

ENERGY

Trade-Offs

Coal

Advantages

Ample supplies in many countries

High net energy yield

Low cost when environmental costs are not included



Disadvantages

Severe land disturbance and water pollution

Fine particle and toxic mercury emissions threaten human health

Emits large amounts of CO₂ and other air pollutants when produced and burned

Trade-Offs

Conventional Oil

Advantages

Ample supply for several decades

High net energy yield but decreasing

Low land disruption

Efficient distribution system

Disadvantages

Water pollution from oil spills and leaks

Environmental costs not included in market price

Releases CO₂ and other air pollutants when burned

Vulnerable to international supply interruptions



Trade-Offs

Heavy Oils from Oil Shale and Tar Sand

Advantages

Large potential supplies

Easily transported within and between countries

Efficient distribution system in place



Disadvantages

Low net energy yield

Releases CO₂ and other air pollutants when produced and burned

Severe land disruption and high water use

Trade-Offs

Synthetic Fuels

Advantages

Large potential supply in many countries

Vehicle fuel

Lower air pollution than coal

Disadvantages

Low to moderate net energy yield

Requires mining 50% more coal with increased land disturbance, water pollution and water use

Higher CO₂ emissions than coal



Trade-Offs

Conventional Nuclear Fuel Cycle

Advantages

Low environmental impact (without accidents)

Emits 1/6 as much CO₂ as coal

Low risk of accidents in modern plants



Disadvantages

Very low net energy yield and high overall cost

Produces long-lived, harmful radioactive wastes

Promotes spread of nuclear weapons

Trade-Offs

Large-Scale Hydropower

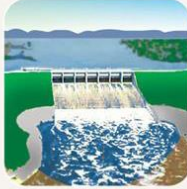
Advantages

Moderate to high net energy

Large untapped potential

Low-cost electricity

Low emissions of CO₂ and other air pollutants in temperate areas



Disadvantages

Large land disturbance and displacement of people

High CH₄ emissions from rapid biomass decay in shallow tropical reservoirs

Disrupts downstream aquatic ecosystems

Trade-Offs

Solid Biomass

Advantages

Widely available in some areas

Moderate costs

No net CO₂ increase if harvested, burned, and replanted sustainably

Plantations can help restore degraded lands



Disadvantages

Moderate to high environmental impact

Increases CO₂ emissions if harvested and burned unsustainably

Clear cutting can cause soil erosion, water pollution, and loss of wildlife habitat

Often burned in inefficient and polluting open fires and stoves

Trade-Offs

Ethanol Fuel

Advantages

Some reduction in CO₂ emissions (sugarcane bagasse)

High net energy yield (bagasse and switchgrass)

Potentially renewable



Disadvantages

Low net energy yield (corn) and higher cost

Higher CO₂ emissions (corn)

