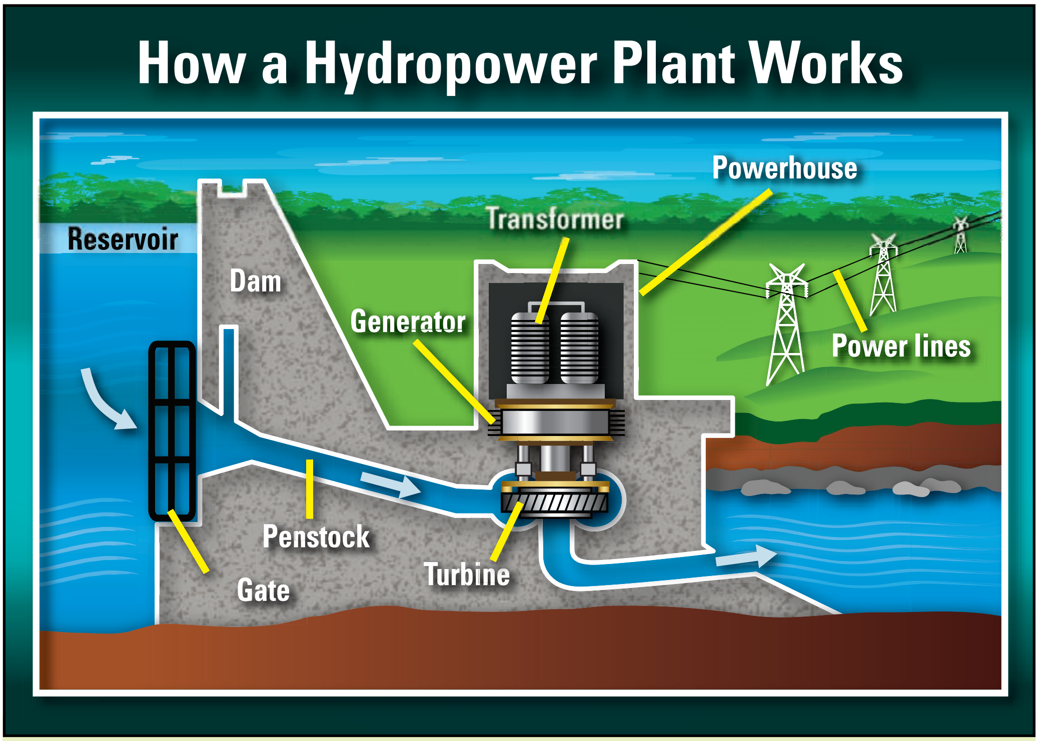
Rushing river waters are the oldest source of water power. People in Asia and Europe used river water to power water wheels more than 2,000 years ago. Some wheels were placed directly in the water. Other times, people built **channels** to carry water from a stream or river to the wheel. One of the largest hydropower mills of that time period was built in southern France. Sixteen wheels worked together to turn large stones. The stones turned corn into flour. The mill could grind up to 10 tons (9 metric tons) of corn each day.

Over the centuries, people used hydropower in other ways. Water wheels powered pumps that took water from rivers and brought it to farms, to **irrigate** the land. Other wheels provided power for machines in the earliest factories. These machines were often used to make cloth.

A problem with water wheels was that they could produce power only near where they were built. People had no way to move the power created by water's kinetic energy to other places. Hydroelectric power plants solved that problem. The first working hydroelectric plant opened in 1882 in Wisconsin. Today, hydroelectric plants and the new forms of water power—tidal power and wave power—are all being used to create electricity. Some of it travels a long distance. Other times, the electricity is used close to the source of the water power.

Modern hydroelectric plants are centered around dams built across rivers. The dam creates a body of water called a **reservoir**. Water from the reservoir passes through a gate and travels through a tube called a penstock. The water flows downward through the penstock and then reaches the turbine. The spinning turbine powers the generator, while the water passes through another tube to return to the river. The electricity created by the generator then goes through a device called a transformer, which makes the electricity easier to send through power lines to homes and businesses.

Today, the United States has about 2,000 hydroelectric plants, which provide about 6 percent of the country's electricity needs.



In a hydropower plant, the movement of water causes a turbine to spin, which powers a generator that creates electricity.

Did You Know?

Telling Time with Water

One early use of water power was to tell time. The ancient Greeks called a water clock a *clepsydra*, which means "water thief." The earliest clepsydras had water that flowed out of a hole in the bottom of a container. The sinking level of the water in the container marked the passing of time. A little more than 2,000 years ago, a Greek inventor created a mechanical water clock. In this clepsydra, water flowed from one container to another. The rising level of water in the second container pushed up a small disk that floated on the surface. The disk was connected to a rod that marked the passing of hours as it moved upward. Some water clocks also powered gears. As the gears turned, they moved small models of humans or dropped stones onto a gong.

In 1086, a Chinese inventor named Su Sung built a water clock that was about 40 feet (12 meters) tall. In the clock, 36 buckets were attached to a water wheel. When one bucket filled with water, its weight made the wheel turn, bringing up the next bucket. The movement of the buckets marked time.

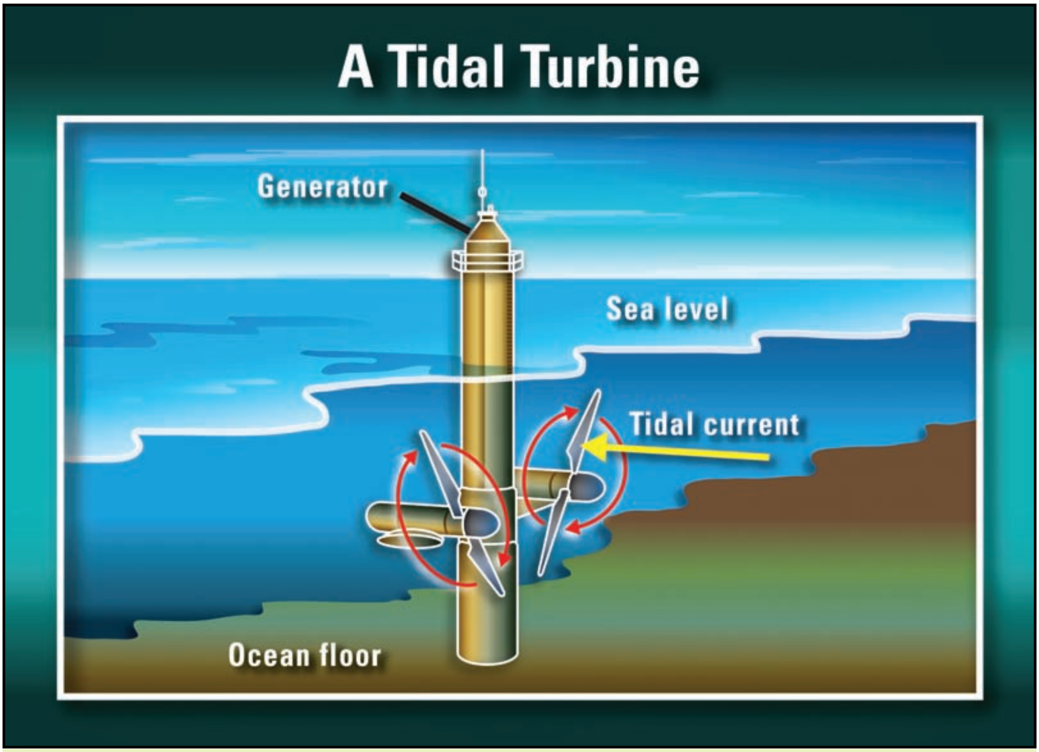
Across the world, about the same percentage of energy comes from hydroelectricity. China is the world's leading producer of hydroelectricity. In 2006, its dams generated 431 billion kilowatt-hours of electricity. Norway gets more of its electricity from hydroelectric dams than any other country. In 2005, the dams provided about 65 percent of the country's needs. The U.S. government estimates that the worldwide use of hydropower will grow 2 percent each year through 2030.

