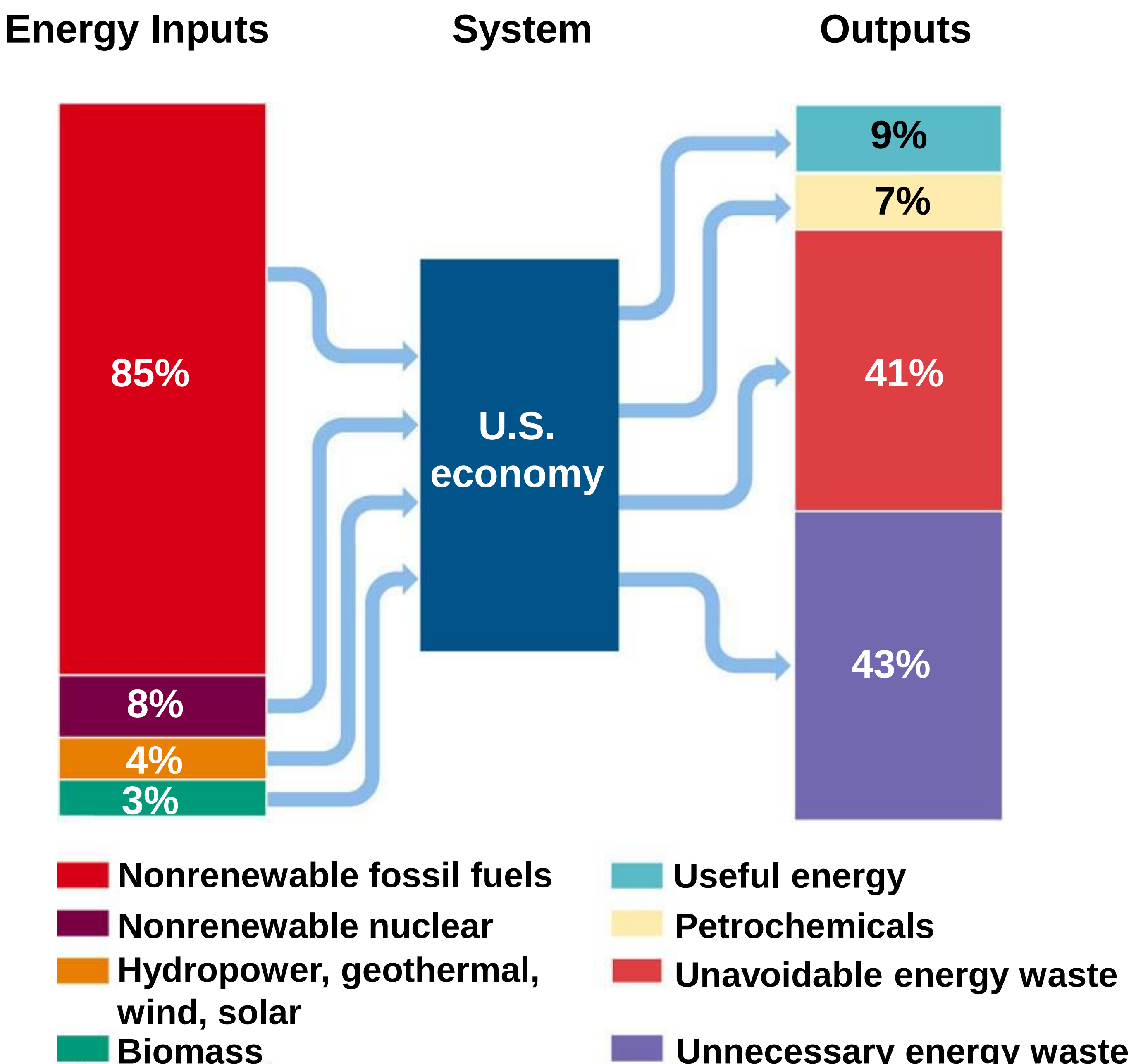
Energy Efficiency and Renewable Energy

Chapter 16

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

- ***Concept 16-1*** *We could save as much as 43% of all the energy we use by improving energy efficiency.*



Energy Inputs
System
Outputs
85%
8%
4%
3%
U.S. economy
9%
7%
41%
43%
Nonrenewable fossil fuels
Nonrenewable nuclear
Hydropower, geothermal, wind, solar
Biomass
Useful energy
Petrochemicals
Unavoidable energy waste
Unnecessary energy waste

Fig. 16-2, p. 401

Net Energy Ratios for Various Energy Systems over Their Estimated Lifetimes

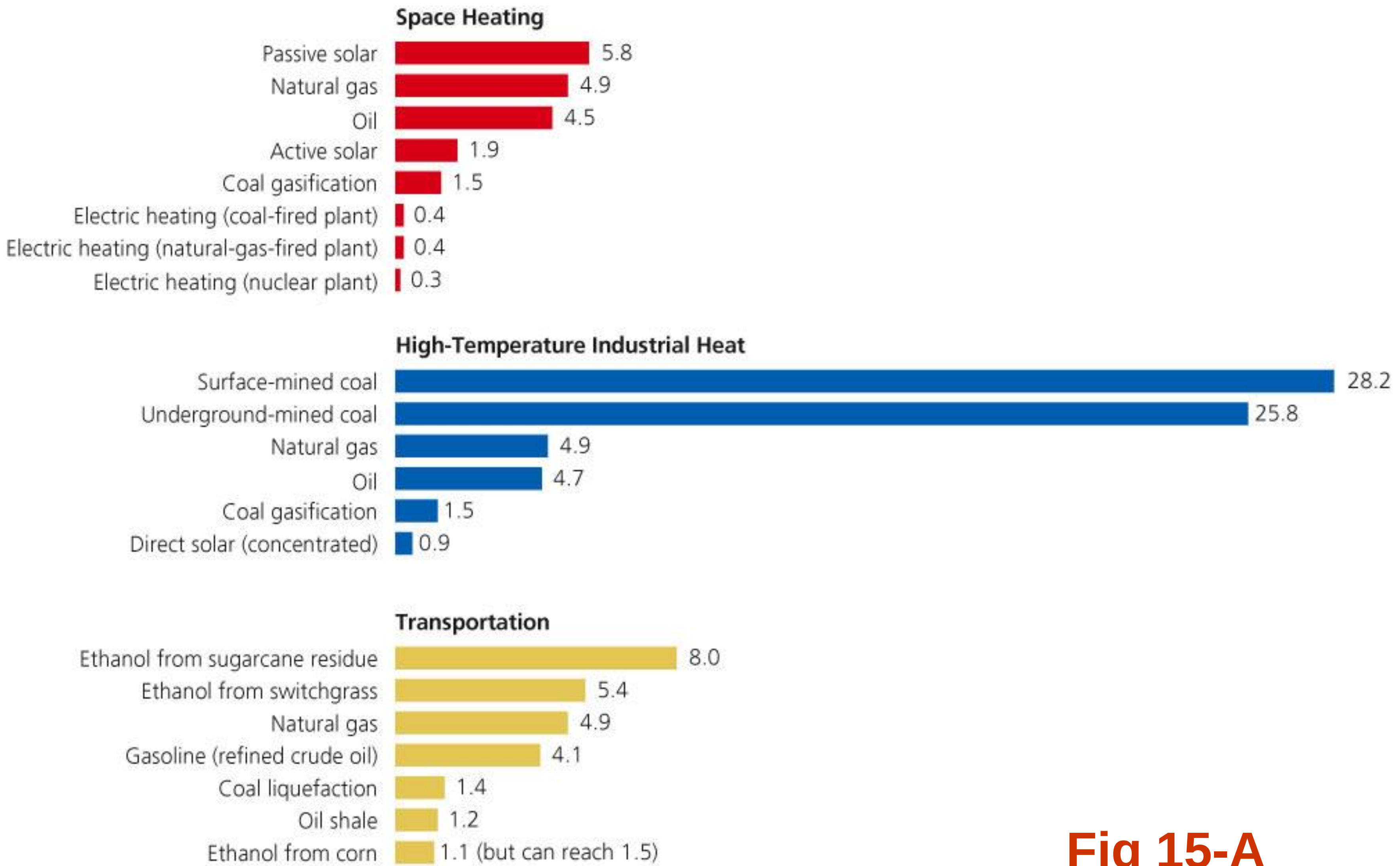


Fig 15-A

Sustainable Energy: Rocky Mountain Institute in Colorado, U.S.

The first, and most important, step is to use what we have at least twice as efficiently.
Fully applying today's best efficiency technologies in a doubled-GDP 2025 economy would save half the projected U.S. oil use at half its forecast cost per barrel.

The second step is to substitute biofuels, saved natural gas, and (optionally) hydrogen where appropriate. These non-oil substitutes would also cost less than oil in 2025.

RMI: Winning the Oil Endgame continued

The study found that a $180-billion investment over the next decade would:

- yield $130-billion annual savings by 2025;
- revitalize the automotive, truck, aviation, and hydrocarbon industries;
- create a million jobs in both industrial and rural areas;
- rebalance trade;
- make the United States more secure, prosperous, equitable, and environmentally healthy;
- encourage other countries to get off oil, too;
- and make the world more developed, fair, and peaceful.

REDUCING ENERGY WASTE AND IMPROVING ENERGY EFFICIENCY

- Four widely used devices waste large amounts of energy:
  - ***Incandescent light bulb***: 95% is lost as heat.
  - ***Internal combustion engine***: 94% of the energy in its fuel is wasted.
  - ***Nuclear power plant***: 92% of energy is wasted through nuclear fuel and energy needed for waste management.
  - ***Coal-burning power plant***: 66% of the energy released by burning coal is lost.

SOLUTIONS

Reducing Energy Waste

Prolongs fossil fuel supplies

Reduces oil imports and improves energy security

Very high net energy yield

Low cost

Reduces pollution and environmental degradation

Buys time to phase in renewable energy

Creates local jobs

Fig. 16-3, p. 401

Comparison of the Net Energy Efficiency for Two Types of Space Heating

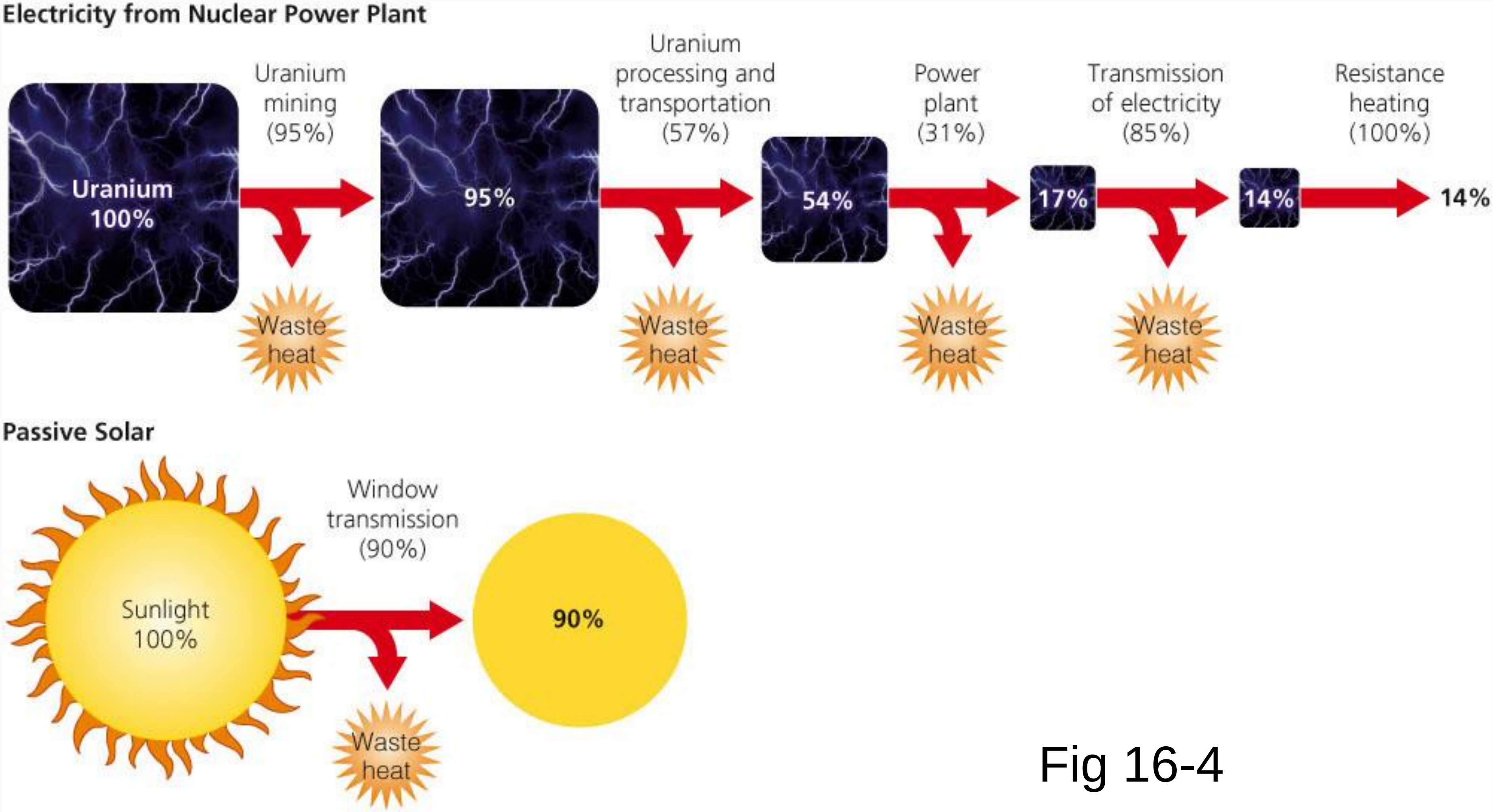


Fig 16-4

16-2 How Can We Cut Energy Waste?

- ***Concept 16-2*** *We have a variety of technologies for sharply increasing the energy efficiency of industrial operations, motor vehicles, and buildings.*

We Can Save Energy and Money in Industry

- **Cogeneration** or **combined heat and power (CHP) = heat and electricity**
- Replace energy-wasting electric motors
- Recycling materials
- Switch from low-efficiency incandescent lighting to higher-efficiency fluorescent and LED lighting

We Can Save Energy and Money in Transportation

- Corporate average fuel standards (CAFE) standards. Before 2011 = 27.5 MPG, 2011 = 30.2 MPG. By 2020 = 35 MPG
- Fuel-efficient cars are on the market
- Hidden prices in the gasoline (i.e. military)
- Should there be tax breaks for buying fuel-efficient cars, or **feebate**?

