Comparison of renewable and conventional energy sources

Renewable energy: ‘Energy obtained from natural and persistent flows of energy occurring in the immediate environment’. An obvious example is solar (sunshine) energy. Such energy may also be called Green Energy or Sustainable Energy.

Non-renewable energy: ‘Energy obtained from static stores of energy that remain underground unless released by human interaction’. Examples are nuclear fuels and fossil fuels of coal, oil and natural gas.

such energy supplies are also called finite supplies or Brown Energy.

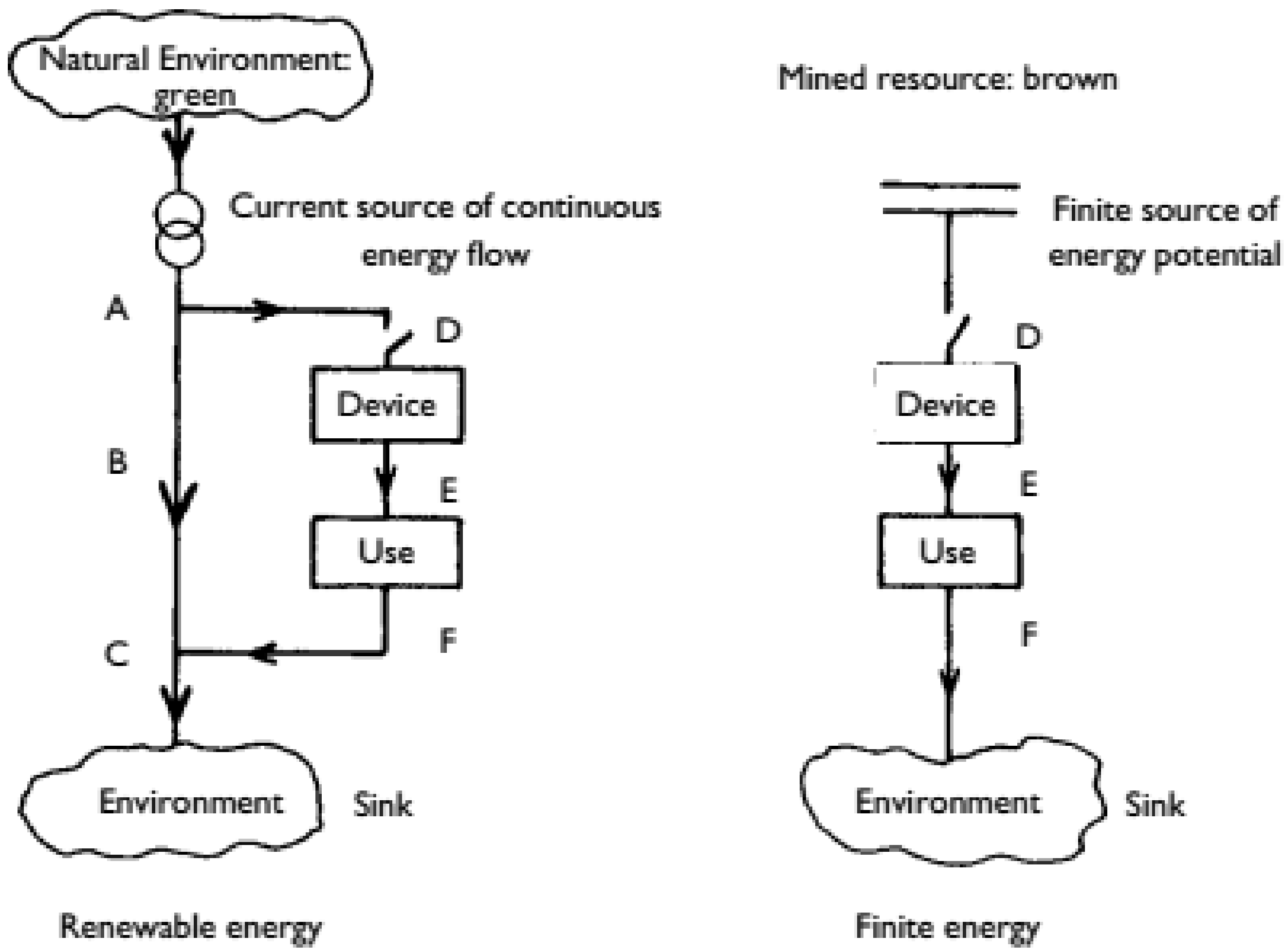


Figure 1.1 Contrast between renewable (green) and finite (brown) energy supplies. Environmental energy flow ABC, harnessed energy flow DEF.