Power in the Tides

Tidal power is also an old form of water power. It is sometimes called lunar energy. The motion of the tides is affected by the Moon, which was called *luna* in ancient Rome. Hundreds of years ago, people saw that the movement of tides contained kinetic energy. They built special dams, called barrages, near the **basins** where the tide went in and out. Water filled the basin during high tide, and the barrage trapped it. At low tide, the people opened gates in the barrage. The gates directed the flowing water to a water wheel.

Tidal power can also create electricity. Barrages are still used for this purpose. The water is used to turn turbines rather than a water wheel. The turbines are connected to a generator that creates electricity. The

Workers prepare to install an underwater turbine in New York City's East River in December 2006.



In a tidal turbine, the force of a tidal current causes turbines to spin, helping to generate electricity.

first large tidal-power barrage began operating in France in 1966. Tidal barrages are not very common. In fact, only one other tidal barrage is currently used. They may harm plants and animals that live near them.

Scientists have found other places where tidal power can be used. Turbines can be lined up below the water in a row. They create what is called a tidal "fence." A fence can be used to connect two land areas and serve as the base of a bridge for cars and trucks. Openings between the turbines let fish swim by. (A tidal barrage often prevents fish from swimming in and out of a bay.) More recently, engineers have placed single turbines directly on the ocean floor. The turbines look like the ones used to create wind power on land, but they are stronger and more sturdy. The underwater turbines cannot be seen from the surface. One of these systems has been tested in New York City's East River. It could lead to 300 turbines being installed there. They would create enough electricity to power 10,000 homes. A similar system may soon be in place off the coast of Washington state.

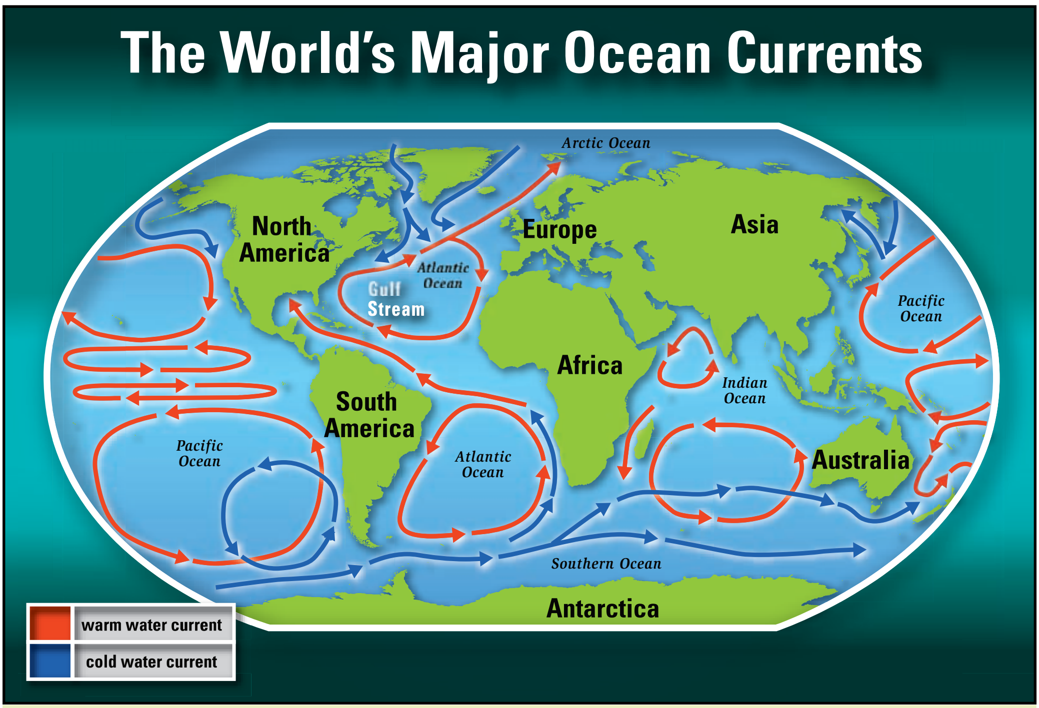
Wave Power

As the tides create "lunar power," ocean waves are a kind of **solar** power. The Sun's energy creates winds near the surface of Earth. The winds blow across ocean waters and create waves. The waves have kinetic energy, which increases as they come closer to shore. Experts think that the wave energy near the coasts of the United States could someday create more electricity than all the country's hydroelectric dams currently produce.

The PowerBuoy® system developed by Ocean Power Technologies, Inc., captures the natural energy in ocean waves.

Scientists around the world have found different ways to capture wave power. Some methods place devices offshore in waters up to 230 feet (70 meters) deep. A **buoy** sits inside a fixed metal container. The buoy moves up and down inside the container as the waves pass by. The buoy is connected to machines that turn its kinetic energy into electricity. Other offshore devices stretch out over the surface of the ocean. These devices bend as the waves rush past them. This bending motion powers pumps inside that generate electricity.