Average Fuel Economy of New Vehicles Sold in the U.S. and Other Countries

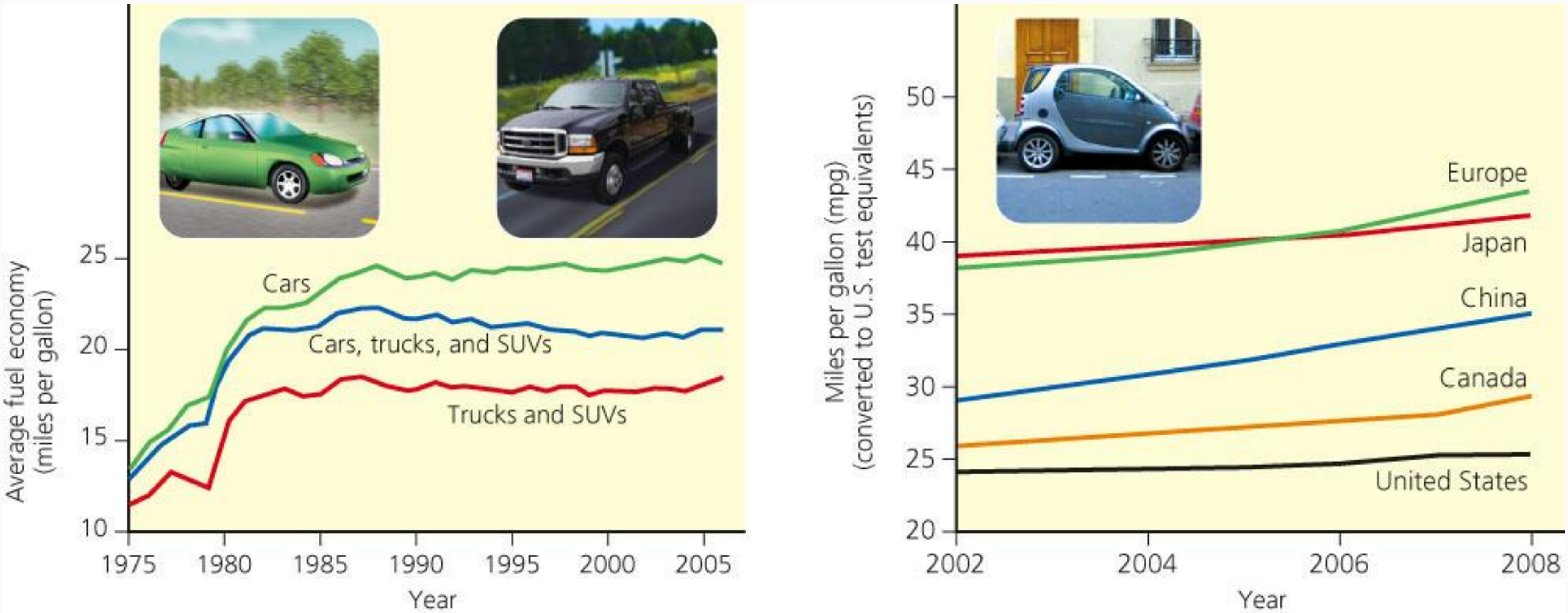


Fig 16-5

Solutions: A Hybrid-Gasoline-Electric Engine Car and a Plug-in Hybrid Car

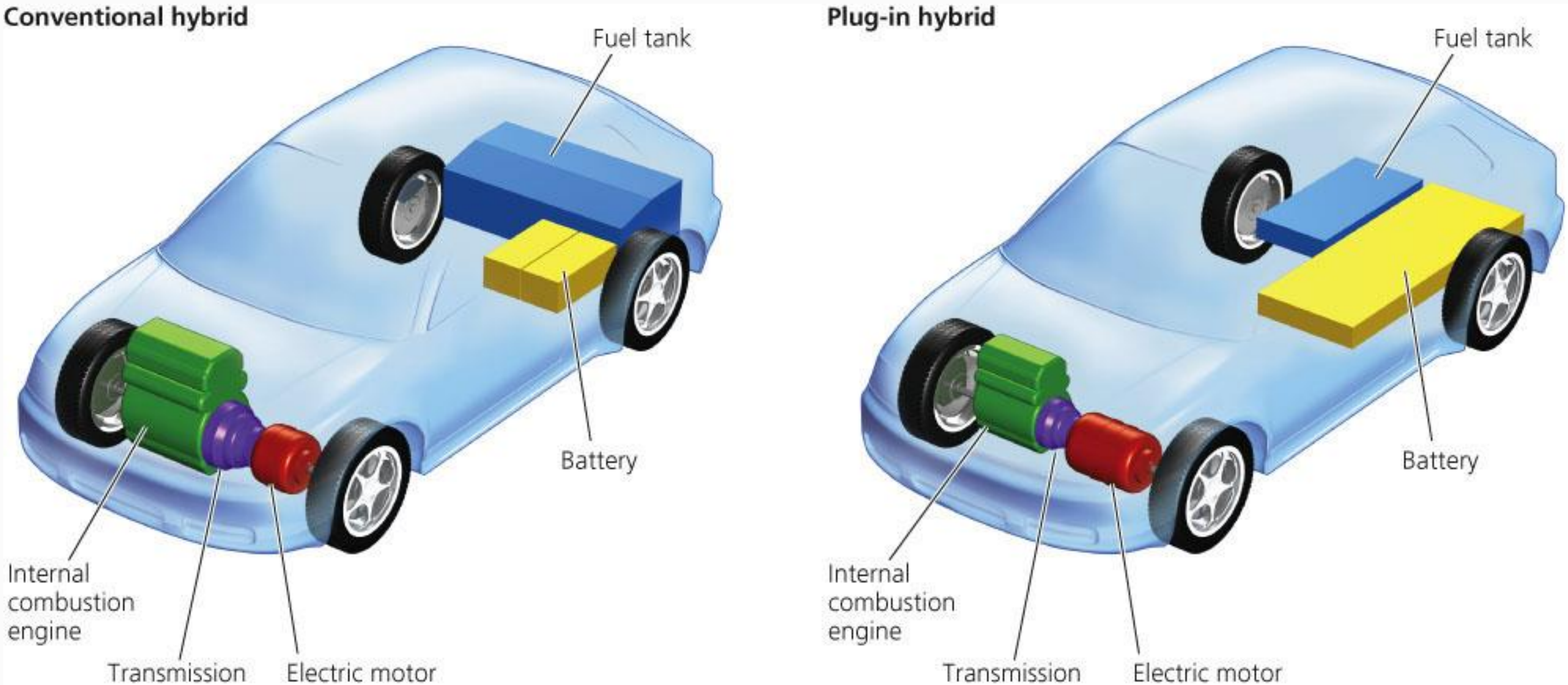
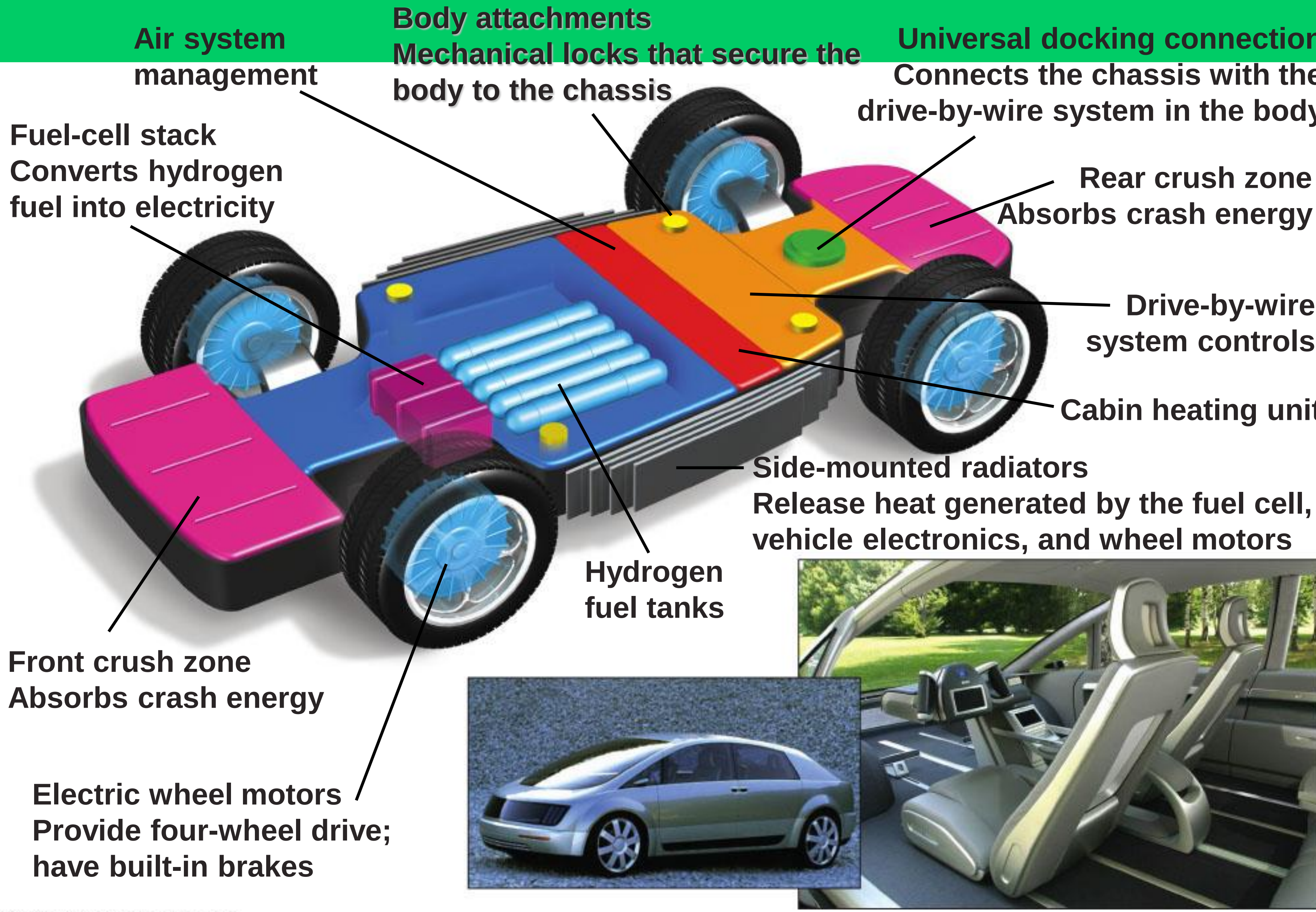


Fig 16-6

Fuel-Cell Vehicles

- Fuel-efficient vehicles powered by a fuel cell that runs on hydrogen gas are being developed.
- Combines hydrogen gas (H_2) and oxygen gas (O_2) fuel to produce electricity and water vapor ($2H_2+O_2 \rightarrow 2H_2O$).
- Emits no air pollution or CO_2 if the hydrogen is produced from renewable-energy sources.


Air system management
Body attachments
Mechanical locks that secure the body to the chassis
Universal docking connection
Connects the chassis with the drive-by-wire system in the body
Fuel-cell stack
Converts hydrogen fuel into electricity
Rear crush zone
Absorbs crash energy
Drive-by-wire system controls
Cabin heating unit
Side-mounted radiators
Release heat generated by the fuel cell, vehicle electronics, and wheel motors
Hydrogen fuel tanks
Front crush zone
Absorbs crash energy
Electric wheel motors
Provide four-wheel drive; have built-in brakes

What alternative fuel vehicles are here or coming?

Click for Fuel Economy page

Click for California Fuel Cell Partnership

DOE car efficiencies projections

Table 4.1. New Car Efficiency in the *AEO2008* Reference Case
(Miles per Gallon)

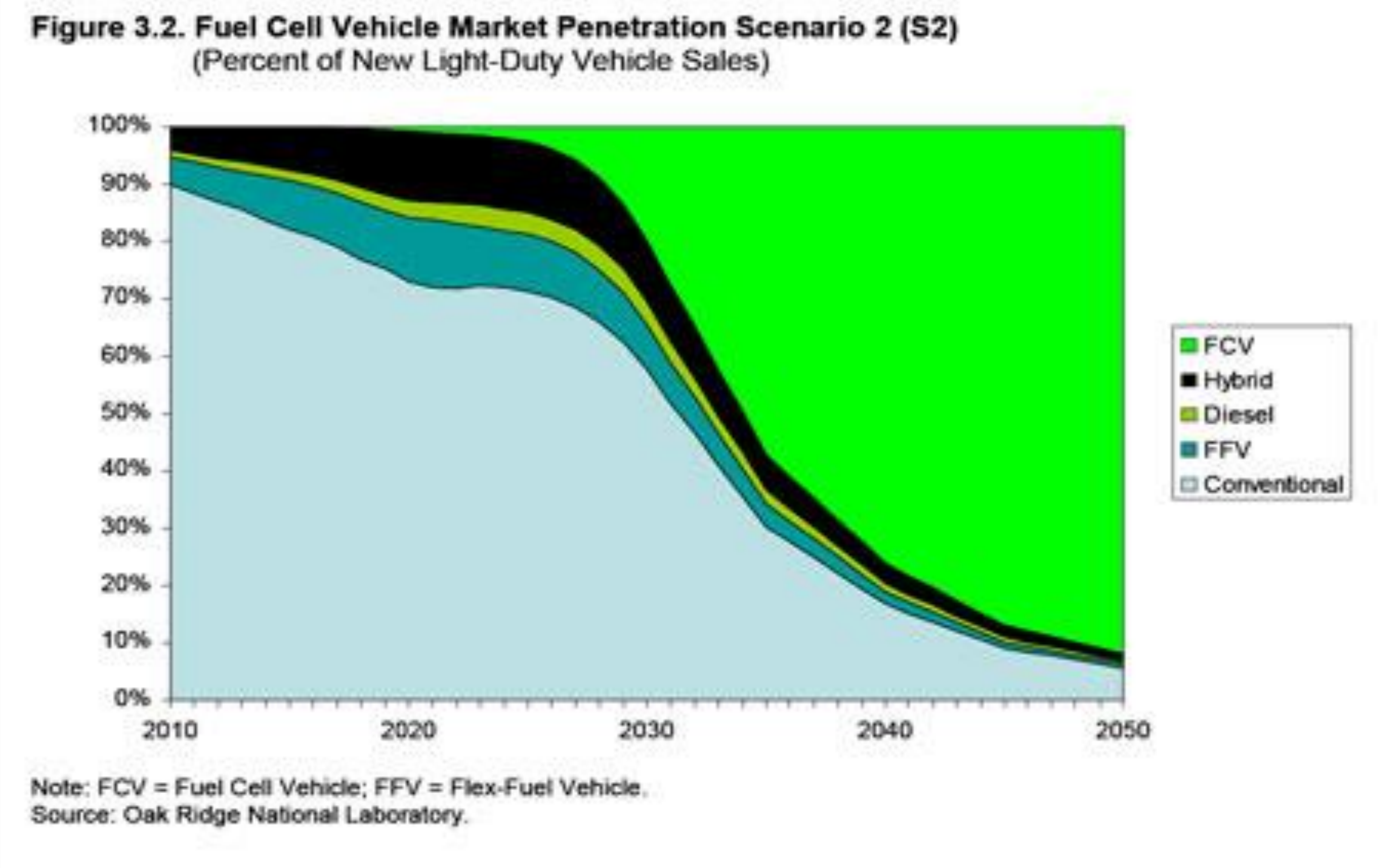
Vehicle Type[a]	2006	2015	2020	2030
Conventional Gasoline ICE	30.8	34.1	40.4	40.3
Conventional Diesel ICE	42.8	44.7	51.4	51.0
Gasoline-Electric Hybrid	45.2	46.8	53.9	53.7
Diesel-Electric Hybrid	–	51.5	57.5	57.4
Plug-in Gasoline Hybrid	–	67.6	73.2	72.9
DOE Target Hydrogen FCV	62[b]	95	95	95[b]

[a]*AEO2008* assumes that the technologies listed are used in cars of almost all sizes, and in the reference case average vehicle weight increases through 2030.

[b]The weight/size classes and performance characteristics for FCVs were not stated in the documents reviewed. The ultimate target for the FCV efficiency is 95 miles per gallon gasoline equivalent, but the achieved date is also unclear. Intermediate goals were not specified.

Source: AEO2008 National Energy Modeling System, run AEO2008.D030208F (reference case).

Fuel Cell Vehicle Market Penetration



Click for report

We Can Design Buildings That Save Energy and Money

- Green architecture
- U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED)

Click for LEED

A Green or Living Roof in Chicago, IL (U.S.)

We Can Save Energy and Money in Existing Buildings

- Insulate and plug leaks
- Use energy-efficient window
- Heat houses more efficiently
- Heat water more efficiently
- Use energy-efficient appliances
- Use energy-efficient lighting

A Thermogram Showing Heat Loss Around Houses and Stores

Individuals Matter: Ways in Which You Can Save Money Where You Live

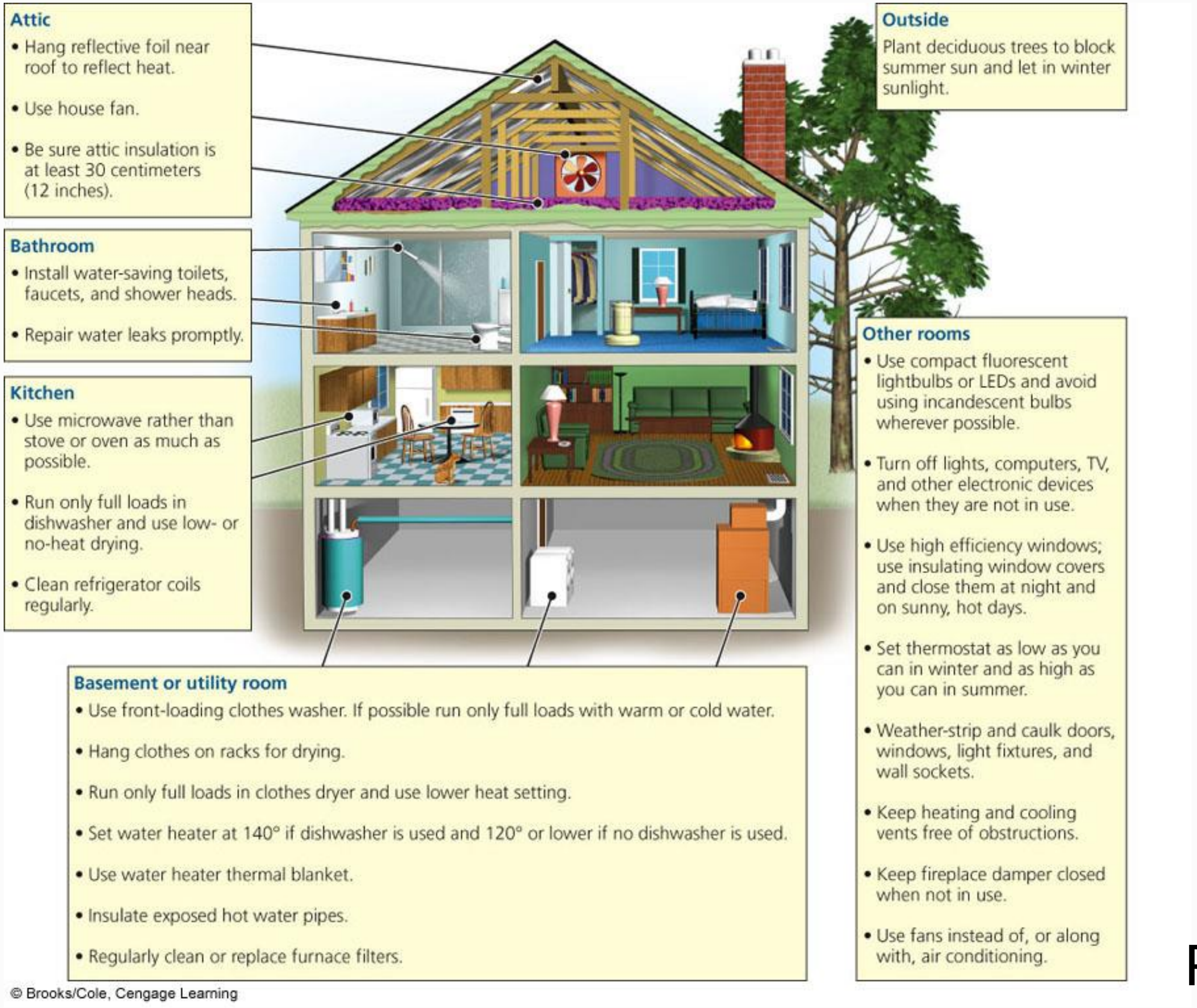


Fig 16-9

Why Are We Still Wasting So Much Energy?

- Energy remains artificially cheap
- Few large and long-lasting government incentives

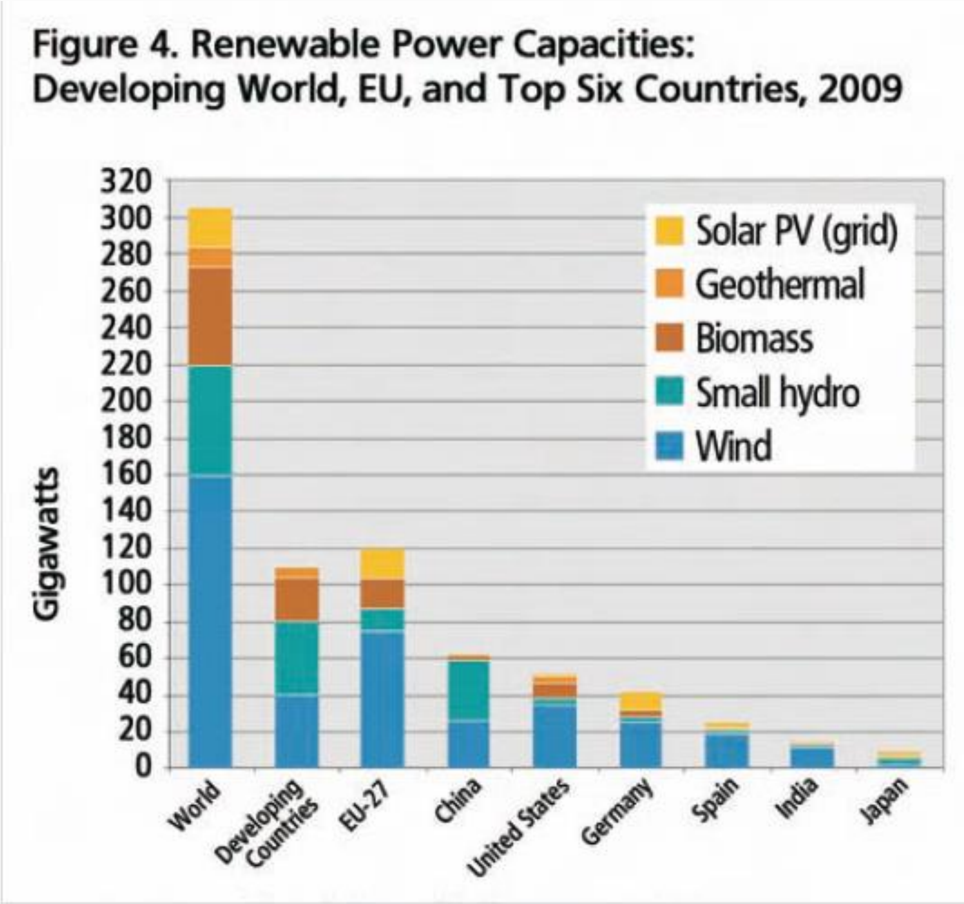
Which countries are using alternative energy?