Table 1.1 Comparison of renewable and conventional energy systems

	Renewable energy supplies (green)	*Conventional energy supplies (brown)*
Examples	Wind, solar, biomass, tidal	Coal, oil, gas, radioactive ore
Source	Natural local environment	Concentrated stock
Normal state	A current or flow of energy. An income	Static store of energy. Capital
Initial average intensity	Low intensity, dispersed: $\leq 300\,\mathrm{W\,m^{-2}}$	Released at $\geq 100\,\mathrm{kW\,m^{-2}}$
Lifetime of supply	Infinite	Finite
Cost at source	Free	Increasingly expensive.
Equipment capital cost per kW capacity	Expensive, commonly $\approx$US\$1000 $\mathrm{kW^{-1}}$	Moderate, perhaps \$500 $\mathrm{kW^{-1}}$ without emissions control; yet expensive >US\$1000 $\mathrm{kW^{-1}}$ with emissions reduction
Variation and control	Fluctuating; best controlled by change of load using positive feedforward control	Steady, best controlled by adjusting source with negative feedback control
Location for use	Site- and society-specific	General and invariant use
Scale	Small and moderate scale often economic, large scale may present difficulties	Increased scale often improves supply costs, large scale frequently favoured
Skills	Interdisciplinary and varied. Wide range of skills. Importance of bioscience and agriculture	Strong links with electrical and mechanical engineering. Narrow range of personal skills
Context	Bias to rural, decentralised industry	Bias to urban, centralised industry
Dependence	Self-sufficient and 'islanded' systems supported	Systems dependent on outside inputs
Safety	Local hazards possible in operation: usually safe when out of action	May be shielded and enclosed to lessen great potential dangers; most dangerous when faulty
Pollution and environmental damage	Usually little environmental harm, especially at moderate scale Hazards from excess biomass burning Soil erosion from excessive biofuel use Large hydro reservoirs disruptive Compatible with natural ecology	Environmental pollution intrinsic and common, especially of air and water Permanent damage common from mining and radioactive elements entering water table. Deforestation and ecological sterilisation from excessive air pollution Climate change emissions
Aesthetics, visual impact	Local perturbations may be unpopular, but usually acceptable if local need perceived	Usually utilitarian, with centralisation and economy of large scale

Ultimate Energy sources

There are five ultimate primary sources of useful energy:

1 The Sun.
2 The motion and gravitational potential of the Sun, Moon and Earth.
3 Geothermal energy from cooling, chemical reactions and radioactive decay in the Earth.
4 Human-induced nuclear reactions.
5 Chemical reactions from mineral sources.