Corn ethanol competes with food crops and may raise food prices

Trade-Offs

Geothermal Energy

Advantages

Moderate net energy and high efficiency at accessible sites

Lower CO₂ emissions than fossil fuels

Low cost at favorable sites



Disadvantages

High cost and low efficiency except at concentrated and accessible sites

Scarcity of suitable sites

Noise and some CO₂ emissions

Trade-Offs

Hydrogen

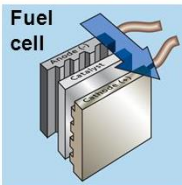
Advantages

Can be produced from plentiful water at some sites

No CO₂ emissions if produced with use of renewables

Good substitute for oil

High efficiency in fuel cells



Disadvantages

Negative net energy yield

CO₂ emissions if produced from carbon-containing compounds

High costs create need for subsidies

Needs H₂ storage and distribution system

Trade-Offs

Wind Power

Advantages

Moderate to high net energy yield

Widely available

Low electricity cost

Little or no direct emissions of CO₂ and other air pollutants

Easy to build and expand



Disadvantages

Needs backup or storage system when winds die down

Visual pollution for some people

Low-level noise bothers some people

Can kill birds if not properly designed and located

Trade-Offs

Solar Cells

Advantages

Moderate net energy yield

Little or no direct emissions of CO₂ and other air pollutants

Easy to install, move around, and expand as needed

Competitive cost for newer cells



Disadvantages

Need access to sun

Need electricity storage system or backup

High costs for older systems but decreasing rapidly

Solar-cell power plants could disrupt desert ecosystems

Trade-Offs

Solar Energy for High-Temperature Heat and Electricity

Advantages

Moderate environmental impact

No direct emissions of CO₂ and other air pollutants

Lower costs with natural gas turbine backup



Disadvantages

Low net energy and high costs

Needs backup or storage system on cloudy days

High water use for cooling

Trade-Offs

Passive or Active Solar Heating

Advantages

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

Very low emissions of CO₂ and other air pollutants

Very low land disturbance

Moderate cost (passive)



