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