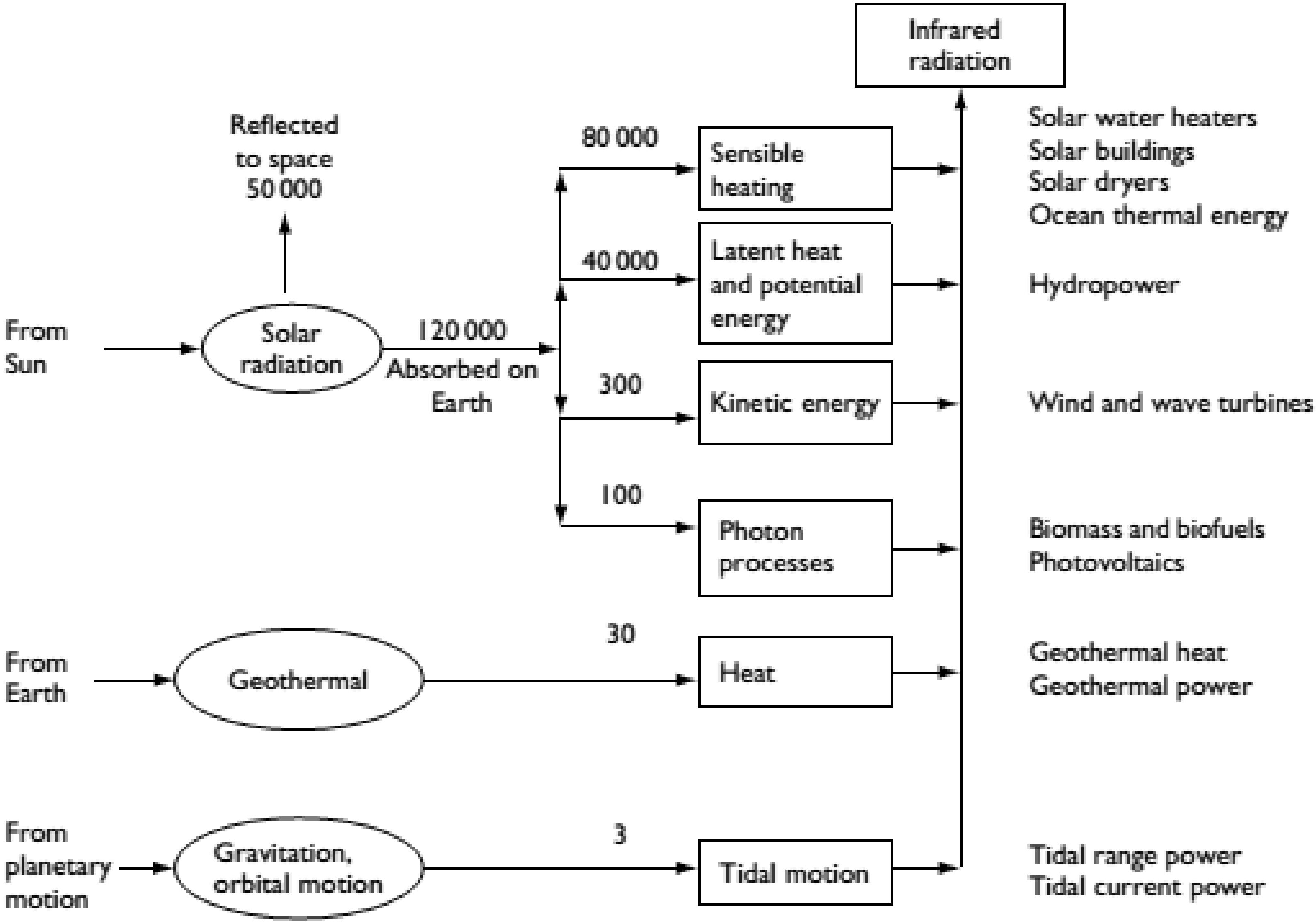


Figure 1.2 Natural energy currents on earth, showing renewable energy system. Note the great range of energy flux ($1:10^5$) and the dominance of solar radiation and heat. Units terawatts (10^{12} W).