TOP FIVE COUNTRIES	#1	#2	#3	#4	#5
Annual amounts for 2009					
New capacity investment	Germany	China	United States	Italy	Spain
Wind power added	China	United States	Spain	Germany	India
Solar PV added (grid-connected)	Germany	Italy	Japan	United States	Czech Republic
Solar hot water/heat added[3]	China	Germany	Turkey	Brazil	India
Ethanol production	United States	Brazil	China	Canada	France
Biodiesel production	France/Germany		United States	Brazil	Argentina
Existing capacity as of end-2009					
Renewables power capacity (including only small hydro)	China	United States	Germany	Spain	India
Renewables power capacity (including all hydro)	China	United States	Canada	Brazil	Japan
Wind power	United States	China	Germany	Spain	India
Biomass power	United States	Brazil	Germany	China	Sweden
Geothermal power	United States	Philippines	Indonesia	Mexico	Italy
Solar PV (grid-connected)	Germany	Spain	Japan	United States	Italy
Solar hot water/heat[3]	China	Turkey	Germany	Japan	Greece

Notes: Rankings are based on absolute capacities and production; per-capita rankings would be quite different for many categories. [1]Renewables power capacity figures rounded to nearest 5 GW. Renewables power capacity (including only small hydro) counts small hydro < 10 MW; this is a change from prior versions of this report. Capacity figures would be higher for other definitions of small hydro with higher limits. Excluding small hydro entirely, rounded capacity figures would be 160 GW, 195 GW, and 245 GW, for years 2007 through 2009, respectively. [2]Feed-in policies total for 2009 also includes early 2010. [3]Solar hot water/heating numbers are for 2008. Many figures in the above table and throughout the report are rounded to two significant digits, so some totals may not exactly reflect underlying data due to rounding.

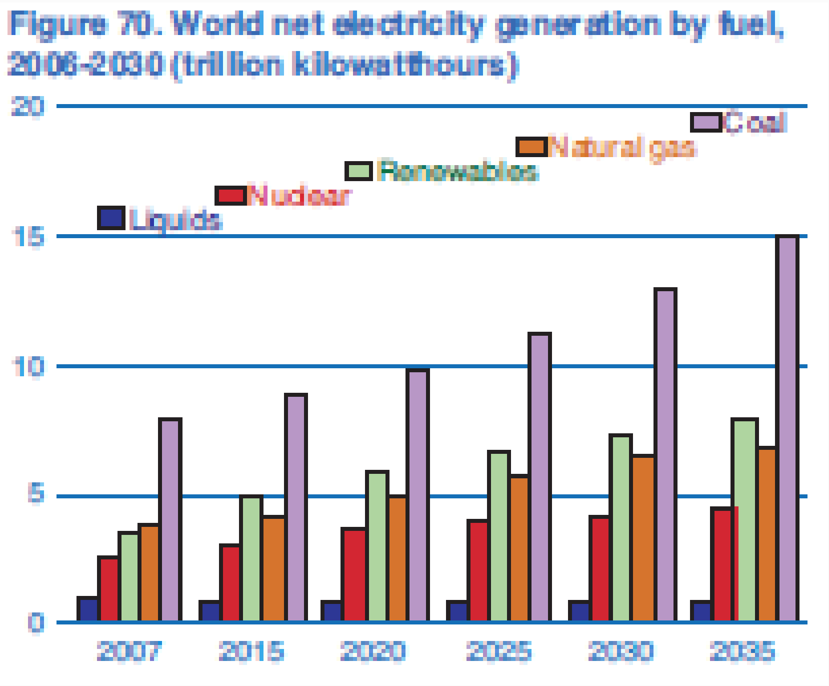
Source Renewable Energy Policy Network (REN21)

World Renewable Energy Capacity

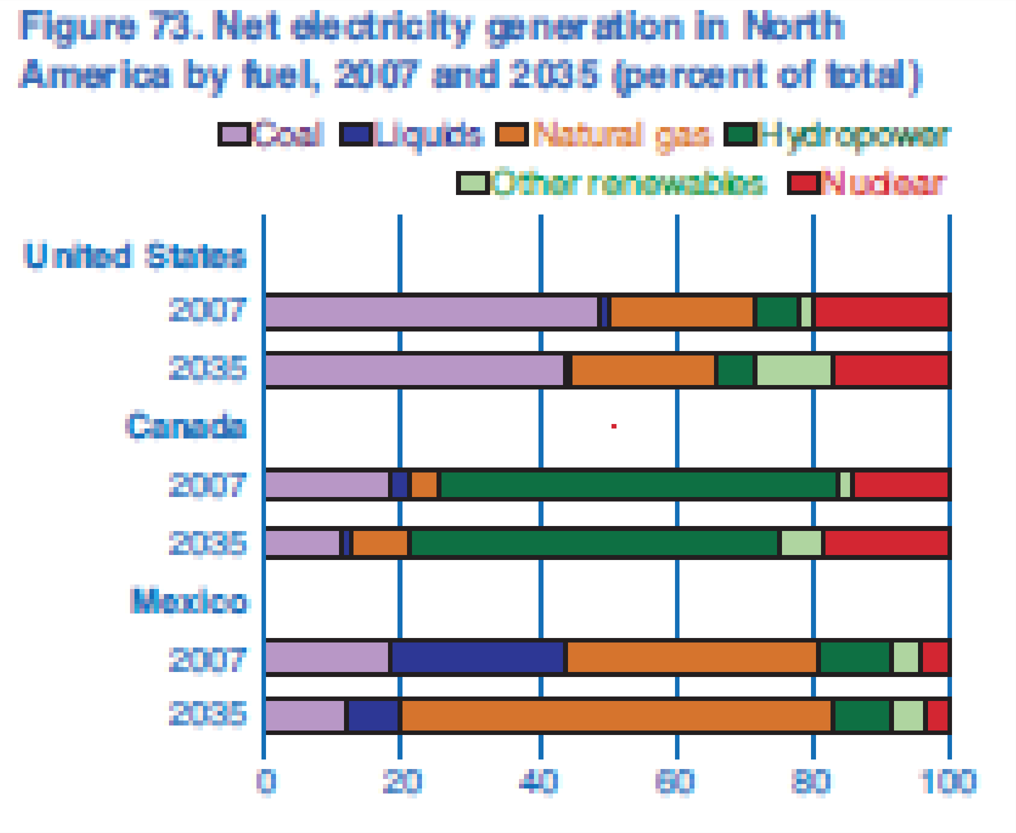


Source REN21

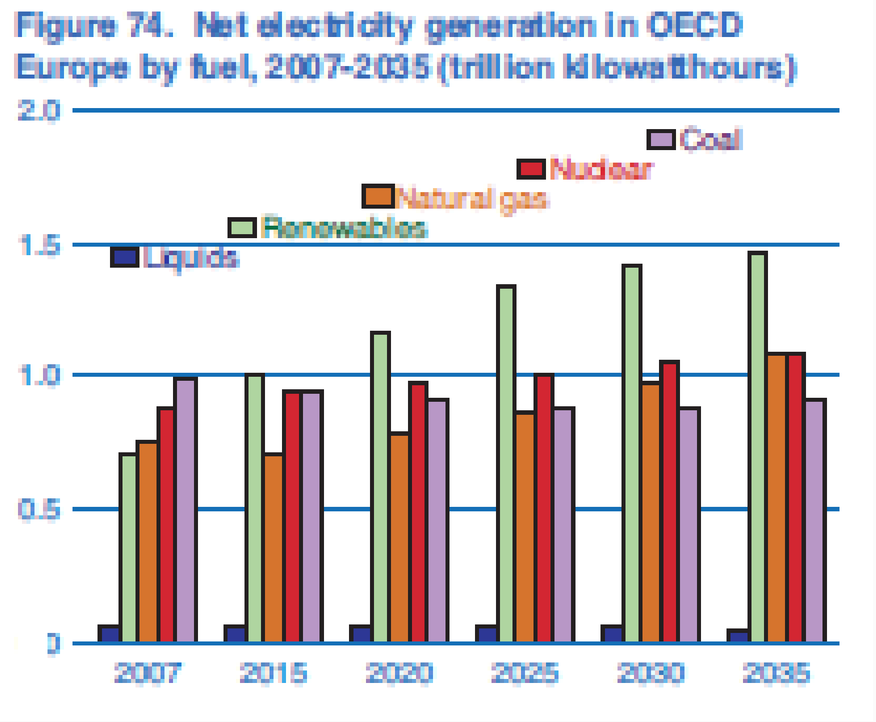
World Generation
EIA Energy Outlook 2010



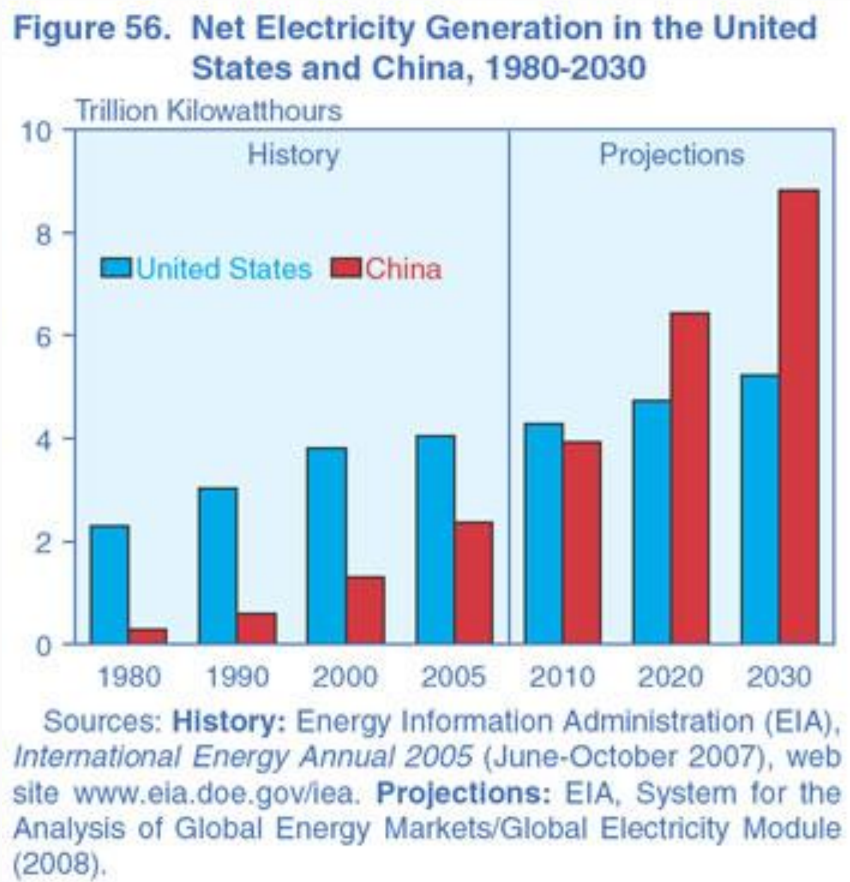
North America Electricity Projection
EIA 2010



Europe Electricity Projection



China and U.S. Generation



How is electricity generation changing in California?

POWER CONTENT LABEL

ENERGY RESOURCES	2009 SCE POWER MIX* (projected)	2007 CA POWER MIX** (for comparison)
Eligible Renewable	16%	10%
-- Biomass & waste	2%	<1%
-- Geothermal	9%	2%
-- Small hydroelectric	1%	6%
-- Solar	1%	<1%
-- Wind	3%	2%
Coal	10%	32%
Large Hydroelectric	5%	24%
Natural Gas	51%	31%
Nuclear	18%	3%
Other	<1%	0%
TOTAL	100%	100%

* 98% of SCE System Power Mix is specifically purchased from individual suppliers.

** Percentages are estimated annually by the California Energy Commission based on electricity sold to California consumers during the previous year.

For specific information about this electricity product, contact Southern California Edison. For general information about the Power Content Label, contact the California Energy Commission at 1-800-555-7794 or www.energy.ca.gov/consumer.

16-3 What Are the Advantages and Disadvantages of Solar Energy?

- ***Concept 16-3*** *Passive and active solar heating systems can heat water and buildings effectively, and the costs of using direct sunlight to produce high-temperature heat and electricity are coming down.*

Solutions: Passive and Active Solar Heating for a Home

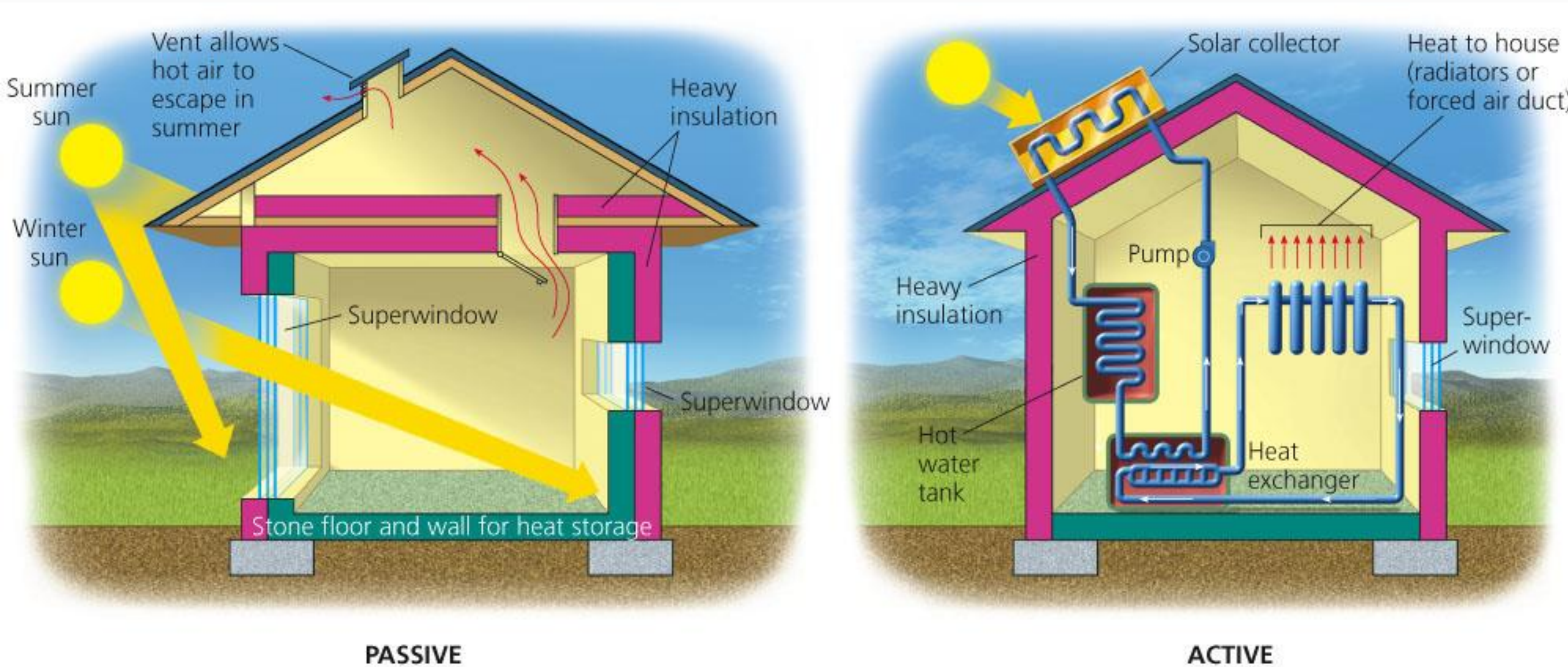
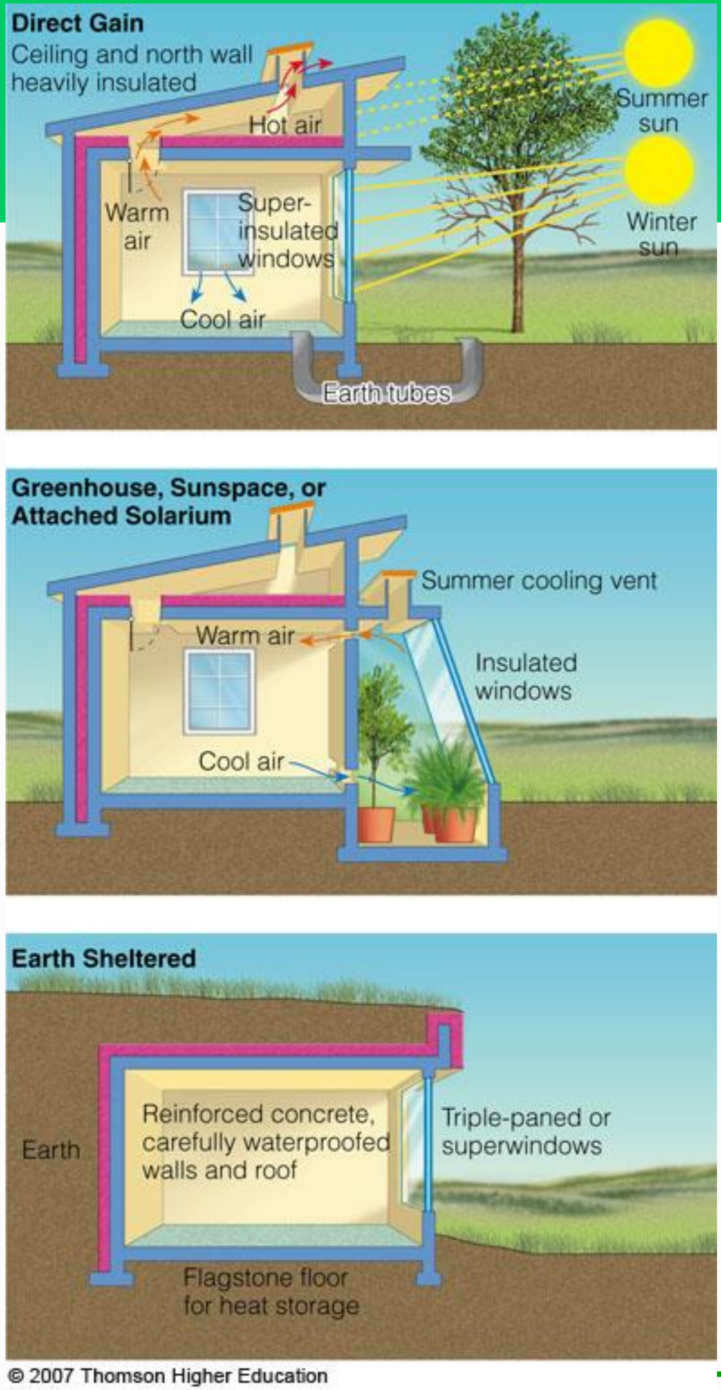


Fig 16-10



Passive Solar Heating

- Passive solar heating system absorbs and stores heat from the sun directly within a structure without the need for pumps to distribute the heat.