Wave power can also be captured onshore. Incoming waves are forced into a basin. The water is then fed into a turbine, which generates electricity. Another onshore method combines water and air. The waves enter the bottom of a chamber that is sealed on all its other sides. Air sits in the space between the top of the chamber and the water surface. The movement of the waves inside the chamber forces the air through a turbine at the top of the chamber, making the turbine turn.



Currents, which are underwater streams, have fast-moving water. The Gulf Stream contains a huge amount of energy.

Moving water below the ocean surface can also generate power. These underwater streams are called currents. Most move much faster than the tides that reach the shore. One well-known current is the Gulf Stream. It carries warm water from the Gulf of Mexico across the North Atlantic Ocean. Experts say that the energy in this one large current is equal to 30 times the energy created by all the rivers on Earth. No one has found a way to tap this energy yet. Some Florida researchers, though, are testing turbines off the coast of their state. The constant speed of the current—5 miles (8 kilometers) per hour—could one day provide energy for some of the large cities in southern Florida.

Did You Know?

Salter and His "Duck"

British scientist Stephen Salter was one of the first modern inventors to explore ways to create electricity from ocean waves. In 1974, he invented a new device for capturing the energy in waves. The device would sit on the ocean surface and move up and down as the waves passed by. Inside the device, the energy of the waves would move metal rods called pistons. The rods would power a generator that created electricity. The shape of Salter's device and the way it moved reminded some people of a duck. Salter wanted to set up rows of his "ducks" to capture the energy in the passing waves. He ran out of money, however, before he could test his device in the ocean. Salter's Duck remains too expensive to build on a large scale, but Salter is still looking for ways to use wave power.

Michigan researchers have an idea for creating electricity from slower currents. A series of pipes would stick out of the ocean floor. As the current passes by the pipes, it would make them vibrate. These vibrations are a form of energy that could be used to power a turbine and generate electricity. The pipes could create electricity from currents slower than 2 miles (3 kilometers) per hour.

Hot and Cold Water

The Sun plays a role in another form of water power. Along the **equator**, the ocean's temperature can reach higher than 90°

Did You Know?

Seeing the Value of Heat

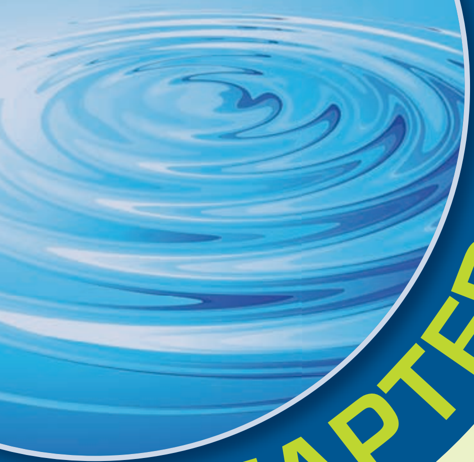
During the 1800s, French author Jules Verne wrote several books in which he imagined great inventions that were not yet built at the time. He suggested the idea of ocean thermal energy conversion (OTEC) in his 1870 book *Twenty Thousands Leagues Under the Sea*. In 1882, a French scientist said Verne's idea could actually be done. The scientist, Jacques-Arsène d'Arsonval, wanted to use the heat in the ocean to boil a gas that could power a turbine. Years later, Georges Claude—another French scientist—developed an OTEC system that directly turned ocean water into steam. In 1930, Claude built the first working OTEC system off the coast of Cuba. Sadly, the plant was destroyed in a storm.

Fahrenheit (32° Celsius) at the surface. Far below the surface, though, the temperature of the ocean can be much cooler—perhaps as cold as 55°F (13°C). Heat is another form of energy, just like the motion in moving waters. Scientists have found several interesting ways to turn the ocean's heat into electricity. These different methods are called ocean thermal energy conversion (OTEC).

One method uses the heat in the water to make the substance ammonia boil. Ammonia boils at a much lower temperature than water. The warm water travels through a pipe into a container that holds ammonia. When the ammonia boils, it becomes a gas that is forced past a turbine, which spins, causing a generator to produce electricity. (The electricity is carried by cables to land.) Then, cold ocean water in another pipe is used to turn the gas back into a liquid, and the ammonia can be reused.

Another OTEC system turns the warm surface water into steam to power a turbine. In a process that is called flash evaporation, the warm water goes from a pipe into a container in which a short, rapid burst of heat creates the steam. After the steam leaves the turbine, it passes through tubes placed in the colder water. Once again, the colder water turns the steam back into water.

The first working OTEC power system was built in Cuba in 1930. It produced 22 kilowatts of electricity, but it required more power than this to work. A power plant must generate more power than it uses, or it does not make sense to build it. The owners would lose money. Newer OTEC systems are able to produce more electricity than they use. Plans are underway to test small OTEC plants that could produce up to 10 megawatts of power.



CHAPTER 3

Why Use Water Power?

When you look at a map of the world, one image leaps out. The land on Earth is surrounded by water. Within the land are lakes, rivers, and streams. All together, about 70 percent of Earth's surface is covered with water. This huge supply is one reason why some people think water makes a great source of power. Most of the fuels used to generate electricity today—fossil fuels—have a limited supply. Coal is the most common fuel used. Experts think the known reserves of coal will run out in about 130 years. Natural gas and oil are also important energy sources used to generate electricity. The known reserves of these fuels will run out even sooner. Water is all around us, and it will never disappear.

Fighting Global Warming

Coal and other fossil fuels have another problem. They add to pollution in the air and water. Burning them is also thought to increase global warming. Scientists know that the temperature of Earth's atmosphere, land, and seas is slowly rising. If the warming continues, the planet may face many dangers.