Disadvantages

Need access to sun 60% of time during daylight

Sun can be blocked by trees and other structures

High installation and maintenance costs for active systems

Need backup system for cloudy days

TRANSPORTATION

Trade-Offs

Bicycles

Advantages

Are quiet and non-polluting

Take few resources to make

Burn no fossil fuels

Require little parking space



Disadvantages

Provide little protection in an accident

Provide no protection from bad weather

Are impractical for long trips

Secure bike parking not yet widespread

Trade-Offs

Mass Transit Rail

Advantages

Uses less energy and produces less air pollution than cars do

Reduced need for more roads and parking areas

Causes fewer injuries and deaths than cars do

Reduces car congestion in cities



Disadvantages

Is expensive to build and maintain

Is cost-effective only in densely populated areas

Commits riders to transportation schedules

Can cause noise and vibration for nearby residents

Trade-Offs

Buses

Advantages

Can greatly reduce car use and air pollution

Can be rerouted as needed

Cost less to develop and maintain than heavy-rail system



Disadvantages

Can lose money because they require affordable fares

Can get caught in traffic and add to noise and pollution

Commit riders to transportation schedules

Trade-Offs

Rapid Rail

Advantages

Is much more energy efficient per rider than cars and planes are

Produces less pollution than do cars and planes

Can reduce need for more air travel, cars, roads, and parking areas



Disadvantages

Is costly to run and maintain

Causes noise and vibration for nearby residents

Has some risk of collision at car crossings

FOOD/NATURAL RESOURCES

Trade-Offs

Aquaculture

Advantages

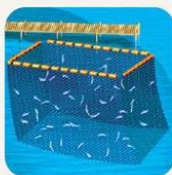
High efficiency

High yield

Reduced over-harvesting of fisheries

Low fuel use

High profits



Disadvantages

Large inputs of land, feed, and water

Large waste output

Loss of mangrove forests and estuaries

Some species fed with grain, fish meal, or fish oil

Dense populations vulnerable to disease

Trade-Offs

Animal Feedlots

Advantages

Increased meat production

Higher profits

Less land use

Reduced overgrazing

Reduced soil erosion

Protection of biodiversity



Disadvantages

Large inputs of grain, fish meal, water, and fossil fuels

Greenhouse gas (CO₂ and CH₄) emissions

Concentration of animal wastes that can pollute water

Use of antibiotics can increase genetic resistance to microbes in humans

Trade-Offs

Genetically Modified Crops and Foods

Advantages

Need less fertilizer

Need less water

More resistant to insects, disease, frost, and drought

Grow faster

May need less pesticides or tolerate higher levels of herbicides

May reduce energy needs



Disadvantages

Unpredictable genetic and ecological effects

Harmful toxins and new allergens in food

No increase in yields

More pesticide-resistant insects and herbicide-resistant weeds

Could disrupt seed market

Lower genetic diversity

WASTE MANAGEMENT

Trade-Offs

Sanitary Landfills

Trade-Offs

Clear-Cutting Forests

Advantages

Higher timber yields

Maximum profits in shortest time

Can reforest with fast-growing trees

Good for tree species needing full or moderate sunlight



Disadvantages

Reduces biodiversity

Destroys and fragments wildlife habitats

Increases water pollution, flooding, and erosion on steep slopes

Eliminates most recreational value

Trade-Offs

Conventional Chemical Pesticides

Advantages

Save lives

Increase food supplies

Profitable

Work fast

Safe if used properly



Disadvantages

Promote genetic resistance

Kill natural pest enemies

Pollute the environment

Can harm wildlife and people

Are expensive for farmers

Trade-Offs

Withdrawing Groundwater

Advantages

Useful for drinking and irrigation

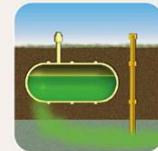
Available year-round

Exists almost everywhere

Renewable if not overpumped or contaminated

No evaporation losses

Cheaper to extract than most surface waters



Disadvantages

Aquifer depletion from overpumping

Sinking of land (subsidence) from overpumping

Aquifers polluted for decades or centuries

Saltwater intrusion into drinking water supplies near coastal areas

Reduced water flows into surface waters

Increased cost and contamination from deeper wells

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Trade-Offs

Recycling

Advantages

- Reduces air and water pollution
- Saves energy
- Reduces mineral demand
- Reduces greenhouse gas emissions
- Reduces solid waste production and disposal
- Helps protect biodiversity
- Can save landfill space
- Important part of economy



Disadvantages

- Can cost more than burying in areas with ample landfill space
- May lose money for items such as glass and some plastics
- Reduces profits for landfill and incinerator owners
- Source separation is inconvenient for some people

Trade-Offs

Surface Impoundments

Advantages

- Low cost
- Wastes can often be retrieved
- Can store wastes indefinitely with secure double liners



Disadvantages

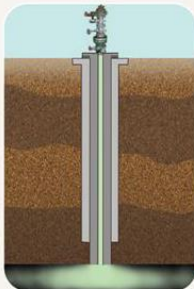
- Groundwater contamination from leaking liners (and overflow from flooding)
- Air pollution from volatile organic compounds
- Output approach that encourages waste production

Trade-Offs

Deep-Well Disposal

Advantages

- Safe if sites are chosen carefully
- Wastes can often be retrieved
- Low cost



Disadvantages

- Leaks from corrosion of well casing
- Emits CO₂ and other air pollutants
- Output approach that encourages waste production

Trade-Offs

Plasma Arc

Advantages

- Small
- Mobile. Easy to move to different sites
- Produces no toxic ash



Disadvantages

- High cost
- Produces CO₂ and CO
- Can release particulates and chlorine gas
- Can vaporize and release toxic metals and radioactive elements

REGULATION

Trade-Offs

Carbon and Energy Taxes

Advantages

- Simple to administer
- Clear price on carbon
- Covers all emitters
- Predictable revenues



Disadvantages

- Tax laws can get complex
- Vulnerable to loopholes
- Doesn't guarantee lower emissions
- Politically unpopular

Trade-Offs

Tradable Environmental Permits

Advantages

- Flexible
- Easy to administer
- Encourage pollution prevention and waste reduction
- Permit prices determined by market transactions



Disadvantages

- Big polluters and resource wasters can buy their way out
- May not reduce pollution at dirtiest plants
- Caps can be too high and not regularly reduced to promote progress
- Self-monitoring of emissions can allow cheating



Trade-Offs

Environmental Taxes and Fees

Advantages

- Help bring about full-cost pricing
- Encourage businesses to develop environmentally beneficial technologies and goods to save money
- Easily administered by existing tax agencies



Disadvantages

- Low-income groups are penalized unless safety nets are provided
- Hard to determine optimal level for taxes and fees
- Governments may use money as general revenue instead of improving environmental quality and reducing taxes on income, payroll, and profits

Trade-Offs

Global Efforts to Solve Environmental Problems

Good News

- Over 500 international environmental treaties and agreements
- UN Environment Programme negotiates and monitors environmental treaties
- 1992 Rio Earth Summit adopted principles for handling global environmental problems
- 2002 Johannesburg Earth Summit tried to implement 1992 Rio summit policies and goals



Bad News

- Most international environmental treaties lack criteria for evaluating their effectiveness
- 1992 Rio Earth Summit led to nonbinding agreements, inadequate funding, and little improvement in major problems by 2010
- 2002 Johannesburg Earth Summit failed to deal with climate change, biodiversity loss, and poverty
- 2009 Copenhagen conference failed to deal with projected climate change