



# Dictionary of Energy Technology

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# Dictionary of Energy Technology

*By the same author*

*Air Pollution*

*Control of Air Pollution*

*Dictionary of Economic Terms*

*Dictionary of Environmental Terms*

*Dictionary of Fuel Technology*

*Environment Policy in Australia*

*The Australian Environment: Twelve Controversial Issues*

To

ELIZABETH, STUART AND DAVID

# Preface

This work first appeared, as a *Dictionary of Fuel Technology*, 12 years ago. Its emphasis was on the commonplace solid, liquid and gaseous fuels and fuel-burning installations. While embracing nuclear power, it paid scant attention to 'other sources of energy', and to the political, economic and environmental content of a subject which has now moved to the centre of world affairs.

This new work, while resting upon the foundations of the old, attempts to broaden the perspectives so that energy and its uses are considered in a contemporary setting. While a fair amount of technology and science pervades the book, there is no longer a tacit acceptance that energy can be treated in an isolated manner.

The work has been strengthened by my several years with the Central Electricity Generating Board in London. Furthermore, in the successful pursuit of a doctorate relating to the role of nuclear power within electricity supply systems, I have gained a deeper understanding of the economic and environmental aspects of the subject.

Much benefit has also been gained from visits to the United States of America, Canada, Scotland, Scandinavia and western European countries generally, together with the Soviet Union, to meet the principal agencies concerned with energy and the environment. Attendance at international conferences, including the UN Conference on the Human Environment in 1972, has also been valuable.

Against an enhanced background, this new book has been written. It is hoped that it will prove of interest and value to a wide range of professional people with interests in the subject, and to those concerned members of the public who follow closely key issues affecting the welfare and survival of an emerging species.

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## Common Abbreviations

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AGR	advanced gas-cooled reactor
AIE	Australian Institute of Energy
API	American Petroleum Institute
ASTM	American Society for Testing Materials
BNOC	British National Oil Corporation
BSI	British Standards Institution
BWR	boiling water reactor
CANDU	Canadian deuterium uranium reactor
CEGB	Central Electricity Generating Board
CEQ	Council of Environmental Quality (US)
ECCS	emergency core cooling system
EEC	European Economic Community
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency (US)
ERDA	Energy Research and Development Administration (US)
FAO	Food and Agriculture Organisation (UN)
FBR	fast breeder reactor
FEA	Federal Energy Administration (US)
HTGR	high-temperature gas-cooled reactor
IAEA	International Atomic Energy Agency
ICRP	International Commission for Radiological Protection
IE	Institute of Energy (UK)
IEA	International Energy Agency
IMCO	Inter-governmental Maritime Consultative Organisation
IP	Institute of Petroleum (UK)
LWR	light water reactor
NCB	National Coal Board (UK)
NEAC	National Energy Advisory Committee (Australia)
NPT	Non-Proliferation Treaty for Nuclear Weapons
NRC	Nuclear Regulatory Commission (US)
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
PHWR	pressurised heavy water reactor
PWR	pressurised water reactor
SGHWR	steam-generating heavy water reactor
VLCC	very large crude carrier
WHO	World Health Organisation
WMO	World Meteorological Organisation

## Scientific Units and Abbreviations

absolute	abs	henry	H
alternating current	AC	hertz	Hz
ampere	A	horsepower	hp
ångström	Å	hour	h
atmosphere	atm		
atomic number	at. no.	inch	in
atomic weight	at. wt.	inch of mercury	inHg
boiling point	b.p.		
British thermal unit	Btu	joule	J
calorie	cal	Kelvin	K
candela	cd	kilocalorie	kcal
centigrade heat unit	Chu	kilogram	kg
centimetre	cm	kilogram per cubic	
centipoise	cP	metre	kg/m <sup>3</sup>
centistokes	cSt	kilograms per hour	kg/h
coulomb	C	kilometre	km
cubic inch	in <sup>3</sup>	kilometres per hour	km/h
cubic centimetre	cm <sup>3</sup>	kilowatt	kW
cubic decimetre	dm <sup>3</sup>	kilowatt-hour	kWh
cubic metre	m <sup>3</sup>		
cubic millimetre	mm <sup>3</sup>	litre	l
curie	c	lumen	lm
		lux	lx
day	d		
dyne	dyn	maximum continuous	
degree Celsius		rating	MCR
(Centigrade)	°C	megajoule	MJ
degree Fahrenheit	°F	megawatt	MW
degree Rankine	°R	melting point	m.p.
direct current	DC	metre	m
		metre per second	m/s
electromotive force	emf	metre per second	
		squared	m/s <sup>2</sup>
farad	F	micrograms per cubic	
foot	ft	metre	μm <sup>3</sup>
		micron	μm
grain	gr	milligram	mg
gram	g	milligrams per cubic	
grams per cubic metre	g/m <sup>3</sup>	metre	mg/m <sup>3</sup>
grams per hour	g/h	millilitre	ml
grams per kilometre	g/km	millimetre	mm
grams per square metre	g/m <sup>2</sup>	millimetre of mercury	mmHg
		minute	min
hectare	ha	molecular weight	mol. wt.