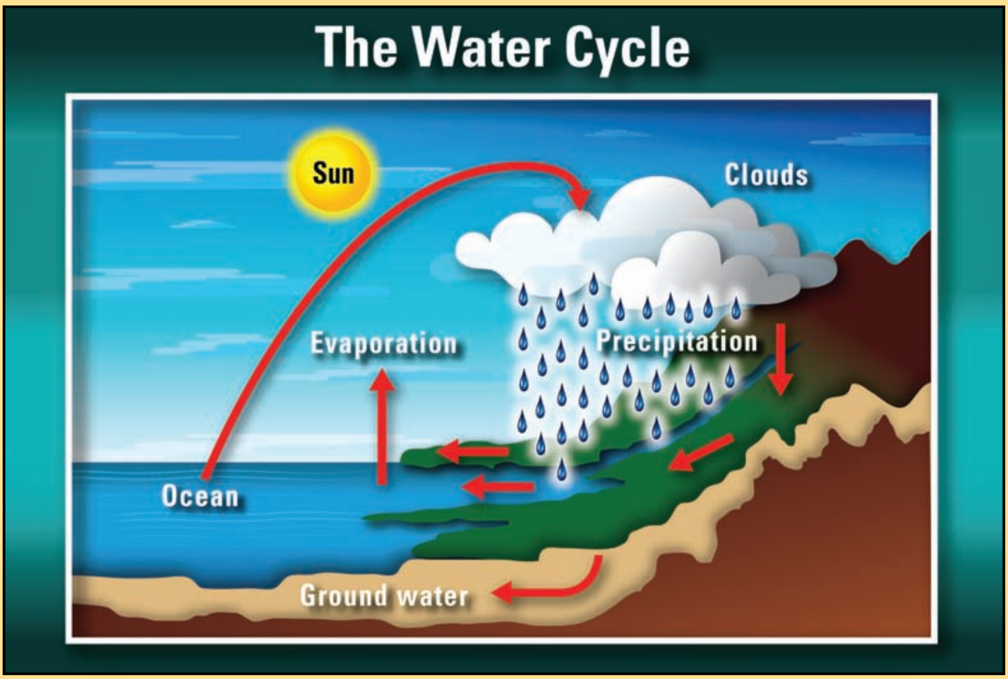
For example, global warming is causing the disappearance of **glaciers** found on some mountains. When these glaciers melt, they provide water for people who live nearby. If the glaciers disappear, that water supply will be gone. In the Arctic, melting ice has already affected polar bears. The bears spend much

Did You Know?

The Water Cycle

Water power is a **renewable** source of energy. This means water will not run out as it is used to create energy. The Sun and Earth's oceans are part of the water cycle. In this cycle, energy from the Sun heats the oceans and other bodies of water. Some of this water evaporates, becoming **vapor**. Air currents carry this vapor into the **atmosphere**. High in the atmosphere, the air is cool. This cool air turns the vapor into tiny drops of water. These drops cling to even smaller pieces of dust, smoke, or salt in the air. The water and the bits the drops attach to combine to form clouds. When some of the drops are large enough, they fall to Earth as rain, snow, or ice.

The various forms of **precipitation** keep the water cycle going. Rain falls into streams, rivers, and oceans. Some rainwater also goes into the ground. Over time, some of this ground water also enters bodies of water. So does ice, after it melts. The water is then heated by the Sun, and the cycle starts all over again.



of their time on the ice hunting food. They have a much harder time hunting as the ice disappears. Global warming could have other serious effects. The seas may rise, for example, which would lead to dangerous flooding.

Global warming poses a threat to polar bears because polar ice is melting.

How does burning coal and other fossil fuels contribute to global warming? When these fuels are burned to create electricity, different gases—including **carbon dioxide**—are released into the air. These gases are called **greenhouse gases**. Through a process that takes place naturally, these gases help keep Earth at the right temperature. It is harmful, however, when too much of these gases builds up in the atmosphere—as they do when people burn fossil fuels. The greenhouses gases are keeping too much heat close to the planet and are causing global warming.

Using more water power means that less coal, oil, and natural gas would be used to generate electricity. This means lower amounts of greenhouse gases would be created. Rushing water and flowing currents do not release any harmful gases.

Experts hope that reducing the amount of those gases in the air will slow or even stop global warming.

Other Benefits of Water Power

Water power is more than just a clean source of electricity. The different forms of water power have other helpful results. When dams are built, they create large bodies of water. These reservoirs and lakes have several uses. For example, water from the reservoirs can be used for drinking and to grow crops. Reservoirs provide a source of water when there are droughts. Lakes created by dams also provide opportunities for outdoor activities. Hoover Dam, on the Colorado River between Arizona and Nevada, helped create Lake Mead. The lake and land around it attract many visitors. They come to sail boats, swim, fish, or just enjoy the outdoors.

Hoover Dam, a huge structure on the Colorado River, created Lake Mead behind it.

Ocean and tidal power have several possible benefits. The cold water used in ocean thermal energy conversion (OTEC) can be used again after it helps create electricity. The water can be piped

Did You Know?

A Wave "Farm"

Stand on the beach near Aguçadoura, Portugal, and look out at the ocean. You can barely see a red line on the surface about 3 miles (4.8 kilometers) away. That line is actually part of the world's first wave "farm." Three large, long devices called **converters** are anchored to the bottom of the Atlantic Ocean. They capture the energy in the moving waves and turn it into electricity. A cable under the water carries the electricity to shore. The wave farm first produced electricity in 2008. Portugal hopes to increase the size of the farm by adding more of the long, red converters. The farm could one day produce 21 megawatts of electricity. That is enough to power almost 15,000 homes.

The wave-energy converters off the coast of Portugal.

into special systems that keep buildings cool. One type of this air conditioning has already been used in Hawaii. In addition, the energy generated by OTEC can help provide drinkable water for parts of the world that need drinking water. A process called desalination can take salt out of ocean water, to make it drinkable. Desalination requires a great deal of energy. An OTEC system or other source of water power could provide

The Sydney Desalination Plant, located in Sydney, Australia.

the needed energy. At the same time, it would not add pollutants (substances that contaminate water, air, or soil) to the water being treated.

Some people think that hydroelectric plants are ugly. The massive dams, power plants, and transmission lines spoil the view in what used to be beautiful outdoor areas. Supporters of wave and tidal power say these sources do not have the same problem. The turbines used to create electricity with wave power are placed below the water's surface and are out of sight. Other methods of ocean energy use buoys that sit far from the shore.

Water power is clean and renewable, and once a system is built, the "fuel" that runs it is free. For these reasons, many governments and companies are exploring all the different forms of water power.

In Their Own Words

"In the process of developing ocean energy, we might be able to minimize [lessen] the harmful effects of greenhouse gas–induced global warming on ocean life and our planet."