TRADE-OFFS

Passive or Active Solar Heating

Advantages

Energy is free

Net energy is moderate (active) to high (passive)

Quick installation

No CO_2 emissions

Very low air and water pollution

Very low land disturbance (built into roof or windows)

Moderate cost (passive)

Disadvantages

Need access to sun 60% of time

Sun can be blocked by trees and other structures

Environmental costs not included in market price

Need heat storage system

High cost (active)

Active system needs maintenance and repair

Active collectors unattractive

Fig. 16-11, p. 412

Rooftop Solar Hot Water on Apartment Buildings in Kunming, China

We Can Cool Buildings Naturally

- Technologies available
  - Superinsulation and high-efficiency windows
  - Overhangs or awnings on windows
  - Light-colored roof
  - Reflective insulating foil in an attic
  - Geothermal pumps
  - Plastic **earth tubes** underground

Solutions: Woman in India Uses a Solar Cooker

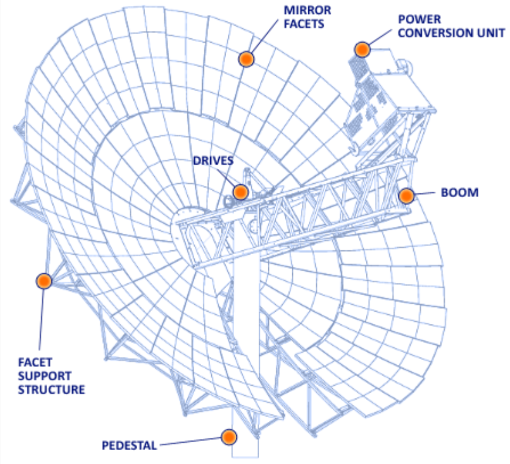
Solutions: Solar Cells Can Provide Electricity Using Solar-Cell Roof Shingles

Fig 16-17

Solutions: Solar Cells Used to Provide Electricity for a Remote Village in Niger

What is the SunCatcher?

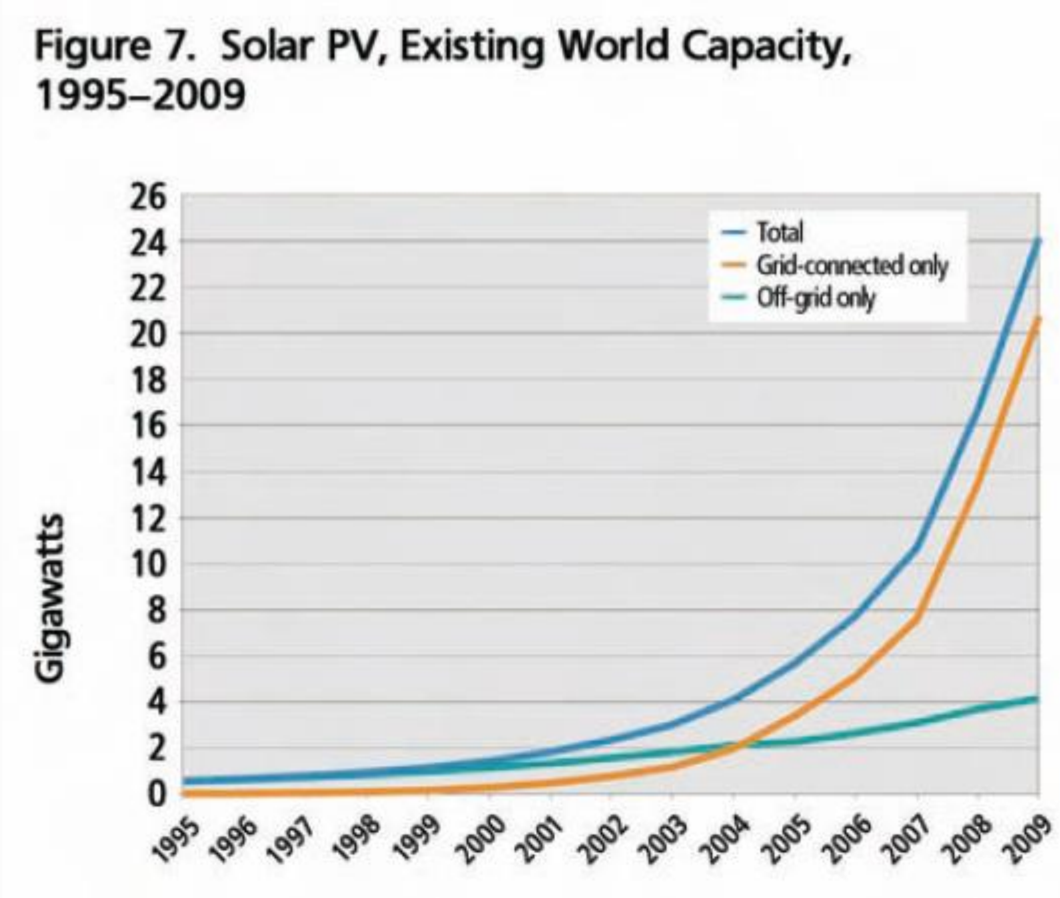
The SES SunCatcher is a 25 kW solar power system that has been designed to automatically track the sun and focus solar heat onto a power conversion unit (PCU).
Starts at 500MW will expand to 850MW.



Projected generation costs are 4-6 Cents/kWhr.
This is as good as coal!

Click for Stirling Energy page

World Solar Capacity



Source REN 21

Photovoltaic Electricity Generation

Table R3. Grid-Connected Solar PV, 2005–2009

Country	Added 2005	Added 2006	Added 2007	Added 2008	Added 2009	Existing 2006	Existing 2007	Existing 2008	Existing 2009
			MW				GW		
Germany	900	830	1,170	2,020	3,800	2.8	4.0	6.0	9.8
Spain	23	90	560	2,430	70	0.2	0.7	3.3	3.4
Japan	310	290	240	240	480	1.5	1.7	2.0	2.6
United States	65	100	160	250	430	0.3	0.5	0.7	1.2
Italy	–	10	70	340	710	<0.1	0.1	0.4	1.1
South Korea	5	20	60	250	70	<0.1	0.1	0.4	0.4
Other EU	40	40	100	60	1,000	0.2	0.3	0.4	1.4
Other World	>20	>50	>150	>250	>400	>0.1	>0.3	>0.5	>0.9
Total Added	1,350	1,400	2,500	5,900	7,000				
Cumulative						5.1	7.6	13.5	21

Notes: All added capacities rounded to nearest 10 MW and all existing capacities rounded to nearest 0.1 GW. Added and existing figures may be slightly inconsistent due to rounding and reporting differences from year-to-year. South Korea existing in 2008 and 2009 were 360 MW and 430 MW. "Other EU" is significantly higher in 2009 relative to previous years due to large 2009 additions by the Czech Republic (410 MW) and Belgium (290 MW), among others. German figures for 2005–08 are revised from previous editions of this table due to revisions by the German Federal Network Agency (Bundesnetzagentur) published in April 2010. Preliminary figure from IDAE for Spain is 100 MW added for 2009. Some figures in the table may include some amounts of off-grid PV, but these are considered small. Figures for the United States are only for on-grid totals. One estimate by Mints/Navigant for total global off-grid solar PV is 3.2 GW. EPIA estimates 22.9 GW of total global solar PV existing in 2009, but this may include off-grid. *Sources*: See Endnotes 66, 70, and 296. Figures in table reflect a variety of sources, some of which differ from each other to small degrees, reflecting differences in accounting or methodology.

Total Costs of Electricity from Different Sources in 2004

Table 16-1

Total Costs of Electricity from Different Sources in 2004 (in U.S. cents per kilowatt-hour)

Electricity Source	Generating Costs	Environmental Costs	Total Costs
Wind	4.7–6.3	0.1–0.3	4.8–6.6
Geothermal	4.8	1.0 (approximately)	5.8
Hydropower	4.9–8.5	0.3–1.1	5.2–9.6
Natural gas	5.2–6.5	1.1–4.5	6.3–11.0
Biomass	5.5–6.4	1.0–3.4	6.5–9.8
Nuclear*	5.9–12.0	0.2–0.7	6.1–12.7
Coal	4.5–5.4	3.0–17.0	7.5–22.4
Solar cells	12.4–26.0	0.7	13.1–26.7

*Plant only. Costs are much higher if entire nuclear fuel cycle is included.

Costs to generate electricity REN21 Report 2010

Table 1. Status of Renewables Technologies, Characteristics and Costs

Technology	Typical Characteristics	Typical Energy Costs (U.S. cents/kilowatt-hou unless indicated otherwi
Power Generation		
Large hydro	*Plant size*: 10 megawatts (MW)–18,000 MW	3–5
Small hydro	*Plant size*: 1–10 MW	5–12
On-shore wind	*Turbine size*: 1.5–3.5 MW *Blade diameter*: 60–100 meters	5–9
Off shore wind	*Turbine size*: 1.5–5 MW *Blade diameter*: 70–125 meters	10–14
Biomass power	*Plant size*: 1–20 MW	5–12
Geothermal power	*Plant size*: 1–100 MW; *Types*: binary, single- and double-flash, natural steam	4–7
Solar PV (module)	*Cell type and efficiency*: crystalline 12–18%; thin film 7–10%	---
Rooftop solar PV	*Peak capacity*: 2–5 kilowatts-peak	20–50
Utility-scale solar PV	*Peak capacity*: 200 kW to 100 MW	15–30
Concentrating solar thermal power (CSP)	*Plant size*: 50–500 MW (trough), 10–20 MW (tower); *Types*: trough, tower, dish	14–18 (trough)

Trade-Offs: Solar Energy for High-Temperature Heat and Electricity

TRADE-OFFS

Solar Energy for High-Temperature Heat and Electricity

Advantages

Moderate net energy

Moderate environmental impact

No CO_2 emissions

Fast construction (1–2 years)

Costs reduced with natural gas turbine backup

Disadvantages

Low efficiency

High costs

Environmental costs not included in market price

Needs backup or storage system

Need access to sun most of the time

Vulnerable to sabotage

May disturb desert areas

TRADE-OFFS

Solar Cells

Advantages	Disadvantages
Fairly high net energy yield	Need access to sun
Work on cloudy days	Low efficiency
Quick installation	Need electricity storage system or backup
Easily expanded or moved	Environmental costs not included in market price
No CO_2 emissions	High costs (but should be competitive in 5–15 years)
Low environmental impact	High land use (solar-cell power plants) could disrupt desert areas
Last 20–40 years	DC current must be converted to AC
Low land use (if on roof or built into walls or windows)	
Reduces dependence on fossil fuels	

Fig. 16-20, p. 417

16-4 Advantages and Disadvantages of Producing Electricity from the Water Cycle

- ***Concept 16-4*** *Water flowing over dams, tidal flows, and ocean waves can be used to generate electricity, but environmental concerns and limited availability of suitable sites may limit the use of these energy resources.*

PRODUCING ELECTRICITY FROM THE WATER CYCLE

- Water flowing in rivers and streams can be trapped in reservoirs behind dams and released as needed to spin turbines and produce electricity.
- There is little room for expansion in the U.S. – Dams and reservoirs have been created on 98% of suitable rivers.

U.S. Electricity Generation
Note hydroelectric dominance

Release Date: May 2010
Next Release Date: May 2011

Table 4 U.S. Electric Net Summer Capacity, 2005 - 2009

(Megawatts)

Source	2005	2006	2007	2008	2009
Total	978,020	986,215	994,888	1,010,171	1,027,584
Renewable Total	98,746	101,934	107,954	116,423	125,800
Biomass	9,802	10,100	10,839	11,050	11,353
Waste	3,609	3,727	4,134	4,186	4,405
Landfill Gas	887	978	1,319	1,429	1,514
MSW[1]	2,167	2,188	2,218	2,215	2,215
Other Biomass[2]	554	561	598	542	676
Wood and Derived Fuels[3]	6,193	6,372	6,704	6,864	6,948
Geothermal	2,285	2,274	2,214	2,256	2,351
Hydroelectric Conventional	77,541	77,821	77,885	77,930	77,951
Solar/PV	411	411	502	536	603
Wind	8,706	11,329	16,515	24,651	33,542
Nonrenewable Total	879,274	884,281	886,934	893,747	901,785

Source US EIA

TRADE-OFFS

Large-Scale Hydropower

Advantages

Moderate to high net energy

High efficiency (80%)

Large untapped potential

Low-cost electricity

Long life span

No CO_2 emissions during operation in temperate areas

Can provide flood control below dam

Provides irrigation water

Reservoir useful for fishing and recreation

Disadvantages

High construction costs

High environmental impact from flooding land to form a reservoir

Environmental costs not included in market price

High CO_2 emissions from rapid biomass decay in shallow tropical reservoirs

Danger of collapse

Uproots people

Decreases fish harvest below dam

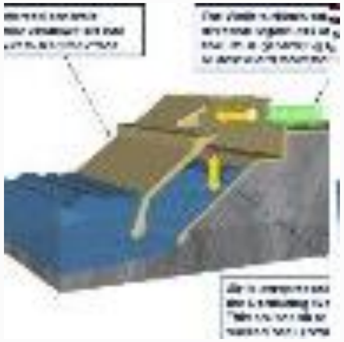
Decreases flow of natural fertilizer (silt) to land below dam

Fig. 16-21, p. 418

Tides and Waves Can Be Used to Produce Electricity

- Produce electricity from flowing water
  - Ocean tides and waves

Click for link



16-5 Advantages and Disadvantages of Producing Electricity from Wind

- ***Concept 16-5*** *When environmental costs of energy resources are included in market prices, wind energy is the least expensive and least polluting way to produce electricity.*

PRODUCING ELECTRICITY FROM WIND

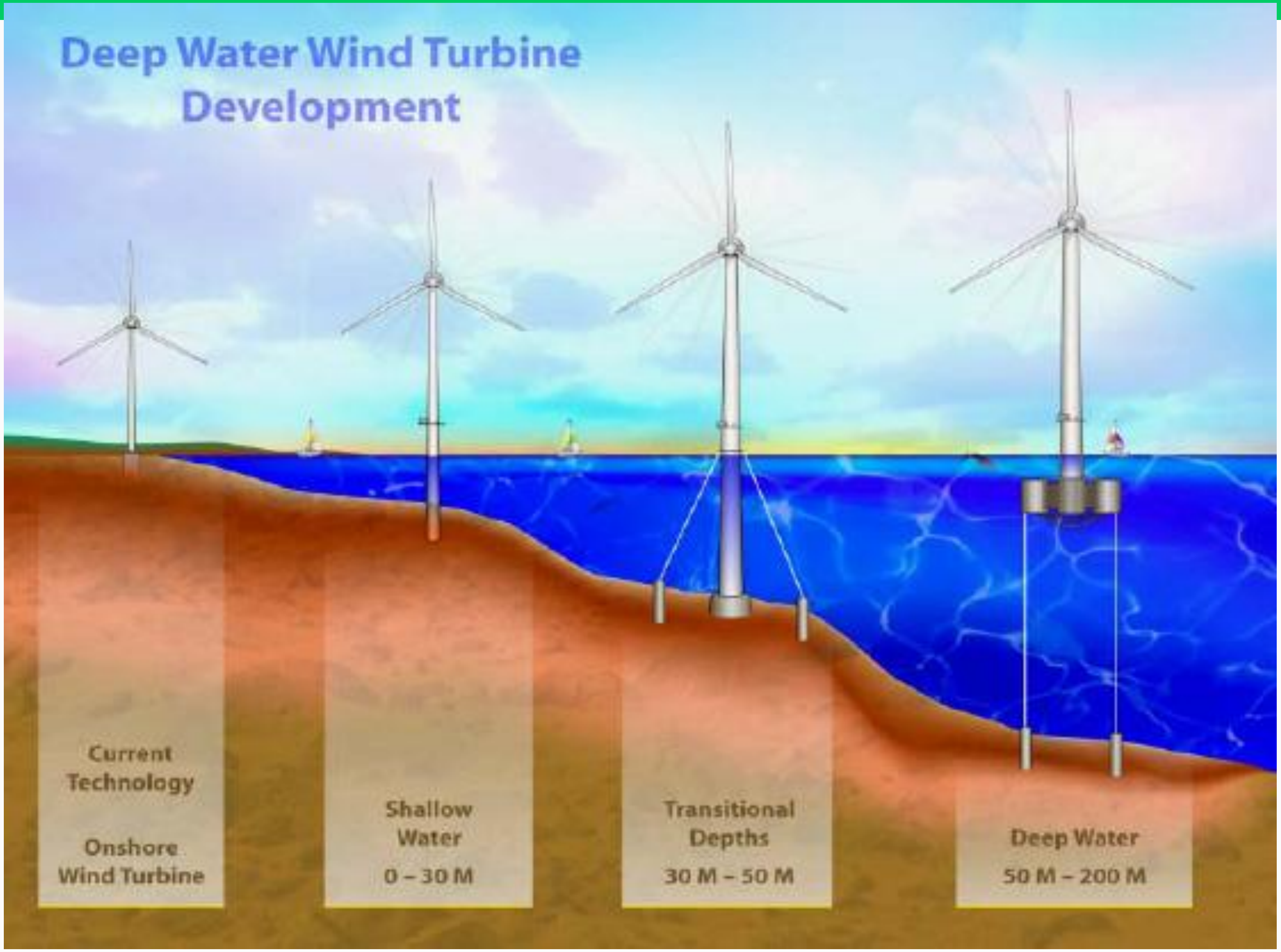
- Wind power is the world's most promising energy resource because it is abundant, inexhaustible, widely distributed, cheap, clean, and emits no greenhouse gases.
- Capturing only 20% of the wind energy at the world's best energy sites could meet all the world's energy demands.