nanometre	nm	specific gravity	sp. gr.
newton	N	specific heat	sp. ht.
newton per square		square inch	in <sup>2</sup>
metre	N/m <sup>2</sup>	square centimetre	cm <sup>2</sup>
normal cubic metre	Nm <sup>3</sup>	square decimetre	dm <sup>2</sup>
normal temperature and		square kilometre	km <sup>2</sup>
pressure	NTP	square metre	m <sup>2</sup>
		square millimetre	mm <sup>2</sup>
ohm	Ω	standard temperature	
		and pressure	STP
poise	P	stokes	St
pound	lb		
pound-force	lbf	tesla	T
poundal	pdl		
parts per hundred		volt	V
million	pphm		
parts per million	ppm	water gauge	w.g.
		watt	W
revolution per minute	rev/min	weber	Wb
		weight	wt.
second	s		
second per second	s <sup>2</sup>	yard	yd

## A

Å See *Ångström*.

**Abel flash point apparatus** Apparatus for determining the *flash point* of petroleum products which flash below 50° C. It consists of a test cup to hold the sample, a lid which carries a thermometer, a test flame device and a stirrer; the test cup is mounted in a water-bath with an annular air space between the two. The temperature of the water-bath is slowly raised and with it the temperature of the oil sample; at regular intervals the test flame is applied through a special aperture to the interior of the cup, the temperature at which a flash occurs in the vapour space being recorded as the 'flash point'. See *Pensky-Martens flash point apparatus*.

**Abiotic** Non-biological; thus an abiotic element is a physical or chemical feature of an *ecosystem* or an *environment*.

**Absolute humidity** The ratio of the mass of water vapour to the volume occupied by a mixture of water vapour and dry air. It is calculated:

$$d_v = \frac{m_v}{V} \text{ g/m}^3$$

in which:

$d_v$  = density of water vapour;

$m_v$  = mass of water vapour, g;

$V$  = volume of water vapour and dry air, m<sup>3</sup>.

See *relative humidity*.

**Absolute pressure** A pressure expressed with zero pressure as the datum, compared with gauge pressure using atmospheric pressure as the datum. Zero pressure is -760 mmHg (approximately -14.7 lb/in<sup>2</sup>). In SI units the pascal (Pa) is the unit of pressure, with some usage of the bar (1 bar = 100 000 Pa). The bar is approximately equal to atmospheric pressure. Hence, absolute pressure is -10<sup>5</sup> Pa or -1 bar.

**Absolute temperature** Temperature measured from absolute zero; that is, the temperature at which a *perfect gas*, kept at constant

volume, exerts no pressure. It is equal to zero on the **Kelvin scale**; it is also equal to  $0^{\circ}\text{R}$ ,  $-273.15^{\circ}\text{C}$  and  $-459.67^{\circ}\text{F}$ . Absolute zero is also the level at which any gas would theoretically be reduced to zero volume, since gases, at constant pressure, lose approximately  $1/273$  of their volume at  $0^{\circ}\text{C}$  for each fall of  $1^{\circ}\text{C}$  in their temperature. *See temperature scales.*

**Absolute thermodynamic temperature** *See Kelvin scale.*

**Absolute viscosity** *See dynamic viscosity; viscosity.*

**Absolute zero** *See absolute temperature.*

**Absorption** The passing of a substance or force into the body of another substance; a liquid may be absorbed and held by cohesion or capillary action in the pores of a solid; or gaseous molecules may be held between the molecules of a liquid. The characteristic waves of heat or light radiations may be retained by a solid, liquid or gas, being transformed into either kinetic energy or greater molecular vibrations, when the temperature of the absorbing substance rises; or into excited atoms or molecules when the substance becomes fluorescent. *See adsorption.*

**Absorption coefficient** (1) The volume of gas, measured at normal temperature and pressure, dissolved by unit volume of a liquid under a pressure of one atmosphere. (2) The degree to which a substance will absorb radiant energy. When a parallel beam of radiation passes through a small thickness,  $x$ , of a uniform substance, the fraction absorbed is  $u_a x$ , where  $u_a$  is the absorption coefficient of the substance for the radiation.

**Absorption control** In respect of a **nuclear reactor**, the use of a neutron absorber to absorb some of the neutrons and vary the reactivity. The absorber, usually cadmium or boron, is incorporated in control rods. The position of these rods can be varied in relation to the core of the reactor.

**Absorption oil** An oil of high affinity for the light hydrocarbons. *See Absorption Plant.*

**Absorption plant** A plant for recovering the condensable portion of natural or plant gas, by absorbing these hydrocarbons in an **absorption oil**, usually under pressure, followed by separation and fractionation of the absorbed material. *See natural gasoline.*

**Absorptivity** The fraction of incident radiation which is absorbed by a surface on which it falls; a perfect absorber is a **black body**. The absorptivity of a material is numerically equal to its **emissivity**.

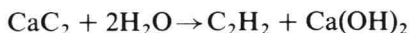
**Abundance ratio** The ratio of the number of atoms of one isotope to others of the same element, in a natural or enriched material. *See isotopes.*

**Acceleration** The rate of change of velocity, measured as a change in velocity in unit time—e.g. metres per second per second ( $\text{m/s}^2$ ).