U.S. Representative Jay Inslee of Washington

CHAPTER 4

Problems with Water Power

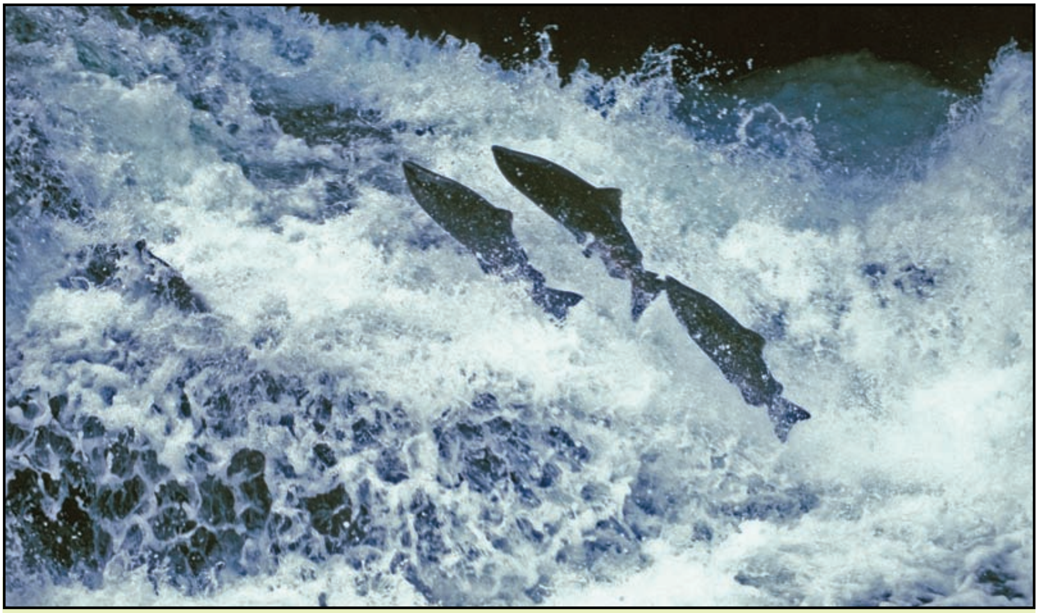
In Egypt, a huge dam stretches across the mighty Nile River. The Aswan High Dam is more than 2 miles (3.2 kilometers) long and 364 feet (111 meters) high. It provides the people in Egypt with more than 10 billion kilowatt-hours of electricity each year. This electricity could fill the power needs of more than one million homes. The dam is considered one of the greatest modern building projects in the world, but not everyone likes giant dams such as the Aswan.

Water power can solve many energy needs, but hydropower and other forms of water power are not perfect. Some people think the problems that dams cause are worse than the good they do. Also, **environmentalists** fear that scientists still do not know all the possible harmful effects of wave, tidal, and thermal power.

The Dangers of Dams

Building a dam for hydropower means changing the way a river flows. This means that fish can no longer swim up and down the river as they once did. A dam also holds back food and other substances fish need to live. Environmentalists say dams have affected many kinds of fish. The fish begin to die off and then disappear in rivers where some dams are built.

A moving river carries tiny bits of rock and other material called sediment. The flow of sediment is important for many



Salmon are among the fish that may be harmed by the construction of a dam.

animals that live in the area. Large dams prevent the sediment from flowing freely. To replace the sediment that has been removed, the water that comes through the dam begins to take sand and other natural material from the riverbanks. This process strips away sand and tiny rocks from the riverbanks. Salmon, other fish, and some mosquitoes normally have their babies in that material. As it gets carried away, the living things that inhabit the area begin to suffer.

Dams form large reservoirs. These large bodies of water and the lakes they create can also hurt the environment. A grassy material called peat normally takes carbon dioxide out of the air. This helps in the battle against global warming. In some areas, the lakes formed by dams flood over the peat. The peat begins to rot and can no longer remove carbon dioxide from the air. In addition, when peat and other plants rot, they release more carbon dioxide into the air. This adds to global warming.

Peat bogs—where peat grows abundantly—are beneficial because they remove carbon dioxide from the air, but the construction of dams can destroy the bogs.

Governments sometimes force people to leave their homes when large dams are being built. The lakes and reservoirs that the dams create flood the land where the people once lived and worked. The reservoirs also force wildlife from their homes. The reservoir's waters can also flood over historic sites. This happened when Egypt built the Aswan High Dam.

Dams can affect people and wildlife in other ways. Slowing a river's flow reduces the amount of water that runs downstream, which means that people living there have less water for drinking or irrigation. In addition, fish, such as salmon, find their usual routes for traveling upstream blocked by the dams.

PEOPLE TO KNOW

PATRICK McCULLY

During the 1980s, Patrick McCully—who was born in 1965 in Northern Ireland—worked for a magazine that printed stories about the environment. He learned about the importance of rivers and the damage that dams can cause. In 1996, he wrote a book called *Silenced Rivers*. He described what he had learned about the threats to rivers from large dams. McCully, who now lives in the United States, is considered an expert on the dangers of those dams. He leads a group called International Rivers, which tries to protect rivers and educate people about dams. He does not oppose all dams. He thinks that very small "micro dams" can be good sources of hydropower and do not harm the environment. McCully and his group, however, try to stop the building of dams that might harm wildlife or humans who live nearby. McCully has spoken out about some of the problems created by China's Three Gorges Dam.

Problems with Tidal Turbines?

Some environmentalists worry that the newer forms of water power could create problems, too. The large underwater turbines used to create wave and tidal power are very new. Scientists have not had much time to study how they will affect fish. Some people worry that the spinning blades could kill fish or force them from their usual paths. The fish might have trouble swimming to the areas where they normally have babies. Also, if fewer fish than usual are living in an area, birds that feed on them will have less food. Fishers also fear they will have a harder time making a living if the turbines affect fish that live near the coasts.

Some scientists worry about whales and other sea mammals. The cables used to hold buoys or carry electricity could block their paths. In addition, the animals might not see the cables and be injured by them.

Did You Know?

A Dangerous Dam in China

In 2006, China completed construction of the dam structure of the Three Gorges Dam, which sits on the Yangtze River. The dam is the largest hydroelectric river dam in the world. Building it, though, forced more than one million people to move to new towns and villages.

The dam has also caused other problems. Scientists say the dam has harmed several hundred types of plants and animals because the reservoir destroyed their habitats (the environments in which they lived). Water from the reservoir has leaked into the ground, making it easier for rocks and earth to tumble down. This has created landslides, forcing even more people to move. Farther down the Yangtze, people are not getting as much water from the river as they once did. At the same time, more salt water is entering the area where the river meets the sea. Some sea creatures that live in salt water can now live farther upstream in the Yangtze. They are eating the eggs of other kinds of river life. Scientists still do not know all the damage the dam could cause in years to come.

There have been problems associated with China's huge Three Gorges Dam.

People in the fishing industry are concerned about the effect of dams and other water power projects on fish.

Another concern is pollution. Many of the buoys and other devices used to generate wave power contain liquid chemicals. Some scientists fear these chemicals could leak and kill life in the oceans. The equipment used to generate electricity also makes noise. Scientists wonder if the noise might scare fish looking for food and upset their usual patterns.

