Chapter 16

**Energy Efficiency and Renewable Energy**

**Core Case Study: The Astounding Potential for Wind Power in the U.S.**

* Wind energy – wind farms convert \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy
* Wind power is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Could meet electricity needs of the lower 48 states
	+ \_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are top producers

**16-1 Why Is Energy Efficiency an Important Energy Resource?**

* Improvements in energy efficiency could save at least a \_\_\_\_\_\_\_\_\_\_ of the energy used in the world and up to \_\_\_\_\_ of the energy used in the United States
* We have a variety of technologies for sharply increasing the energy \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_of industrial operations, motor vehicles, appliances, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

We Use Energy Inefficiently

* Energy efficiency
	+ How much \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ work we get from each unit energy
* Advantages of reducing energy waste
	+ Usually the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ way to provide more energy
	+ Reduces \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and degradation
	+ \_\_\_\_\_\_\_\_\_\_ global warming
	+ Increases economic and national \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Four widely used devices that waste energy
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ light bulb
	+ Motor vehicle with internal \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ engine
	+ \_\_\_\_\_\_\_\_\_\_ power plant
	+ \_\_\_\_\_\_\_\_\_\_-fired power plant

We Can Improve Energy Efficiency in Industry and Utilities

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ Combined \_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_ (CHP)
	+ Two forms of energy from \_\_\_\_\_\_\_\_\_\_ fuel source
* Replace energy-wasting \_\_\_\_\_\_\_\_\_\_ motors
* Recycle materials
* Switch from low-efficiency incandescent lighting to higher-efficiency \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_and LED lighting

**Case Study: Saving Energy and Money with a Smarter Electrical Grid**

* Current electrical grid system – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_ grid
	+ Ultra-\_\_\_\_\_\_\_\_\_\_-voltage
	+ Super-efficient \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ lines
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ controlled
	+ Responds to local changes in demand and supply
	+ Easier to buy \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy

We Can Improve Energy Efficiency and Save Money in Transportation

* Hidden prices in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ Should be \_\_\_\_\_/gallon
	+ Car manufacturers and oil companies \_\_\_\_\_\_\_\_\_\_ to prevent laws to raise fuel \_\_\_\_\_\_\_\_\_\_
* Build or expand \_\_\_\_\_\_\_\_\_\_ transit and high-speed \_\_\_\_\_\_\_\_\_\_
* Encourage \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

More Energy-Efficient Vehicles Are on the Way

* Superefficient and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cars
* Gasoline-electric \_\_\_\_\_\_\_\_\_\_ car
* Plug-in hybrid \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ vehicle
* Energy-efficient \_\_\_\_\_\_\_\_\_\_ car
* Electric vehicle with a \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_

We Can Design Buildings That Save Energy and Money

* \_\_\_\_\_\_\_\_\_\_ architecture
* \_\_\_\_\_\_\_\_\_\_ or green roofs
	+ With specially designed soil and vegetation
* Superinsulation
	+ No need for \_\_\_\_\_\_\_\_\_\_ system
* U.S. Green Building Council’s Leadership in Energy and Environmental Design (LEED)

We Can Save Money and Energy in Existing Buildings

* Conduct an energy \_\_\_\_\_\_\_\_\_\_:
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and plug leaks
	+ Use energy-efficient \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ Stop other heating and cooling losses
	+ Heat houses more efficiently
	+ Use energy-efficient \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ Use energy-efficient \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ Use motion sensors to turn lights on and off

Why Are We Still Wasting So Much Energy and Money?

* Energy remains artificially cheap
	+ Government \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ \_\_\_\_\_ breaks
	+ \_\_\_\_\_\_\_\_\_\_ don’t include true cost
* Few large and long-lasting incentives
	+ Government \_\_\_\_\_\_\_\_\_\_
	+ Low-interest \_\_\_\_\_\_\_\_\_\_
* Lack of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

We Can Use Renewable Energy to Provide Heat and Electricity

* Renewable energy
	+ \_\_\_\_\_\_\_\_\_\_ energy
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy
* Renewable energy will be cheaper if we eliminate:
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ subsidies
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ prices
	+ Artificially low pricing of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy

**16-2 What Are the Advantages and Disadvantages of Solar Energy?**

* \_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_ solar heating systems can heat water and buildings effectively
* The costs of using direct sunlight to produce high-temperature heat and electricity are coming down