Solutions: Wind Turbine and Wind Farms on Land and Offshore

Wind turbine | Wind farm | Wind farm (offshore)

Fig 16-22

Off shore wind generation



[Click for link to web page]

Today, at least three offshore wind facilities are in the planning stages in the United States:

- • Cape Wind facility off the coast of Massachusetts. Developers filed for a permit from the U.S. Army Corps of Engineers in 2001 to build this 130-turbine facility slated to produce up to 420 MW. It is on the OCS (just beyond 5 km offshore), and it would be the largest offshore wind energy facility in the world.

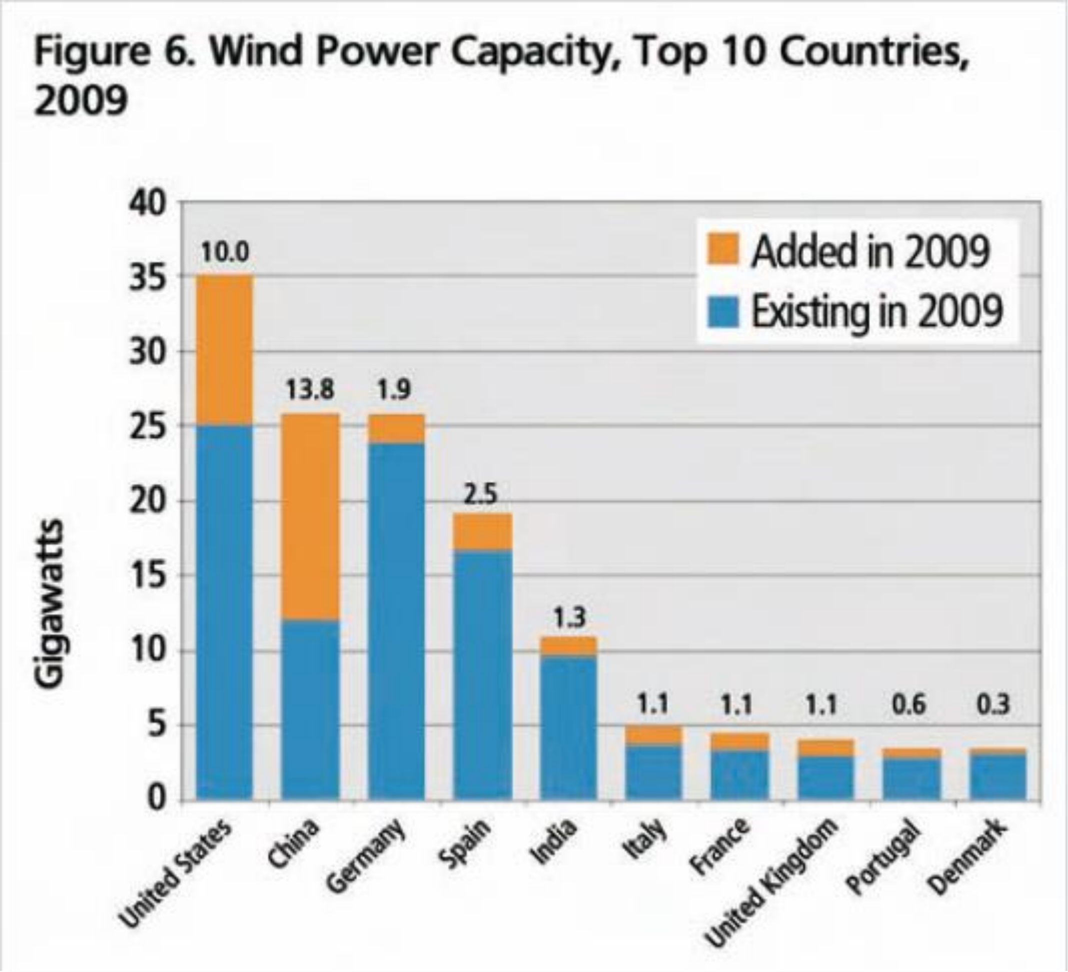
- • Long Island Offshore Wind Park. Off the southern coast of Long Island, New York, and also on the OCS, this facility is planned to consist of 40 turbines producing 140 MW of power. A permit application for this facility was submitted to the Corps in April 2005 (FPL 2006).

- • Fifty-turbine facility off the Galveston, Texas coast. While this facility is not in the Northeast, where offshore winds are considered to be the strongest and other energy alternatives are lacking, its developers believe it will be successful because of the area's experience with other offshore energy development and a more favorable state regulatory environment (Miller 2006). (State of Texas regulatory authority extends to 16 km off the coast, whereas other states' authorities extend for 5 km.)

PRODUCING ELECTRICITY FROM WIND

- The United States once led the wind power industry, but Europe now leads this rapidly growing business.
  - The U.S. government lacked subsidies, tax breaks and other financial incentives.
- European companies manufacture 80% of the wind turbines sold in the global market
  - The success has been aided by strong government subsidies.

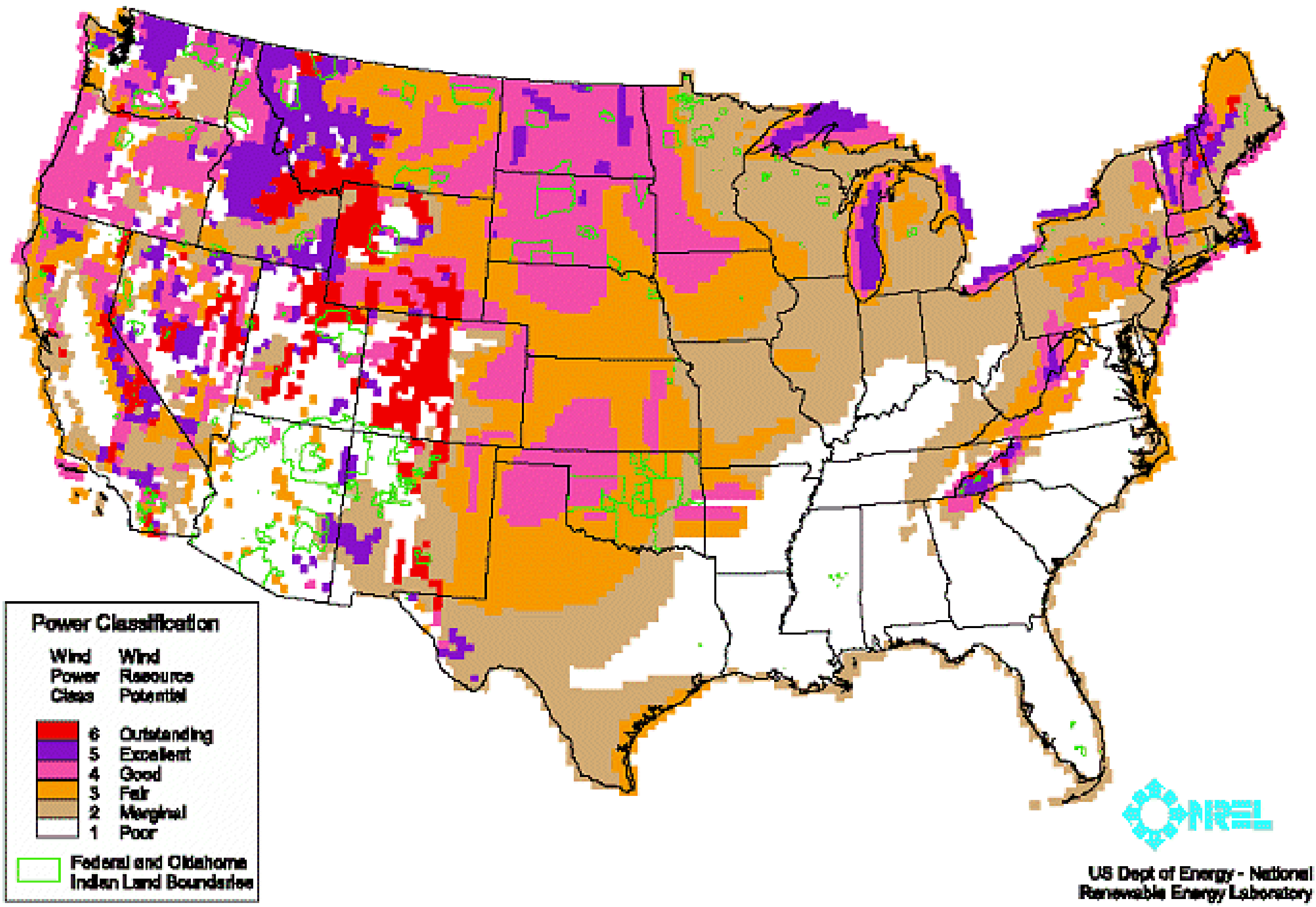
Wind Power Capacity



Source REN21

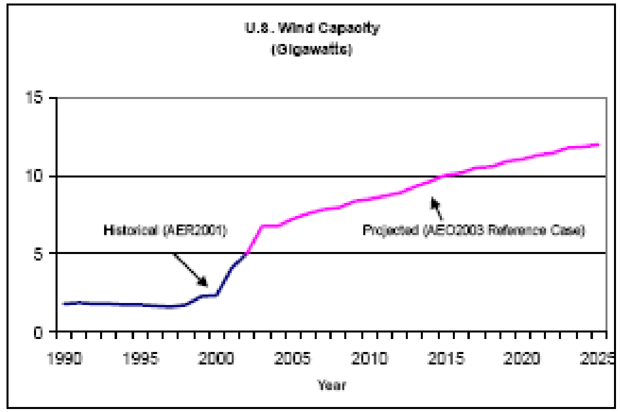
U.S. Wind Energy Generation Potential

Figure 13. Wind Resource Potential



U.S. Wind Energy Projection

AEO2003 Wind Projection



Wind power has expanded quite rapidly in the past five years as the result of several factors:

-Improving economics

-Federal-level subsidies such as the PTC

-State-level mandates and incentives

Achieves 12 GW by 2025 from about 4.3 GW in 2001

IF the U.S. constructed enough wind farms to fully tap the wind potential, we would generate 3 time the national 2006 generation needs (11 trillion kWhr). S.A. Sept 2006

TRADE-OFFS

Wind Power

Advantages

Moderate to high net energy yield

High efficiency

Moderate capital cost

Low electricity cost (and falling)

Very low environmental impact

No CO_2 emissions

Quick construction

Easily expanded

Can be located at sea

Land below turbines can be used to grow crops or graze livestock

Disadvantages

Steady winds needed

Backup systems needed when winds are low

Plastic components produced from oil

Environmental costs not included in market price

High land use for wind farm

Visual pollution

Noise when located near populated areas

Can kill birds and interfere with flights of migratory birds

Fig. 16-23, p. 421

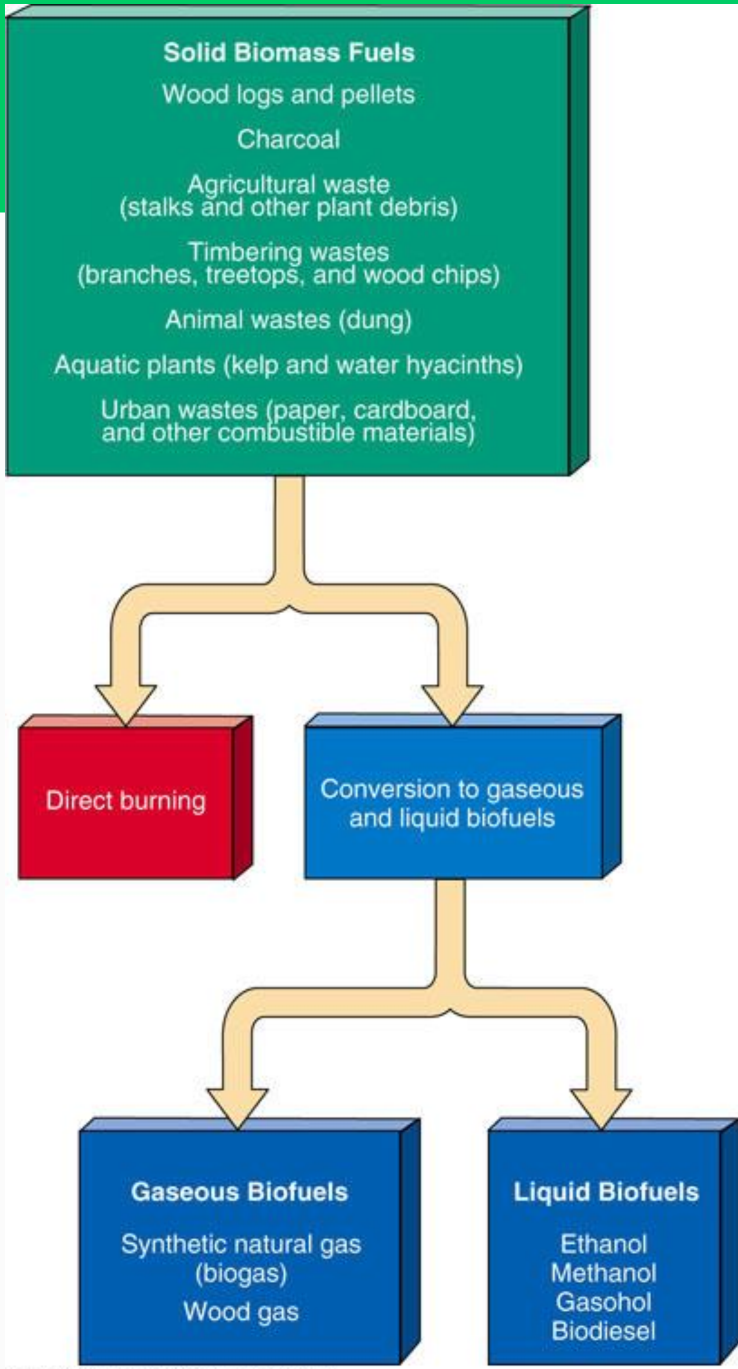
16-6 Advantages and Disadvantages of Biomass as an Energy Source (1)

- ***Concept 16-6A*** *Solid biomass is a renewable resource, but burning it faster than it is replenished produces a net gain in atmospheric greenhouse gases, and creating biomass plantations can degrade soil biodiversity.*

16-6 Advantages and Disadvantages of Biomass as an Energy Source (2)

- ***Concept 16-6B*** *Liquid biofuels derived from biomass can be used in place of gasoline and diesel fuels, but creating biofuel plantations could degrade soil and biodiversity and increase food prices and greenhouse gas emissions.*

PRODUCING ENERGY FROM BIOMASS



- Plant materials and animal wastes can be burned to provide heat or electricity or converted into gaseous or liquid biofuels.

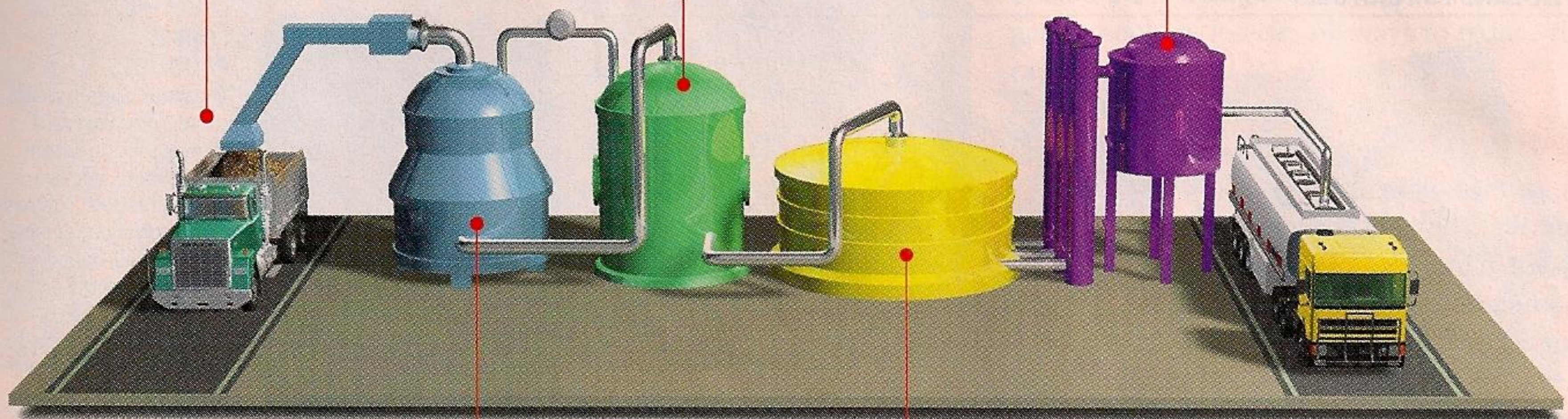
PRODUCING ENERGY FROM BIOMASS

- The scarcity of fuelwood causes people to make fuel briquettes from cow dung in India. This deprives soil of plant nutrients.