Ocean thermal energy conversion (OTEC) systems—which are expensive to build and maintain—might have their own problems. Using warm ocean water to create electricity removes heat from the water. This could harm plants and animals that need the warmth to survive. It could also affect plants and animals that live in the cold waters below.

High Costs

Although the newer forms of water power can create electricity, the cost of doing so is high. Many of the companies trying to create electricity from the tides or currents are small. Some do not have the money to develop their plans on a large scale, which would help cut costs. They also may not have the money to carry out experiments over a long period of time.

Seawater causes a process called **corrosion**. Chemicals in the water make metal weak and then break down. Companies using underwater turbines will have to keep replacing metal parts to make sure the systems work. If the turbines are far off the coast, the companies will have to spend more money bringing workers and supplies to these sites. Right now, electricity from wave power costs about 20 cents per kilowatt-

Many people were killed and a great deal of damage was done when a dam burst in Indonesia in March 2009.

hour. Coal costs only about 5 cents per kilowatt-hour, while hydroelectricity is just 3 cents.

Transmitting energy from the oceans or coasts to homes and businesses can also be costly. In general, building transmission lines is expensive, because companies usually have to buy land from many owners before setting up towers to hold the lines. Electric companies also must avoid placing towers in certain areas if the towers might harm the environment. The process can take many years.

> **In Their Own Words**
>
> "If a whale is moving along at 5–6 miles [8–10 kilometers] per hour and they run into a cable, it's not going to be a nice situation."
>
> Scientist George Boehlert, director of the Hatfield Marine Science Center, Newport, Oregon

Limits of Water Power

Although Earth has plenty of water, not all of it can be used for water power. The best rivers for creating power, for example, are located near hills and mountains, where water runs downhill with much kinetic energy. Some rivers move too slowly to be useful. For tidal power, only certain coastlines have the strong movement of the tides needed to create electricity. OTEC is limited to areas near the equator, where the water gets warm enough at the surface.

Some nations are surrounded by other countries. They have no direct contact with the oceans, so they may not be able to use water power to generate the energy they need. Water power is not the answer for all electricity needs.

CHAPTER 5

Looking Ahead

The dangers and problems associated with water power are real. Scientists around the world are working to solve these problems. Some of the problems may never be totally fixed. No source of electricity is completely harmless and free of all problems. The goal is to make water power as safe as possible.

The dangers of large dams have led some people to oppose the building of new ones. Because of the concerns about those dams, the number of new ones will likely fall, though small "micro dams" may be built in greater numbers. These dams sit on small rivers and provide power to small communities. They have fewer harmful effects than large dams. Hydropower will still be used to create electricity. In the future, though, companies and governments will probably do more research on the other forms of water power. Tidal and wave energy seem to be the most likely sources.

Researchers know some people have concerns about the turbines used to create tidal and wave power. One way to prevent possible harm is to use turbines that move very slowly. In 2008, the world's largest tidal turbine began working off the coast of Ireland. The huge blades on the turbine spin slowly—between 10 and 15 times in one minute. The propellers on a ship spin about 10 times faster. Fish have time to avoid the spinning blades. Since the turbine does not move, the fish can

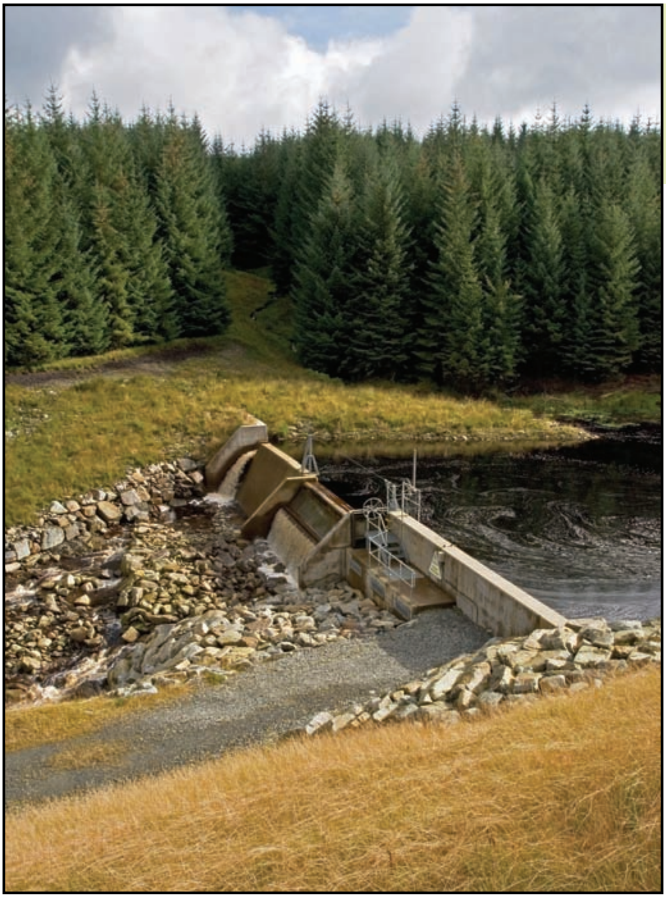
The world's largest tidal turbine is operating off the coast of Ireland.

also just swim around it. Scientists hope to find ways to reduce other worries about the newer forms of water power.

Worldwide Effort

The strong interest in water power first grew during the 1970s. At the time, the price of oil rose quickly. Companies and countries began to study if water power could be cheaper to use. Then, when oil prices fell, interest in water power dropped, too.

Now, though, people are once again exploring the use of water power. They realize that oil, coal, and natural gas will one day run out. They also know that water power will help cut down on greenhouse gases. In 2009, in countries around the world, more than 300 water power projects were started or planned. Some tested new water power systems, while others focused on generating electricity for homes and businesses.



A small "micro dam" in Scotland. Such small-scale water projects may become more common.

Engineers know both tidal and wave energy systems can work. They just need the money to build them. Some money comes from investors, who hope to make more money in the future from generating and selling electricity. Over the next few years, about $2 billion will be spent to build turbines and other systems that use water power. About the same amount will be spent on research. The research should lead to better and cheaper ways to tap water power.

Great Britain has been a leader in exploring ocean energy. Britain is an island nation that has several spots with strong tides, and it sits near the Gulf Stream. Experts say the country could some day get 20 percent of its electricity from different forms of water power. Other countries that could generate a great deal of electricity from water include the United States, Canada, South Korea, Japan, and Australia.

Did You Know?