We Can Heat Buildings and Water with Solar Energy

* Passive solar heating system
	+ Absorbs and stores heat from the sun \_\_\_\_\_\_\_\_\_\_ within a well-insulated structure
* Active solar heating system
	+ Captures energy from the sun in a heat-absorbing \_\_\_\_\_\_\_\_\_\_

We Can Cool Buildings Naturally

* Technologies available
	+ Open \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ when cooler outside
	+ Use \_\_\_\_\_
	+ Superinsulation and high-efficiency windows
	+ Overhangs or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ on windows
	+ Light-colored \_\_\_\_\_
	+ Geothermal pumps

We Can Concentrate Sunlight to Produce High-Temperature Heat and Electricity

* Solar thermal systems
	+ Collect sunlight to \_\_\_\_\_ water, generate electricity
	+ \_\_\_\_\_ of world deserts could supply all the world’s electricity
	+ Require large amounts of water
		- \_\_\_\_\_ cooling
		- \_\_\_\_\_ cooling
* Low \_\_\_\_\_ energy yields

We Can Use Solar Cells to Produce Electricity

* Photovoltaic (PV) cells
	+ Convert \_\_\_\_\_\_\_\_\_\_ energy to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy
* Design of solar cells
	+ Sunlight hits cells and releases \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ into wires
* What are the benefits of using solar cells?
* Key problems
	+ High \_\_\_\_\_\_\_\_\_\_ of producing electricity
	+ Need to be located in sunny \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ areas
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ used in production
	+ Solar cells contain \_\_\_\_\_\_\_\_\_\_ materials
* Cost could drop with:
	+ Mass production and new designs
	+ Government subsidies and tax breaks

**16-3 What Are the Advantages and Disadvantages of Using Hydropower**

* We can use water flowing over \_\_\_\_\_\_\_\_\_\_, tidal flows, and ocean waves to generate electricity
	+ However, environmental concerns and limited availability of suitable \_\_\_\_\_\_\_\_\_\_ may limit the use of these energy resources

We Can Produce Electricity from Falling and Flowing Water

* Hydropower
	+ Uses \_\_\_\_\_\_\_\_\_\_ energy of moving water
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ form of solar energy
	+ World’s leading renewable energy source used to produce electricity
* What are the advantages and disadvantages?
* Micro-hydropower \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_: floating turbines

We Can Use Tides and Waves to Produce Electricity

* Produce electricity from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_water
	+ Ocean tides and waves in coastal \_\_\_\_\_and \_\_\_\_\_\_\_\_\_\_
* Power systems are limited
	+ \_\_\_\_\_\_\_\_\_\_ suitable sites
	+ High \_\_\_\_\_\_\_\_\_\_
	+ Equipment damaged by storms and corrosion

**16-4 What Are the Advantages and Disadvantages of Using Wind Power?**

* When we include the environmental costs of using energy resources in their market prices, wind power is the least \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and least \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ way to produce electricity

Using Wind to Produce Electricity Is an Important Step toward \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Tall, long-blade turbines can extract more energy from the wind
* Rapidly growing power source
	+ U.S., Europe, and China
	+ Future is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ wind farms
* Wind power has potential to produce \_\_\_\_\_ times of the world’s current electricity used
* Wind is abundant, widely distributed, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* High \_\_\_\_\_ energy yield
* Drawbacks:
	+ Largest potential areas are usually rural
	+ Winds can die down – need \_\_\_\_\_\_\_\_\_\_ power source

**16-5 Advantages and Disadvantages of Using Biomass as an Energy Source**

* Solid biomass is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ resource for much of the world’s population, but burning it faster than it is replenished produces a net gain in atmospheric \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ gases
* We can use liquid biofuels derived from biomass to lessen our dependence on oil-based fuels, but creating biofuel plantations can:
	+ \_\_\_\_\_\_\_\_\_\_ soil and biodiversity
	+ Increase greenhouse gas \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ Lead to higher \_\_\_\_\_\_\_\_\_\_ prices

We Can Produce Energy by Burning Solid Biomass

* Biomass
	+ Plant materials and animal \_\_\_\_\_\_\_\_\_\_ we can burn or turn into biofuels
* Production of solid mass fuel
	+ Plant fast-growing trees; biomass \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ Collect crop residues and animal manure
* What are the advantages and disadvantages of biomass energy?