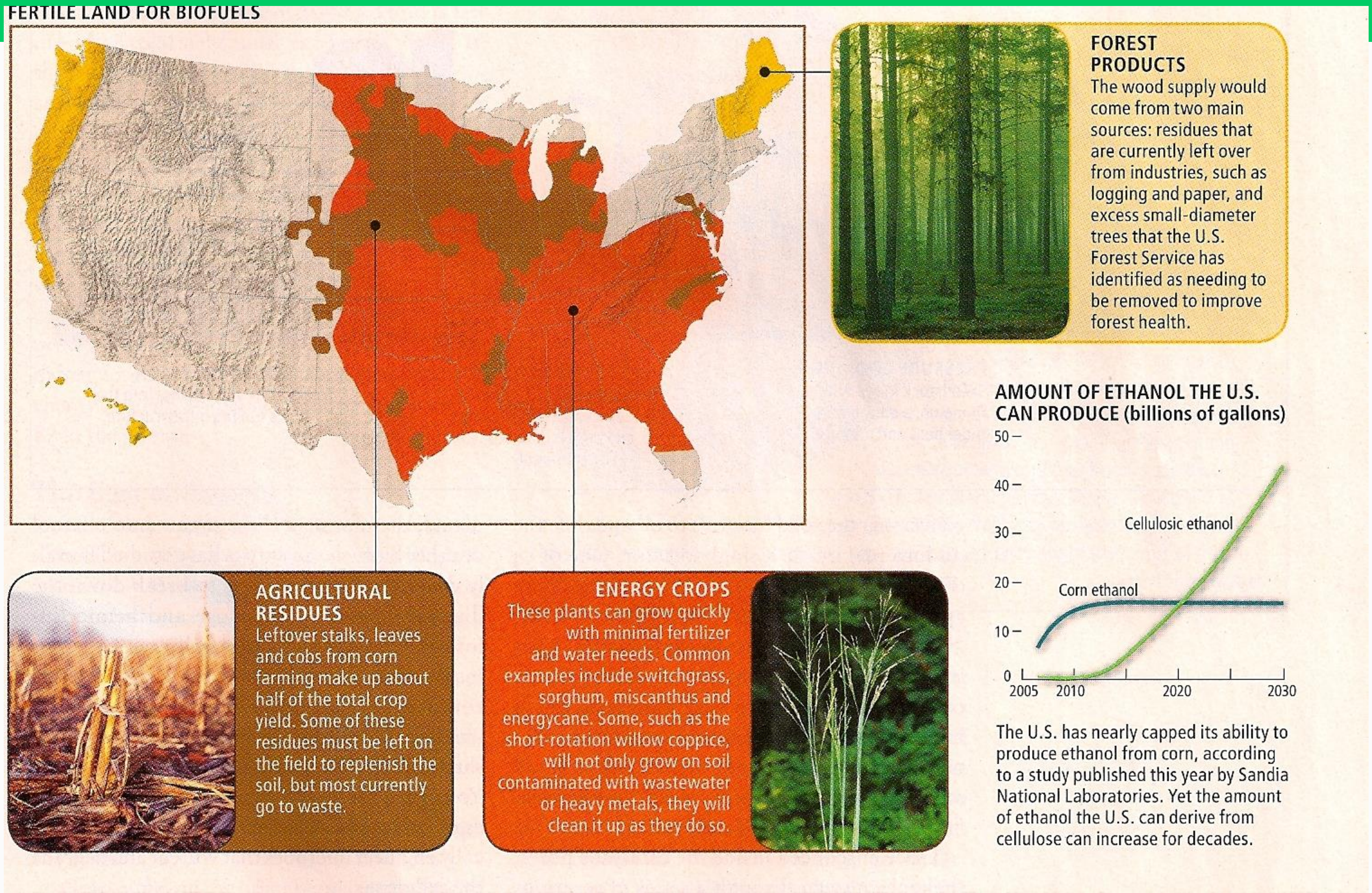
[HOW-TO #2]

BREAKING DOWN CELLULOSE WITH AMMONIA

Although there are many possible ways to pretreat plant fibers to get at the cellulose—acids and heat are most commonly mentioned—the ammonia fiber expansion (AFEX) process offers a unique combination of low energy requirements, low costs and high efficiency.

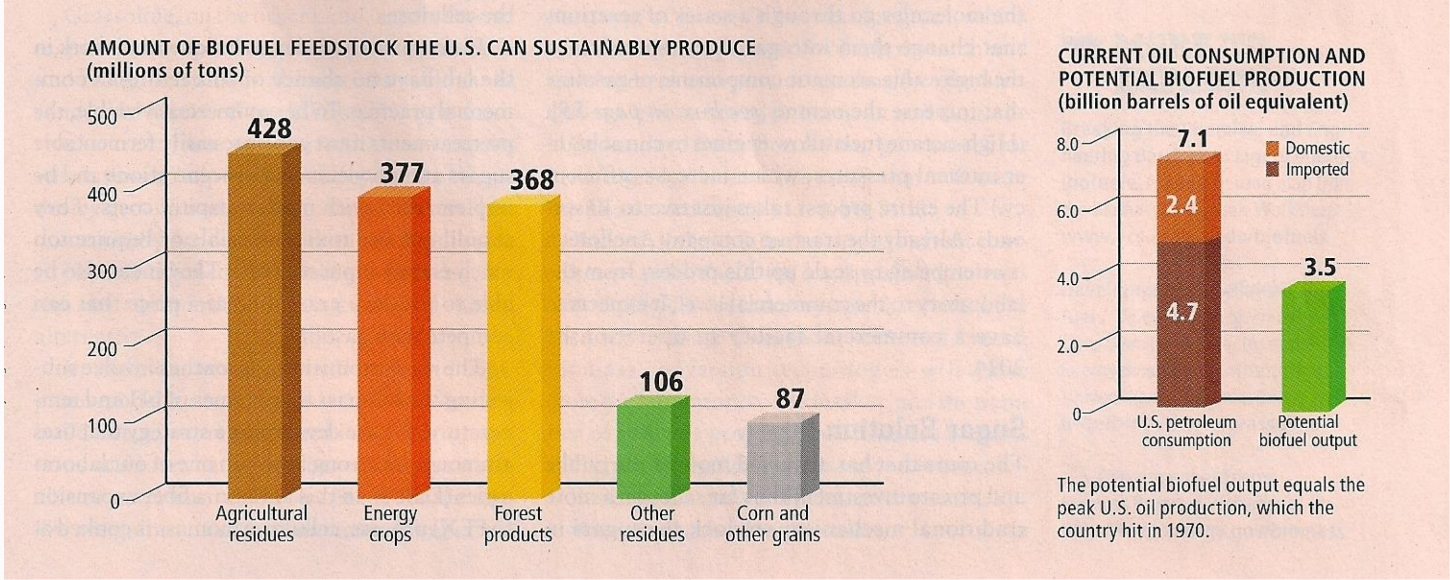


Biofuel Sources

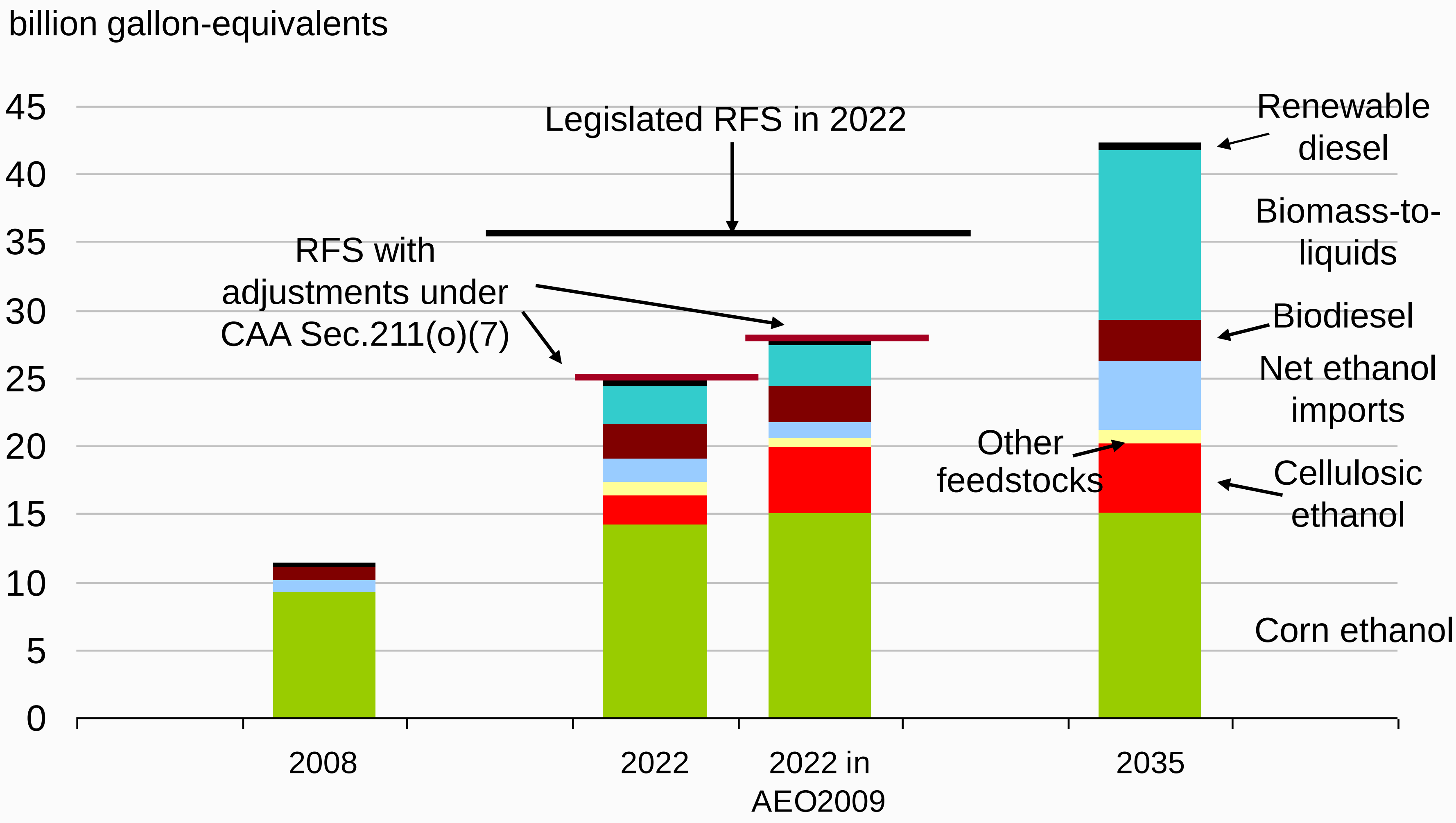


Natural Capital: Rapidly Growing Switchgrass in Kansas, U.S.

Biofuel Feedstock in U.S.



Biofuels grow, but fall short of the 36 billion gallon RFS target in 2022, exceed it in 2035



Source: *Annual Energy Outlook 2010*

Trade-Offs: Solid Biomass, Advantages and Disadvantages

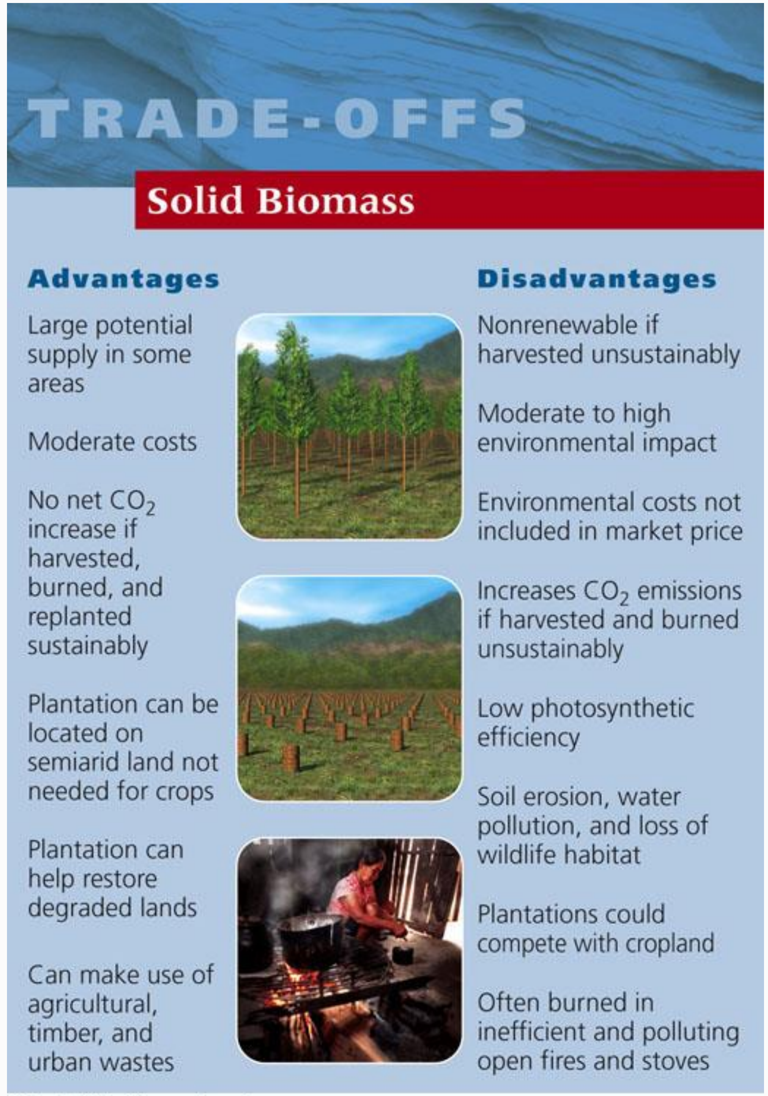


Fig 16-24

Trade-Offs: Biodiesel, Advantages and Disadvantages

TRADE-OFFS

Biodiesel

Advantages	Disadvantages
Reduced CO emissions	Increased NO_x emissions and more smog
Reduced CO_2 emissions (78%)	Higher cost than regular diesel
High net energy yield for oil palm crops	Environmental costs not included in market price
Moderate net energy yield for rapeseed crops	Low net energy yield for soybean crops
Reduced hydrocarbon emissions	May compete with growing food on cropland and raise food prices
Better gas mileage (40%)	Loss and degradation of biodiversity from crop plantations
Potentially renewable	Can make engines hard to start in cold weather

Fig 16-25

Trade-Offs: Ethanol Fuel, Advantages and Disadvantages

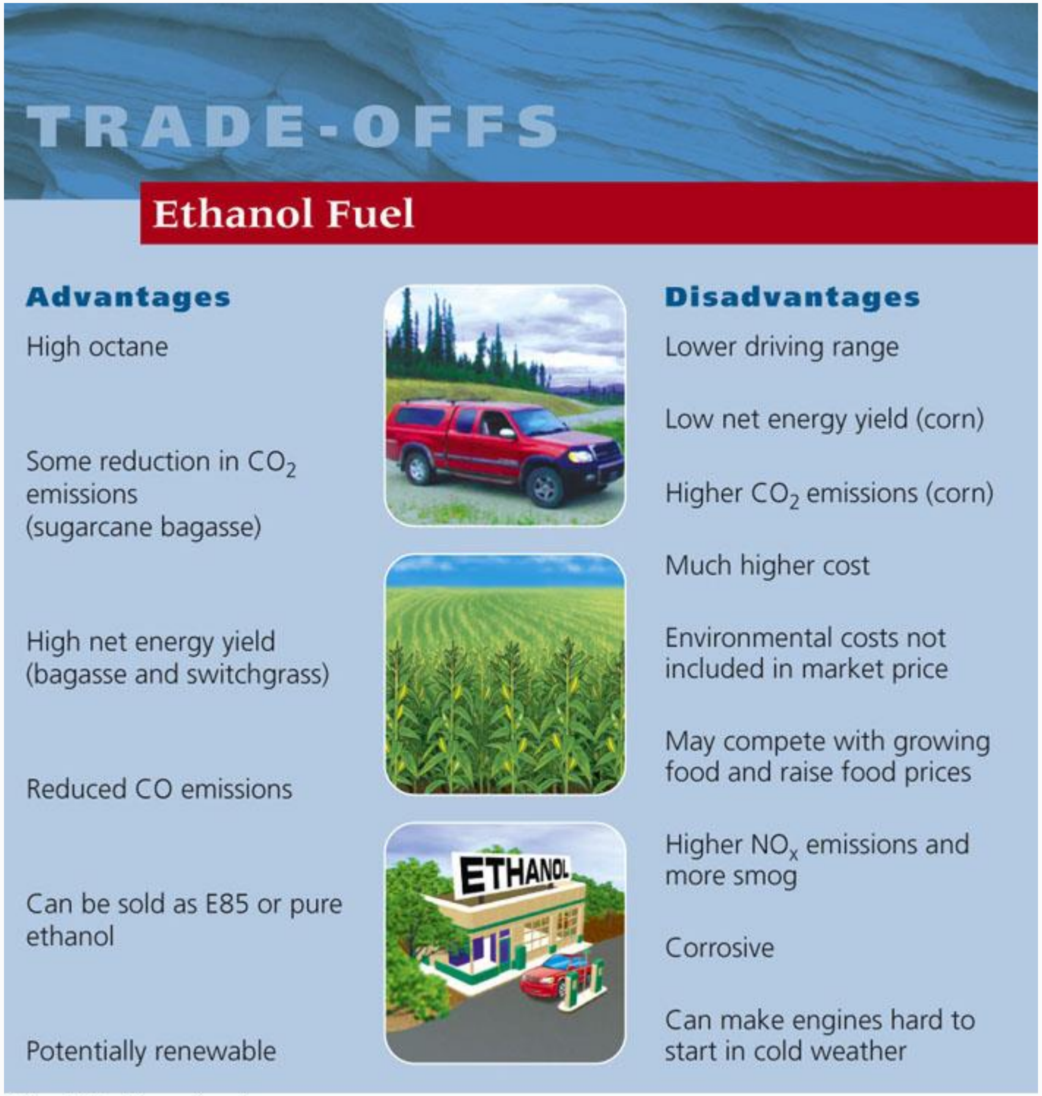
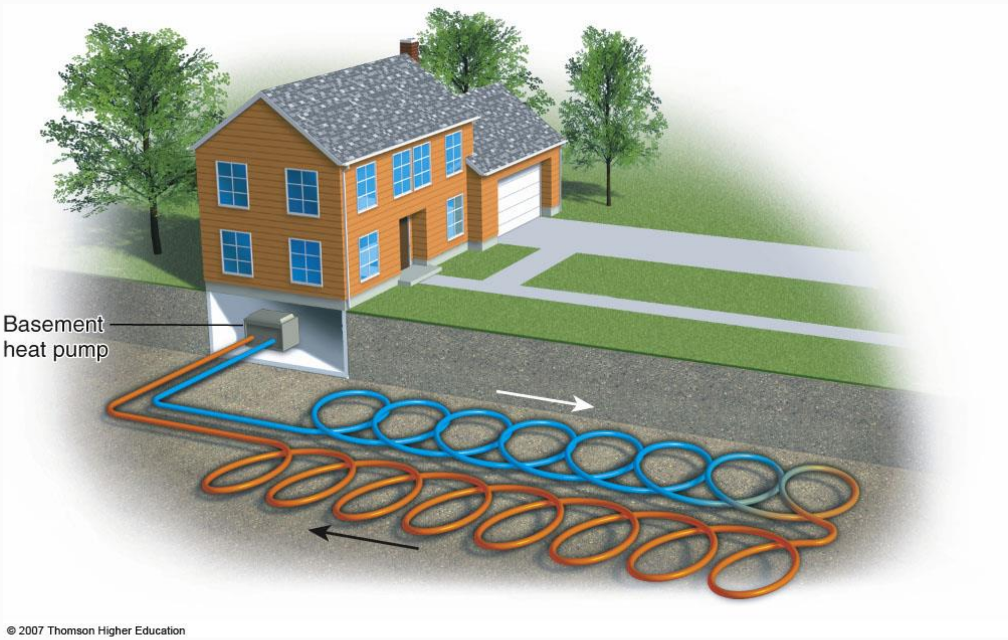


Fig 16-27

16-7 What Are the Advantages and Disadvantages of Geothermal Energy?