Rising Tides in Canada

The Bay of Fundy sits between Nova Scotia and New Brunswick, Canada. The tides there are the highest in the world. From low tide to high tide, the bay's waters can rise as much as 50 feet (15 meters). About 100 billion tons (90.7 billion metric tons) of water move through the bay every day. That is more than the water flowing in all the world's rivers. That much moving water means the Bay of Fundy is a perfect site for creating electricity from the tides.

People have discussed the idea for years. In 1984, a local power company began using a barrage in the bay to power a generator. Electricity was generated, however, only when the tides were falling. In 2009, the same company began work to install its first tidal turbine. The turbine can generate power when the tides rise and when they fall. This turbine will create only a small amount of power, but if it works well, many more turbines will be put in place. The turbines may be the best hope for creating large amounts of energy from the Bay of Fundy.

An experimental tidal power station on the Bay of Fundy.

Work in the United States

The United States has several programs to help develop new sources of water power. In 2007, the government created the Advanced Research Projects Agency–Energy within the Department of Energy to pay for research and fund projects involving water power and other forms of renewable energy. The country also has a National Renewable Energy **Laboratory**. This lab works on projects for water power and other kinds of renewable energy.

The U.S. government sometimes pays companies to set up water power systems. In one recent project, the U.S. Navy—working with a private company—installed buoys near a U.S. Navy base in Hawaii. The buoys convert wave energy to electricity, which is carried by underwater cables to the land. If the project is successful, the Navy hopes to use wave energy to provide power for its bases around the world. In Maine, the Coast Guard is installing equipment to generate electricity using tidal power at one of its stations. If this project is successful, tidal power could also be used at Coast Guard stations in Alaska and Washington. The U.S. Navy also hopes to use ocean thermal energy conversion. OTEC systems could be used in Hawaii, where the waters are warm.

Despite these projects, the building of water power projects may slow somewhat. In 2009, U.S. President Barack Obama called for cutting the amount of money the government spent on tidal and wave energy. Instead, he wanted more money to be spent for other forms of renewable energy, such as wind power and solar power. Even with the cuts, though, President Obama was ready to spend more on water power than past presidents had.

Did You Know?

Working with Waves in Oregon

Many U.S. states have a coastline, but Oregon might be the leader in trying to make ocean energy a main source of its power. The state's waves are larger than waves in other parts of the country. In addition, many state residents support using as much renewable energy as possible. The Oregon Wave Energy Trust, a group formed in 2007, studies how to bring ocean energy to the state without harming the environment. Its goal is for ocean energy to provide 500 megawatts of power to the state by 2025. People at Oregon State University have been doing research on wave energy for more than 10 years. By 2009, several different companies were ready to test different wave energy systems off the Oregon coast.

Researchers at work testing wave energy off the coast of Oregon.

A drawing of what an OTEC plant might look like. Such plants could someday deliver a great deal of electricity.

Did You Know?

Removing Outdated Dams

In 1999, a small, old hydroelectric dam in Maine called the Edwards Dam was taken down. The dam had been on the Kennebec River. A government agency had ruled that the **ecological** value of letting the river flow freely was greater than the economic value of the dam. When the river was able to flow freely, many fish returned. This led birds to return to the area as well. In addition, people were able to go boating and fishing. Since the Edwards Dam was removed, more than 400 other outdated U.S. dams have been taken down.

The Future of Water Power

The amount of electricity created by water power will probably continue to grow. In the United States, about 10 percent of all electricity could someday come from the oceans. Around the world, by 2030, about 250 gigawatts of power could come from all sources of water power.

Currently, the cost of building turbines and plants to generate and transmit this electricity is high. It is cheaper, however, than building plants that generate electricity from the Sun or wind. Still, keeping ocean and tidal turbines running will cost money. The effects of corrosion mean that large, expensive parts must be replaced after a period of time. Investors and governments will have to consider that cost when they decide which kinds of renewable energy they should use.

In the future, the world's need for electricity will continue to rise. The population keeps growing, and people keep buying more goods that run on electricity. Concerns about global warming will raise more interest in renewable energy that does not contribute to global warming. If rivers, tides, and waves are nearby, people will turn to water power for more of their energy needs.

In Their Own Words

"Ocean energy should be a part of…American energy needs. These technologies can help solve global warming, and we can build in protection for healthy oceans from the start…to make sure that the technologies meet strong environmental standards."

Diane Regas, Environmental Defense Fund

GLOSSARY

atmosphere: The envelope of air that surrounds the planet.

basin: A section of Earth that dips lower than the surrounding area, where water can be easily trapped. Also the area of land that surrounds a river or lake, from which water drains into the river or lake.

buoy: A device that floats on water while attached to a cable that keeps it in one spot.

carbon dioxide: A gas formed when fossil fuels are burned; also written as CO_2.

channel: A stretch of water connecting two areas of land.

climate: The weather and overall environmental conditions in a place as measured over a long period of time.

converter: A device that changes one form of energy into another.

corrosion: The act of eating away at something, destroying it little by little.

ecological: Concerned with the relationships between living things and their environment.

environment: The land, water, and air in a particular area.

environmentalist: A person who cares about and seeks to protect nature and the environment.

equator: An imaginary circle around the middle of Earth, halfway between the North and South Poles.

fossil fuels: Fuels, such as coal, natural gas, or oil, that were formed underground over millions of years from the remains of prehistoric plants and animals. Such fuels are not renewable.

glacier: A large body of ice that moves slowly across land.

global warming: The gradual warming of Earth's atmosphere and surface, caused by the buildup of carbon dioxide and other greenhouse gases that trap heat.

greenhouse gases: Gases that trap heat from the Sun within the atmosphere; carbon dioxide is one of the most common.

hydropower: Power created from the energy in moving water.

irrigate: To supply water to land so that crops can grow.

kinetic: Relating to motion.

laboratory: A place where scientists do research and conduct experiments.

natural resources: Minerals, plants, or other items that are found in nature and are taken and used to make products or produce energy.

power plant: A place for the production of electric power, also sometimes called a "power station."

precipitation: The different forms of water that fall from the sky, such as rain, sleet, or snow.

radioactive: Giving off radiation, which can be harmful.

renewable: A resource that never gets used up. Energy sources such as sunlight and wind are renewable; sources such as coal, natural gas, and oil are nonrenewable.

reservoir: A large body of water created by people, often behind a dam.

shaft: A rod that turns.

solar: Relating to the Sun.

thermal: Relating to heat.

tide: The rise and fall of the oceans twice each day, caused by the gravity of the Sun and the Moon.

turbine: A machine that produces a turning action, which can be used to make electricity. The turning action may be caused by steam, wind, or some other energy source.

vapor: Particles of moisture in the air in the form of steam, clouds, fumes, or smoke.

watt: A common unit of measurement for the rate at which electric energy is used.