Primary supply to end-use

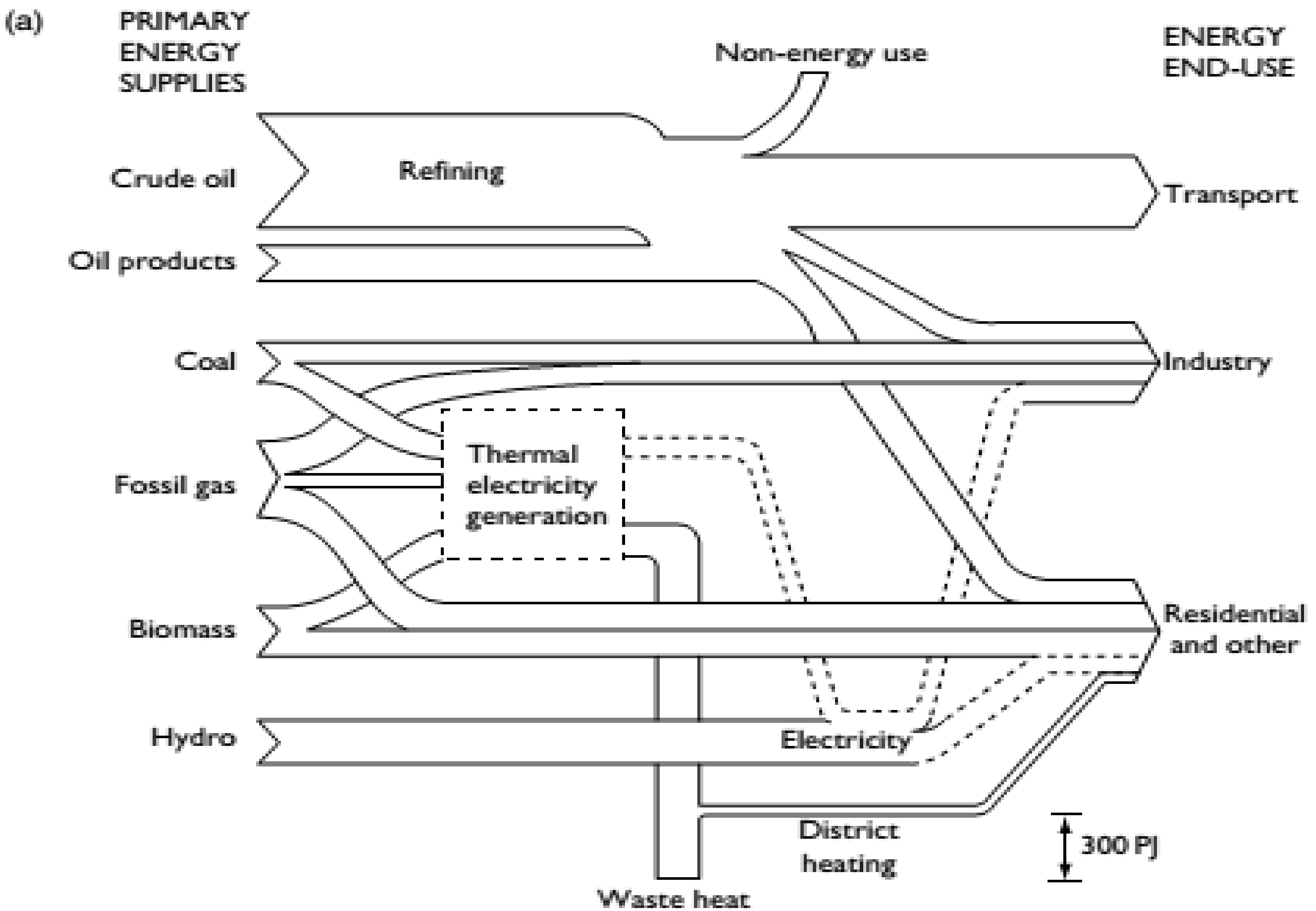
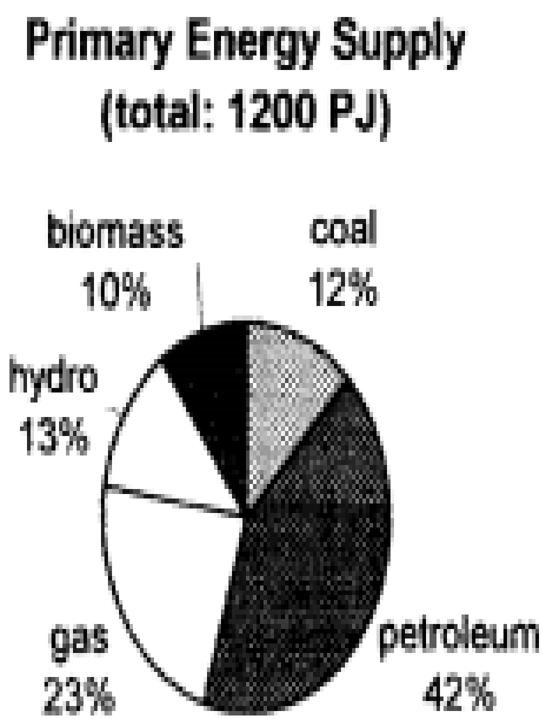
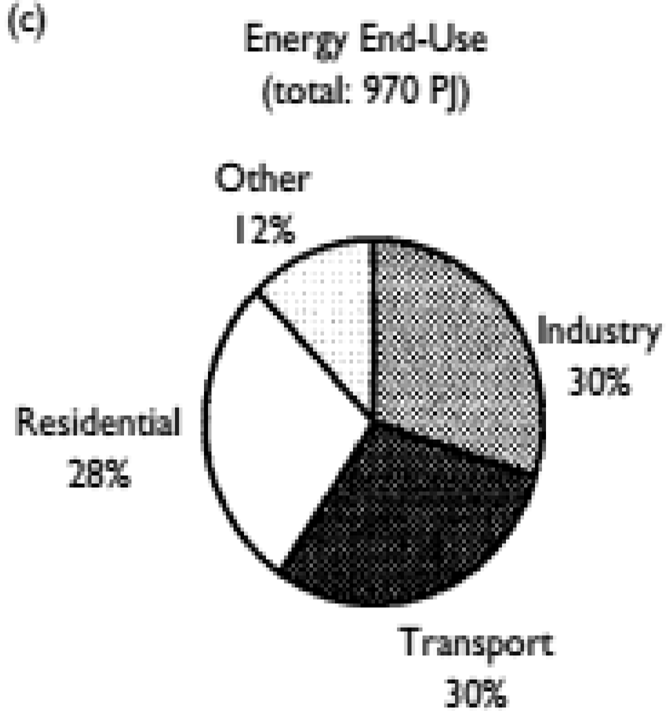


Figure 1.3 Energy flow diagrams for Austria in 2000, with a population of 8.1 million. (a) Sankey ('spaghetti') diagram, with flows involving thermal electricity shown

(b)


Primary Energy Supply
(total: 1200 PJ)
biomass
10%
coal
12%
hydro
13%
gas
23%
petroleum
42%

(c)


Energy End-Use
(total: 970 PJ)
Other
12%
Industry
30%
Residential
28%
Transport
30%

Energy planning:

Complete energy systems must be analyzed, and supply should not be considered separately from end-use. Unfortunately precise needs for energy are too frequently forgotten, and supplies are not well matched to end-use. Energy losses and uneconomic operation therefore frequently result.

Energy efficiency :

calculations can be most revealing and can pinpoint unnecessary losses. Here we define ‘efficiency’ as the ratio of the useful energy output from a process to the total energy input to that process.

Energy management:

It is always important to improve overall efficiency and reduce economic losses. No energy supply is free, and renewable supplies are usually more expensive in practice than might be assumed. Thus there is no excuse for wasting energy of any form unnecessarily. Efficiency with finite fuels reduces pollution; efficiency with renewables reduces capital costs.