- ***Concept 16-7*** *Geothermal energy has great potential for supplying many areas with heat and electricity and generally has a low environmental impact, but locations where it can be exploited economically are limited.*

Geothermal Heat Pump



- The house is heated in the winter by transferring heat from the ground into the house.
- The process is reversed in the summer to cool the house.

Figure 16-28

GEOTHERMAL ENERGY

- Deeper more concentrated hydrothermal reservoirs can be used to heat homes and buildings and spin turbines:
  - ***Dry steam***: water vapor with no water droplets.
  - ***Wet steam***: a mixture of steam and water droplets.
  - ***Hot water***: is trapped in fractured or porous rock.

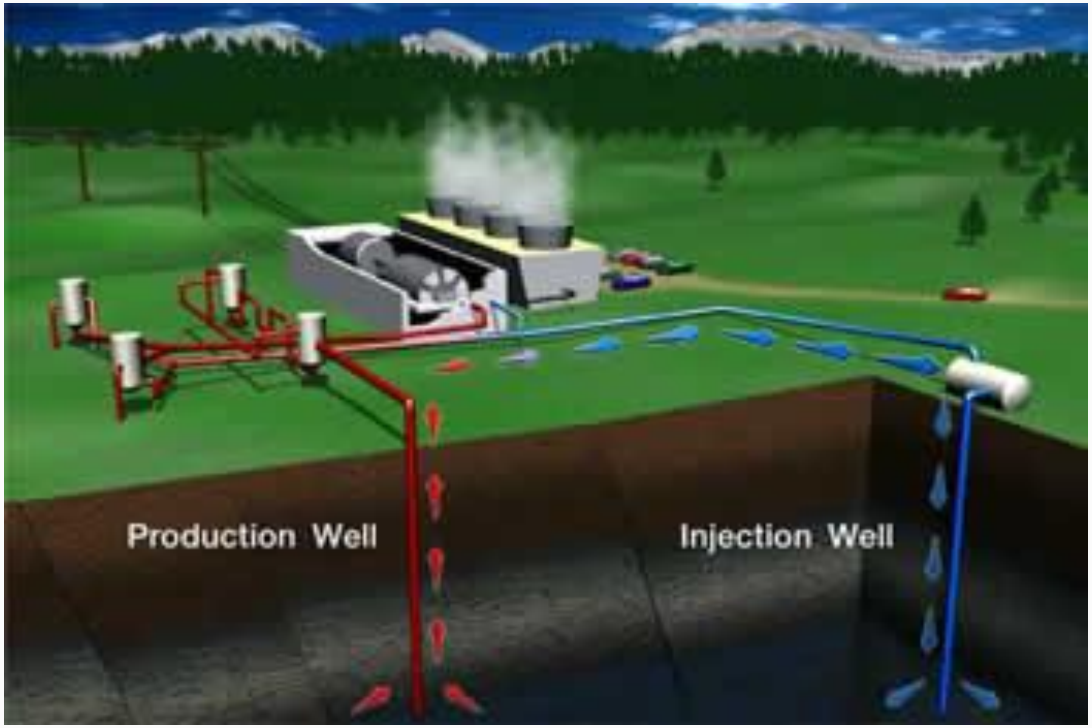
California
Known Geothermal Resource Areas (KGRA)

Geothermal Energy in California

- California's geothermal power plants produce about one-half of the world's geothermally generated electricity.
- The geothermal power plants produce enough electricity for about two million homes.

[Click for UC Davis]

[Click for CA En Commission]



TRADE-OFFS

Geothermal Energy

Advantages

Very high efficiency

Moderate net energy at accessible sites

Lower CO_2 emissions than fossil fuels

Low cost at favorable sites

Low land use and disturbance

Moderate environmental impact

Disadvantages

Scarcity of suitable sites

Can be depleted if used too rapidly

Environmental costs not included in market price

CO_2 emissions

Moderate to high local air pollution

Noise and odor (H_2S)

High cost except at the most concentrated and accessible sources

Fig. 16-29, p. 428

16-8 The Advantages and Disadvantages of Hydrogen as an Energy Source

- ***Concept 16-8*** *Hydrogen fuel holds great promise for powering cars and generating electricity, but to be environmentally beneficial, it would have to be produced without the use of fossil fuels.*

A Fuel Cell Separates the Hydrogen Atoms’ Electrons from Their Protons

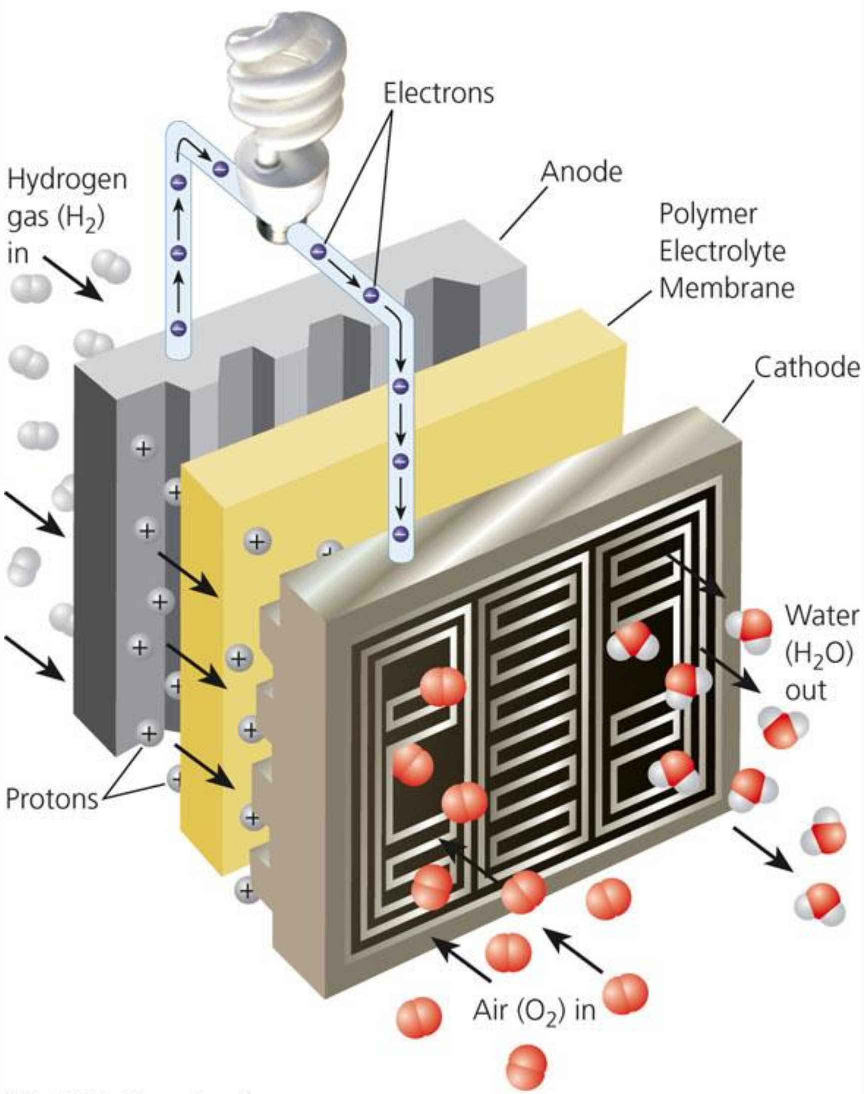
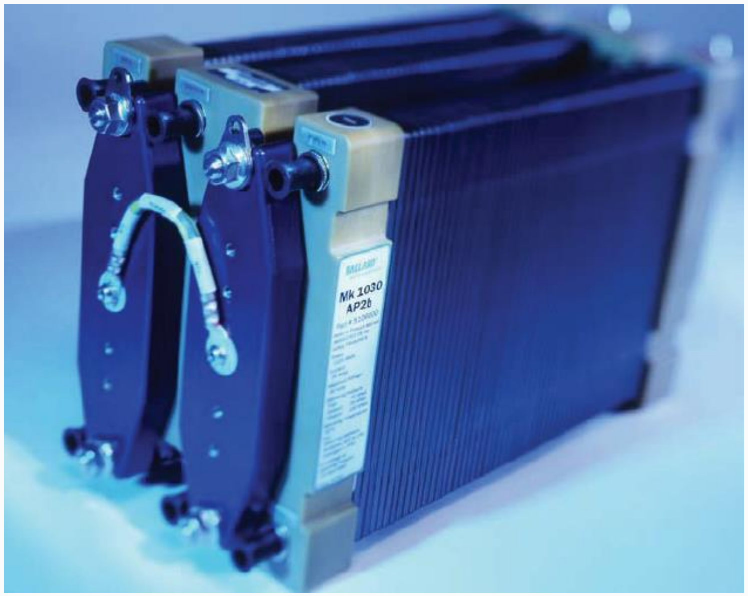


Fig 16-30

Cogeneration using Hydrogen



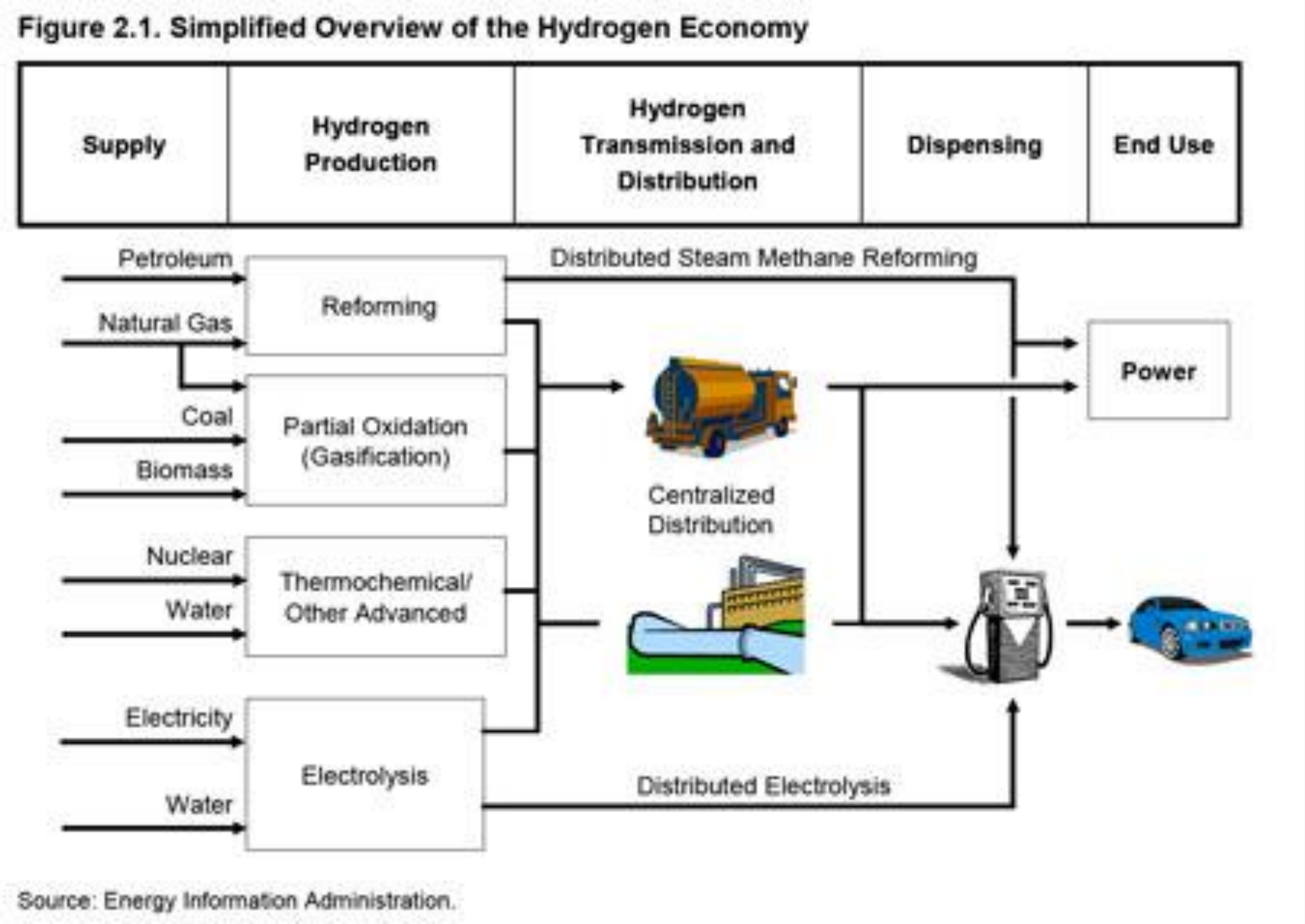
Click for Ballard web page

Click for Panasonic

What is needed to get FCV (fuel cell vehicles) on the Road? Source DOE

- The cost of hydrogen must decline to between $2 and $3 per gallon gasoline equivalent, or approximately $2 to $3 per kilogram of hydrogen, because 1 kilogram of hydrogen contains about the same energy as a gallon of gasoline. Current cost is $2.50 - $7.00. Click for report. Future price in table.
- Federal and State policies must be instituted to facilitate the construction of all phases of a hydrogen production, transmission, distribution, and dispensing infrastructure.
- Fuel cell and vehicle manufacturers must be convinced that the Federal and State governments will provide a stable and supportive (long term) set of policies.
- Hydrogen storage costs for fuel cells must fall to about $2 per kilowatt from their currently estimated price of about $8 per kilowatt for the 5,000 psi system.
- Ideally, the first FCV markets must be developed in areas with high population densities.

How will a Hydrogen Economy work?



Trade-Offs: Hydrogen, Advantages and Disadvantages

TRADE-OFFS

Hydrogen

Advantages	Disadvantages
Can be produced from plentiful water	Not found as H_2 in nature
Low environmental impact	Energy is needed to produce fuel
Renewable if produced from renewable energy resources	Negative net energy
No CO_2 emissions if produced from water	CO_2 emissions if produced from carbon-containing compounds
Good substitute for oil	Environmental costs not included in market price
Competitive price if environmental and social costs are included in cost comparisons	Nonrenewable if generated by fossil fuels or nuclear power
Easier to store than electricity	High costs (that may eventually come down)
Safer than gasoline and natural gas	Will take 25 to 50 years to phase in
Nontoxic	Short driving range for current fuel-cell cars
High efficiency (45–65%) in fuel cells	No fuel distribution system in place
	Excessive H_2 leaks may deplete ozone in the atmosphere

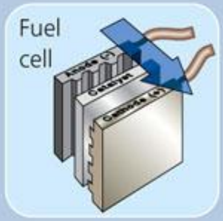


Fig 16-21

16-9 How Can We Make a Transition to a More Sustainable Energy Future?

- ***Concept 16-9*** *We can make a transition to a more sustainable future if we greatly improve energy efficiency, use a mix of renewable energy resources, and include environmental costs in the market prices of all energy resources.*

Choosing Energy Paths

- General conclusions about possible energy paths
  - Gradual shift to smaller, decentralized micropower systems
  - Transition to a diverse mix of locally available renewable energy resources Improved energy efficiency
  - Fossil fuels will still be used in large amounts