TO LEARN MORE

Read these books:

Cooper, Jason. *High Tide, Low Tide*. Vero Beach, Florida: Rourke Publishing, 2007.

Hile, Kevin. *Dams and Levees*. Detroit: KidHaven Press, 2007.

Nardo, Don. *Climate Crisis: The Science of Global Warming*. Mankato, Minnesota: Compass Point Books, 2009.

Peppas, Lynn. *Ocean, Tidal, and Wave Energy*. New York: Crabtree, 2009.

Sherman, Josepha. *Hydroelectric Power*. Mankato, Minnesota: Capstone Press, 2004.

Solway, Andrew. *Water Power*. Pleasantville, New York: Gareth Stevens, 2008.

Waldron, Melanie. *Coasts*. Chicago: Heinemann, 2008.

Look up these Web sites:

Energy Kids Page
http://tonto.eia.doe/kids

Global Warming—Kids Page
http://www.pewclimate.org/global-warming-basics/kidspage.cfm#Q3

How Hydropower Plants Work
http://www.howstuffworks.com/hydropower-plant.htm

Ocean Energy
http://www.mms.gov/mmsKids/PDFs/OceanEnergyMMS.pdf

WaterHistory.org
http://waterhistory.org

Water Science for Schools
http://ga.water.usgs.gov/edu

Key Internet search terms:

hydroelectricity, hydropower, tidal power, water power, water wheel, wave power

INDEX

The abbreviation *ill.* stands for illustration, and *ills.* stands for illustrations. Page references to illustrations and maps are in *italic* type.

Ancient Greece 14
Andes Mountains (Peru) 10
Animals and plants 16, 22, 24, 28, 31
- dams, effects of 29, 31, 32, 42

Aswan High Dam (Egypt) 28, 30

Barrages 15, 16
Bay of Fundy (Canada) 39; *ill. 39*
Bears 22, 24; *ill. 24*
Benefits of water power 7–8, 11, 22, 24, 25–27
Buoys 17–18, 27, 33, 40

Carbon dioxide 24, 29
China 14, 31, 32
Claude, Georges 20
Clepsydras 14
Coal 8, 11, 22, 24; *ill. 8*
Converters 26; *ill. 26*
Corrosion 34, 43
Costs of water power 34, 35, 43
Cuba 20, 21
Currents (ocean) 19, 20; *ill. 18*

D'Arsonval, Jacques-Arsène 20
Dams 4, 10, 13, 14, 25; *ill. 6*
- dangers of 28–30, 32, 36; *ill. 34*
- micro dams 31, 36; *ill. 38*
- removal of 42

Desalination 26; *ill. 27*
Drawbacks of water power 11, 27, 28–35

Earth (planet) 22, 23, 24
East River (New York City) 17; *ill. 15*
Edwards Dam (Kennebec River) 42
Environmental damage 11, 28–33
Evaporation 21, 23; *ill. 23*

Fish 16, 28, 30, 31, 32, 36–37; *ill. 29*
Flooding 30
Florida 19, 23
Forms of water power 4–7
Fossil fuels 7, 8, 11, 22, 24
Future of water power 36–38, 43

Generation of hydroelectricity 5, 12, 13, 14, 15, 17–18, 35
- OTEC systems 20, 21

Generators 5, 7, 13; *ill. 13*
Global warming 11, 22, 24, 29, 43
Great Britain 38
Greenhouse gases 24
Gulf Stream 19, 38; *ill. 18*

Hawaii 26, 40
Heat 20, 21, 24
History of water power's use 12
Hoover Dam (Arizona-Nevada) 25; *ill. 25*
Hydropower 4, 7, 10, 12, 13, 26, 36

Ireland 36; *ill. 37*
Irrigation 12, 30

Kinetic energy 4, 5, 6, 15, 17, 18

Lakes and rivers 4, 12 17, 25; *ill. 15*
- dams, dangers of 28, 30
- habitat destruction 32

Limits of water power 35

Maine 40, 42
McCully, Patrick 31
Measurements of electricity 9
Moon (satellite) 15

Natural gas 8, 11, 22, 24; *ill. 8*
Niagara Falls (U.S.) 7
Niagara River (U.S.) 9; *ill. 9*
Norway 14, 15
Nuclear power 8, 11; *ill. 8*

Ocean thermal energy conversion (OTEC) 7, 20, 21, 25, 26, 33
research and experimentation 40; *ill. 42*
Oceans 6, 19, 26, 33; *ill. 5*
Oil 8, 11, 22, 24, 37; *ill. 8*
Oregon 41

Peat 29; *ill. 30*
Pollution 11, 22, 27, 33
Portugal 26; *ill. 26*
Power plants 7, 9, 10, 11, 12–13, 21; *ills. 10, 13*
PowerBuoy® system *ill. 17*
Precipitation 23; *ill. 23*

Research and experimentation 17, 19, 20; *ill. 39*
environmental concerns 36, 37
funding for 38
programs and projects 37, 40, 41
Reservoirs 13, 25, 29, 30
Rivers *see* Lakes and rivers

Salmon 29, 30; *ill. 29*
Salter, Stephen 19
Sediment 28, 29
Sources of energy *ill. 8*
Sun (star) 17, 20, 23
Sydney Desalination Plant (Australia) *ill. 27*

Temperature 6, 7, 20, 21, 22, 24
Tesla, Nikola 7
Three Gorges Dam (China) 31, 32; *ill. 32*
Tidal fences 16
Tidal power 5, 6, 12, 15–17, 27, 39, 40
Transmission of electricity 12, 13, 26, 35
Turbines 5, 6, 7, 13, 18, 21; *ills. 13, 37*
problems with 36
underwater turbines 16–17, 31, 34; *ills. 15, 16*

United States 9, 13, 17, 38, 40, 43

Verne, Jules 20

Water clocks 14
Water cycle 23; *ill. 23*
Water mills 4, 12
Water wheels 4, 12
Watts 9
Wave power 5, 6, 12, 17–20, 26, 27, 40; *ill. 41*
Worldwide use of water power 14–15, 37, 38, 43

Yangtze River (China) 32

About the Author

Michael Burgan is the author of more than 200 books for children and young adults, both fiction and non-fiction. His works include the five-volume series *Science in Everyday Life in America*, *The Automobile*, and biographies of the scientists Nikola Tesla, Thomas Edison, Robert Hooke, and George Washington Carver. A graduate of the University of Connecticut, he is also a produced playwright. He lives in Connecticut.