**Case Study: Is Biodiesel the Answer?**

* Biodiesel
	+ Produced from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ oil
	+ European Union countries produce \_\_\_\_\_ of the world’s biodiesel
* Crops require large amounts of \_\_\_\_\_\_\_\_\_\_
* Production \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ fossil fuels

**Case Study: Is Ethanol the Answer?**

* Ethanol
	+ Can be made from sugarcane, corn, switchgrass, and various wastes
	+ United States largest producer
		- Made from \_\_\_\_\_\_\_\_\_\_; \_\_\_\_\_ net energy yield
	+ Brazil second
		- \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ has \_\_\_\_\_\_\_\_\_\_ net energy yield
* Cellulosic ethanol
* Produced from cellulose
* Problems with cellulosic ethanol
	+ Chemical processes still being developed
	+ Growing enough switchgrass would require too much land
* Evaluating use of \_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**16-6 What Are the Advantages and Disadvantages of Geothermal Energy?**

* Geothermal energy has great potential for supplying many areas with heat and electricity, and has a generally \_\_\_\_\_ environmental impact
	+ However, the sites where it can be produced economically are \_\_\_\_\_\_\_\_\_\_

We Can Get Energy by Tapping the Earth’s Internal Heat

* With geothermal energy, heat is stored in:
	+ \_\_\_\_\_
	+ Underground \_\_\_\_\_\_\_\_\_\_
	+ \_\_\_\_\_\_\_\_\_\_ in the earth’s mantle
* Geothermal heat pump system
	+ Energy efficient and \_\_\_\_\_\_\_\_\_\_
	+ Environmentally \_\_\_\_\_\_\_\_\_\_
* Cost effective to heat or cool a space
* Hydrothermal reservoirs
	+ Drill wells and extract various steams, water
	+ U.S. is the world’s largest producer
* Geothermal energy problems
	+ High cost of tapping hydrothermal reservoirs
	+ Dry- or wet-steam geothermal reservoirs could be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ Could create \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**16-7 The Advantages and Disadvantages of Using Hydrogen as an Energy Source**

* Hydrogen is a \_\_\_\_\_\_\_\_\_\_ energy source as long as it is not produced with the use of fossil fuels
	+ However, it has a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ net energy yield

Will Hydrogen Save Us?

* Hydrogen as a fuel
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ most of the air pollution problems
	+ Reduces threats of global warming
* Some challenges
	+ Chemically locked in water and organic compounds – net \_\_\_\_\_\_\_\_\_\_ energy yield
	+ Expensive \_\_\_\_\_ \_\_\_\_\_ are the best way to use hydrogen
	+ CO2 levels dependent on method of hydrogen production
* Production and storage of H2
	+ Must be produced using \_\_\_\_\_\_\_\_\_\_ sources of energy
* Hydrogen-powered vehicles – prototypes available
* Can we produce hydrogen on demand?
* Larger fuel cells – fuel-cell stacks

**16-8 How Can We Make the Transition to a More Sustainable Energy Future?**

* We can make the transition to a more sustainable energy future by:
	+ Greatly improving energy \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ Using a \_\_\_\_\_\_\_\_\_\_ of renewable energy resources
	+ Including the environmental and health \_\_\_\_\_\_\_\_\_\_ of energy resources in their market prices

Choosing Energy Paths

* General conclusions:
	+ Gradual shift to smaller, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ micropower systems
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of increased energy efficiency and regulated use of natural gas will be the best way to transition to renewable energy
	+ Because fossil fuels are \_\_\_\_\_\_\_\_\_\_, we will continue to use them

Economics, Politics, Education, and Sustainable Energy Resources

* Government strategies:
	+ Keep the prices of selected energy resources artificially low to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ their use
	+ Keep energy prices artificially high for selected resources to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ their use
	+ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ education

Three Big Ideas

* We should evaluate energy resources on the basis of:
	+ Their potential supplies
	+ Their net energy yields
	+ Environmental and health impacts of using them
* By using a mix of renewable energy sources we could drastically reduce pollution, greenhouse gas emissions, and biodiversity losses
	+ Solar, wind, flowing water, sustainable biofuels, and geothermal energy
* Making the transition to a more sustainable energy future will require:
	+ Sharply increasing energy efficiency
	+ Using a mix of environmentally friendly renewable energy resources
	+ Including the harmful environmental and health costs of energy resources in their market prices

Tying It All Together: Wind Power and Sustainability

* Relying on a diversity of direct and indirect forms of solar energy:
	+ Would implement three principles of sustainability
	+ Recycle and reuse materials to reduce consumption of energy
	+ Mimic nature’s reliance on biodiversity by diversifying energy sources