Solutions: Decentralized Power System

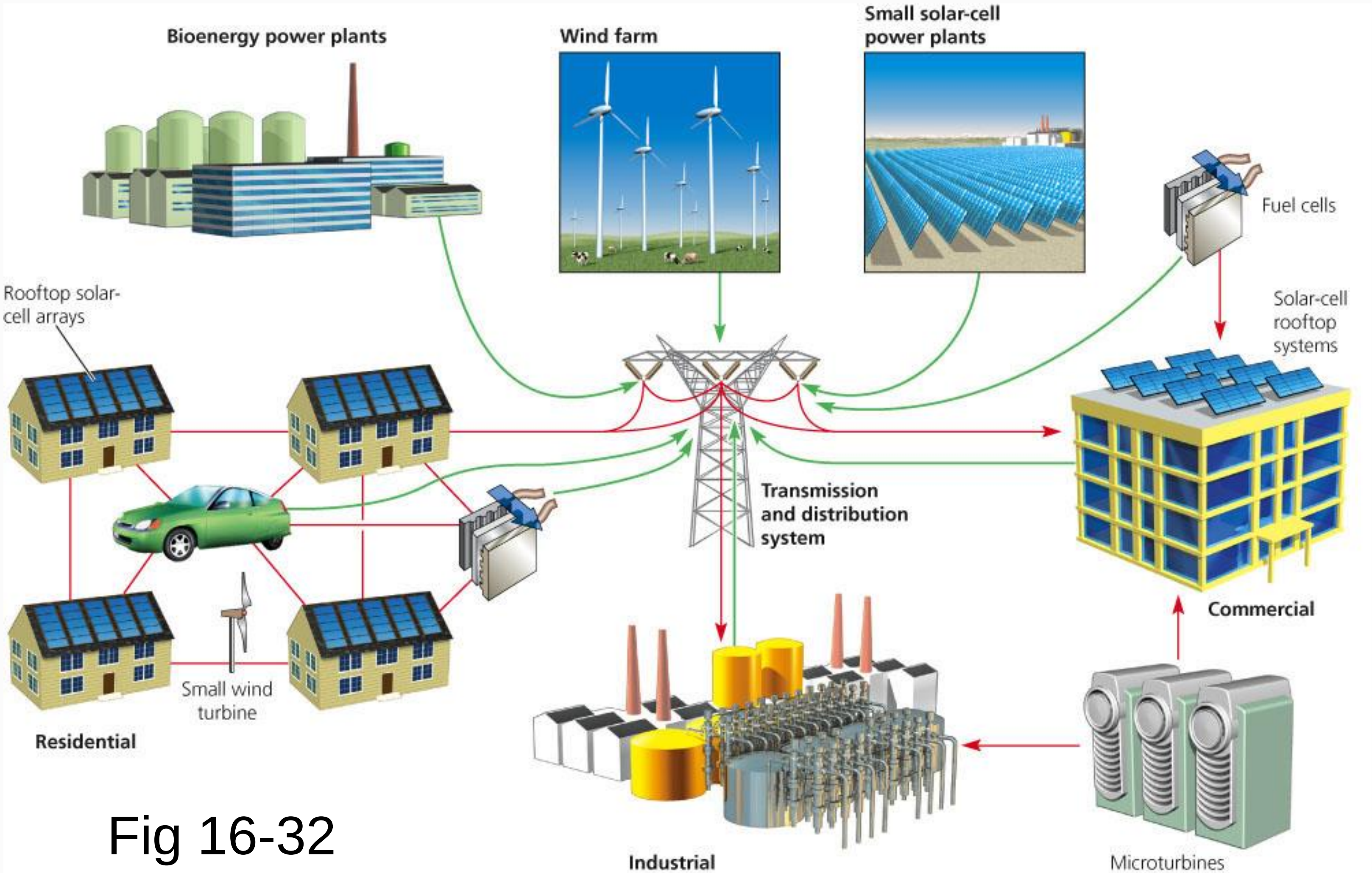
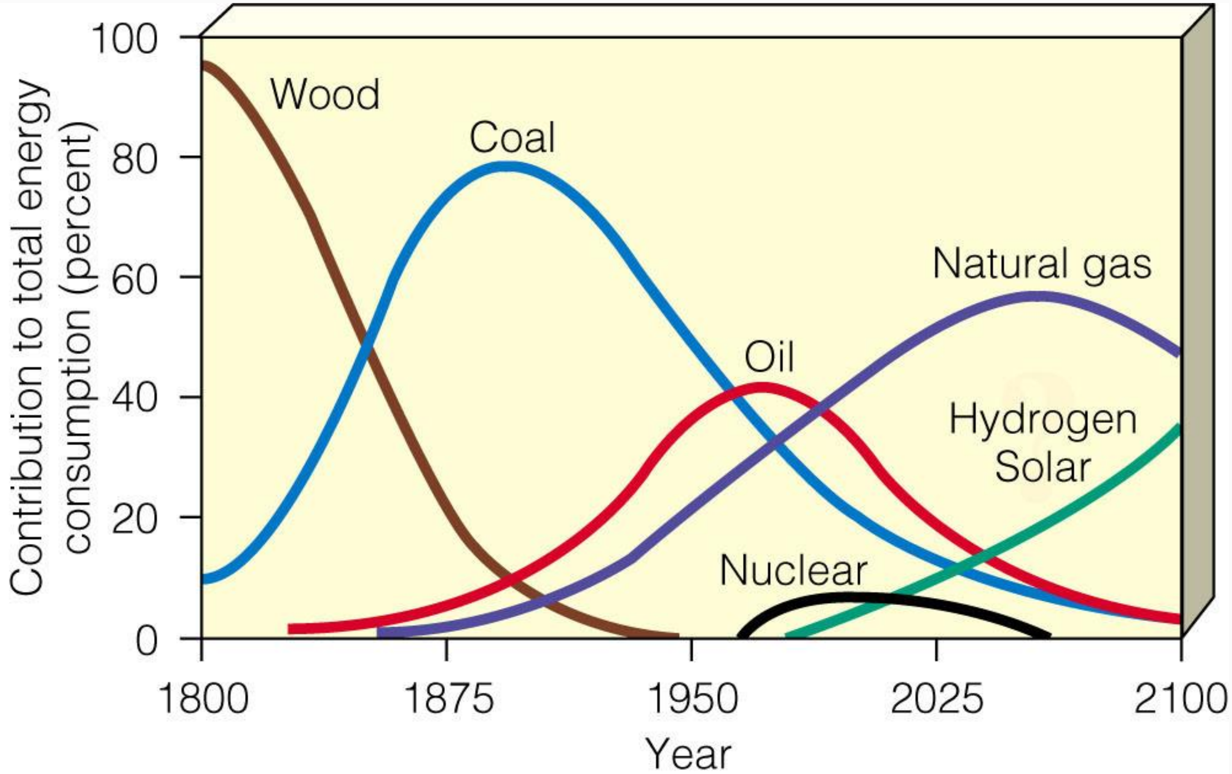


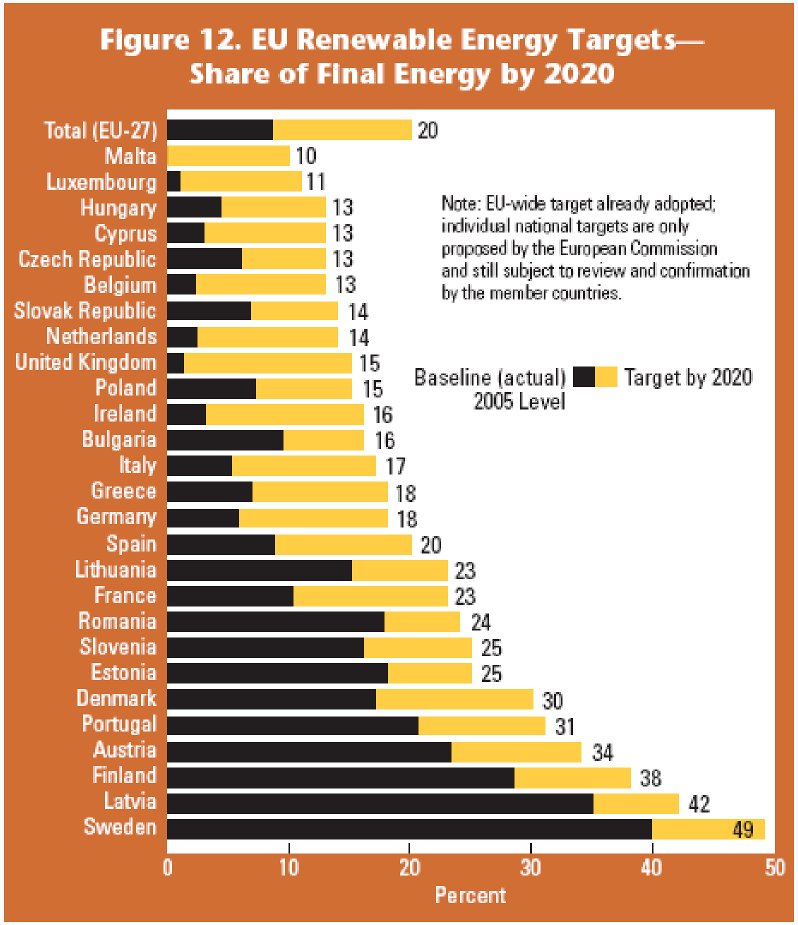
Fig 16-32

A SUSTAINABLE ENERGY STRATEGY



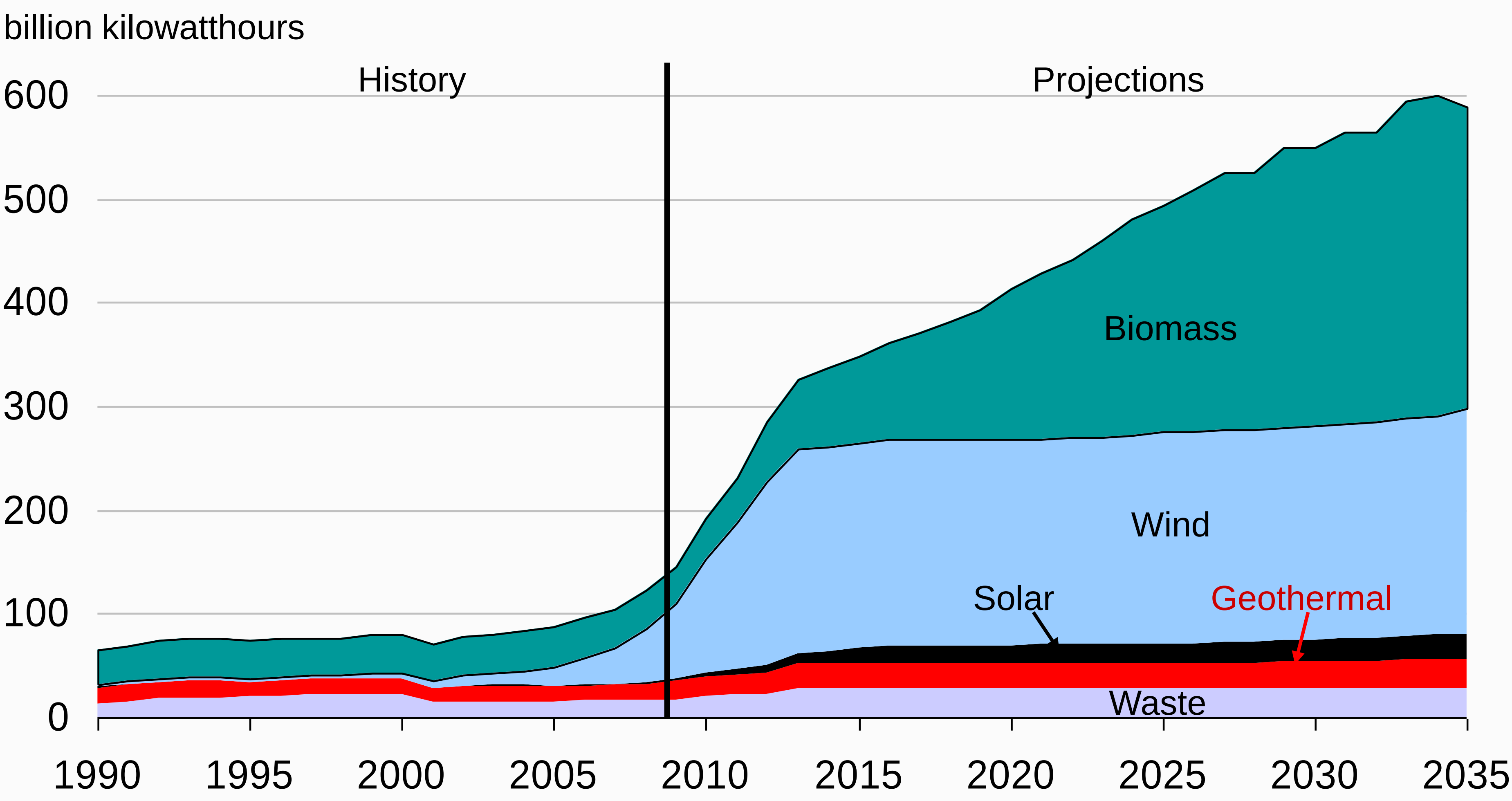
- Shifts in the use of commercial energy resources in the U.S. since 1800, with projected changes to 2100.

EU renewable targets



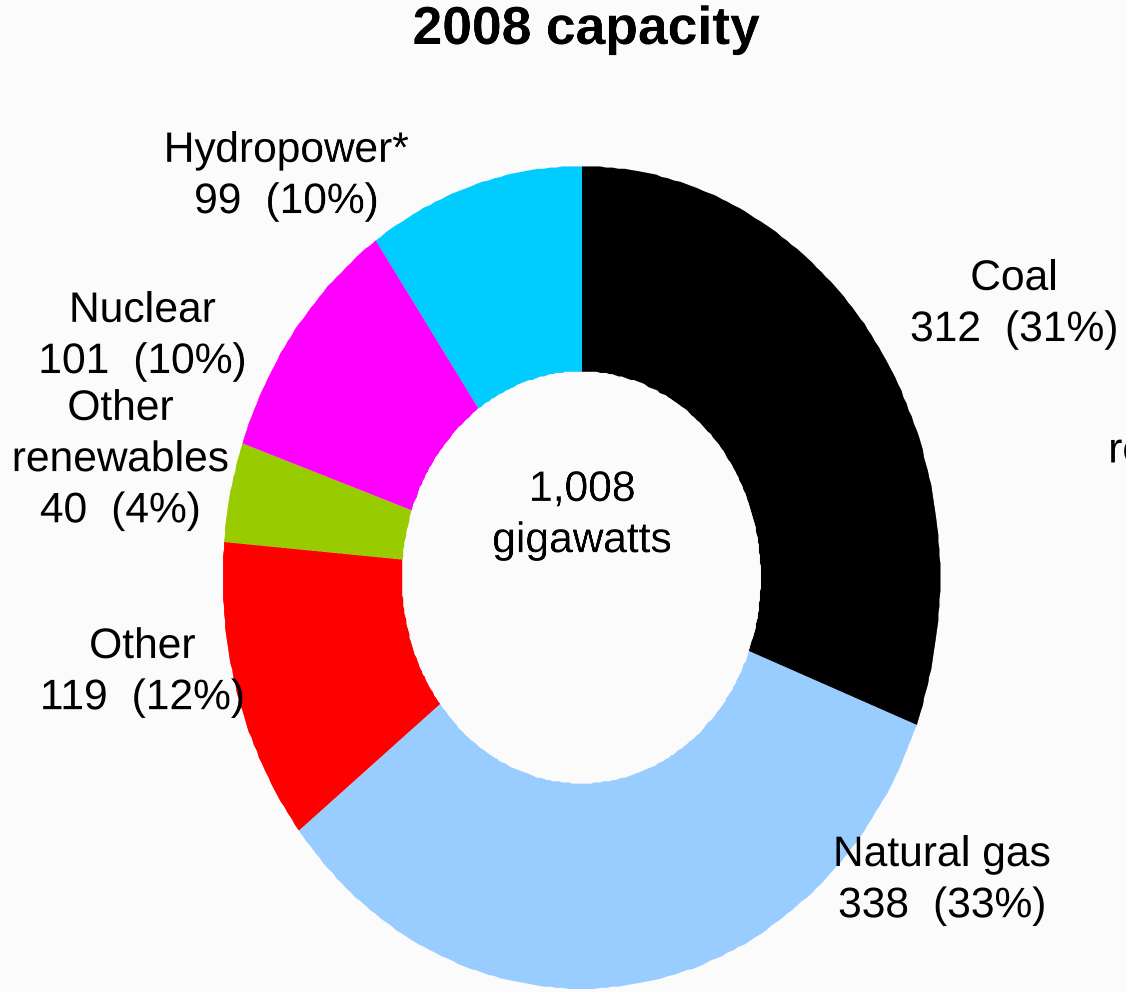
Source Worldwatch Institute

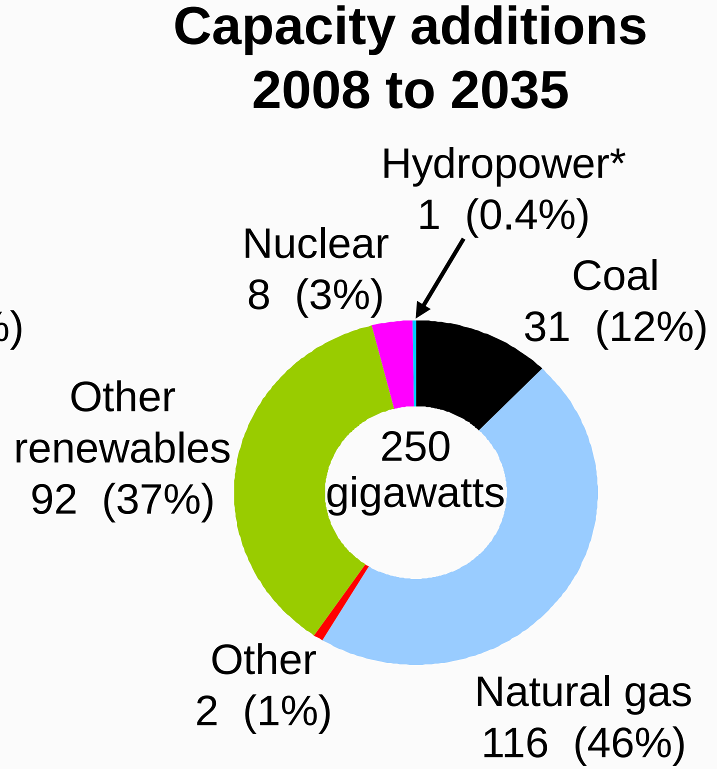
Nonhydropower renewable sources meet 41% of total electricity generation growth from 2008 to 2035



Source: *Annual Energy Outlook 2010*

Natural gas and renewables account for the majority of capacity additions from 2008 to 2035





* Includes pumped storage

Source: *Annual Energy Outlook 2010*

Solutions: Making the Transition to a More Sustainable Energy Future

SOLUTIONS

Making the Transition to a More Sustainable Energy Future

Improve Energy Efficiency

Increase fuel-efficiency standards for vehicles, buildings, and appliances

Mandate government purchases of efficient vehicles and other devices

Provide large tax credits or feebates for buying efficient cars, houses, and appliances

Offer large tax credits for investments in energy efficiency

Reward utilities for reducing demand for electricity

Greatly increase energy efficiency research and development

More Renewable Energy

Greatly increase use of renewable energy

Provide large subsidies and tax credits for use of renewable energy

Include environmental costs in prices for all energy resources

Encourage government purchase of renewable energy devices

Greatly increase renewable energy research and development

Reduce Pollution and Health Risk

Cut coal use 50% by 2020

Phase out coal subsidies

Levy taxes on coal and oil use

Phase out nuclear power subsidies, tax breaks, and loan guarantees

Fig 16-33

Economics, Politics, Education, and Sustainable Energy Resources

- Governments can use a combination of subsidies, tax breaks, rebates, taxes and public education to promote or discourage use of various energy alternatives:
  - Can keep prices artificially low to encourage selected energy resources.
  - Can keep prices artificially high to discourage other energy resources.
  - Emphasize consumer education.

What Can you Do? Shifting to Sustainable Energy Use

WHAT CAN YOU DO?

Shifting to Sustainable Energy Use

- Get an energy audit done for your house or office
- Drive a car that gets at least 15 kilometers per liter (35 miles per gallon)
- Use a carpool to get to work or to school
- Walk, bike, and use mass transit
- Superinsulate your house and plug all air leaks
- Turn off lights, TV sets, computers, and other electronic equipment when they are not in use
- Wash laundry in warm or cold water
- Use passive solar heating
- For cooling, open windows and use ceiling fans or whole-house attic or window fans
- Turn thermostats down in winter and up in summer
- Buy the most energy-efficient home, lights, and appliances available
- Turn down the thermostat on water heaters to 43–49 °C (110–120 °F) and insulate hot water heaters and pipes

Fig 16-34