**Accelerator** A machine for accelerating to high kinetic energy

charged atomic particles such as electrons, protons, deuterons and helium ions. Common machines are the cyclotron, synchrocyclotron, synchrotron, betatron, linear accelerator and Van de Graaff accelerator.

**Acetylene**  $C_2H_2$ . A colourless, poisonous, gaseous fuel. It may be produced by the chemical reaction of calcium carbide and water:



Hydrated lime is a by-product of the process. It is also manufactured from methane, heavy gas oil and naphtha. In one example, oxygen and *natural gas* are preheated to 510–650° C and mixed, there being insufficient oxygen for complete combustion; the reaction achieved is:



Acetylene is an important industrial gas; an oxygen and acetylene mixture (used with an oxyacetylene torch) burns with the highest temperature of any common combustible gas, and, hence, has great value welding and cutting steel and other metals. The temperature of the inner brilliant part of the flame has been estimated to be of the order of 3300° C. Acetylene has a gross calorific value of about 57 MJ/m<sup>3</sup>. *See Neutral Flame.*

**Acid** A substance which, in solution in water, forms hydrogen ions.

Acids neutralise alkalis, with the formation of salts. *See pH.*

**Acid chimney** A chimney in which the temperature of the process waste gases is below the *dew point* of the vapours, so that acidic condensates are formed. Such chimneys require special acid-resisting linings. In cases where the problem is marginal, insulation of the chimney may be sufficient to keep the gases above acid dew point.

**Acid cleaning** A common method of internal cleaning of pipework, tanks, heater shells, boilers and condensers; acid is circulated to remove dirt or scale.

**Acid dew point** *See sulphur cycle; sulphur dioxide.*

**Acid refractories** Refractory materials containing over 90 per cent of *silica*; they are used in open-hearth and other metallurgical furnaces to resist high temperatures and attack by acid slags.

**Acid sludge** A black, viscous residue left after the treatment of petroleum oils with sulphuric acid for the removal of impurities. The sludge contains both spent acid and the impurities removed from the oil. *See acid treatment.*

**Acid soot (or acid smut)** An agglomeration of carbon particles held together by moisture which has become acidic through combination with sulphur trioxide; soot particles range in size from about 1 mm to about 3 mm in diameter. The carbon particles are mainly

coke spheres produced during combustion. Acid soot emitted from chimneys leaves brown stains on materials and damages paint-work; the brown stain is caused by iron sulphate. The problem has been mainly associated with oil-fired installations equipped with metal chimneys. The potential hazard can be reduced by using fuels of relatively low sulphur content; operating plant with a minimum of excess air in order to reduce the formation of sulphur trioxide; the elimination of air in-leakage to flues; the raising of backend temperatures; the use of additives; or the insulation of chimneys and ductwork; or by a combination of such measures.

**Acid treatment** (1) In respect of oil wells, the use of hydrochloric acid in limestone formations to enlarge production channels and improve the movement of fluid towards the well; hydrochloric acid is used for the ease with which it will attack limestone. (2) An oil refinery process in which unfinished petroleum products, such as gasoline, kerosine, diesel fuel and lubricating stocks, are brought into contact with sulphuric acid to improve their colour, odour and other properties. *See acid sludge.*

**Acre-foot** A unit representing a volume of water sufficient to cover an acre of land to a depth of one foot.  $1 \text{ acre-foot} = 43\,560 \text{ ft}^3 = 1233.48 \text{ m}^3$ .

**Actinides** Elements with 89 or more protons in their nuclei; they include uranium and plutonium. Many are long-lived alpha-emitters.

**Activity** The number of disintegrations per unit time taking place in a radioactive specimen. The unit of activity is the *curie*.

**Additives** *See detergent; diesel index; gasoline additives; lead susceptibility; pour point depressant; viscosity index improver.*

**Adiabatic** Without loss or gain of heat to a system. Thus, an adiabatic change is a change in the volume and pressure of a parcel of gas without exchange of heat between the parcel and its surroundings.

**Adiabatic efficiency** In respect of a *steam engine* or *steam turbine*, the ratio of the work done per pound of steam to the available energy represented by the *adiabatic heat drop*.

**Adiabatic heat drop** In respect of a *steam engine* or *steam turbine*, the heat energy released and theoretically capable of transformation into mechanical work during the *adiabatic* expansion of unit weight of steam.

**Adiabatic lapse rate** *See lapse rate.*

**Administered pricing** Pricing by 'price makers', not 'price takers' as under truly competitive conditions; the pricing policies of monopolistic and oligopolistic sellers. Administered prices tend to be cost-determined—i.e. they are arrived at by applying various

percentages to direct labour and material costs to allow for overheads and profits. The adjustment of production to changes in demand tends to take place independently of price changes through stock adjustments; production is reduced in response to an accumulation of unsold goods and raised in the face of a depletion.

**Adsorption** The taking up of one substance on the surface of another; adhesion. Adsorbents in industrial use include activated carbon, activated alumina, silica gel and fuller's earth. *See absorption.*

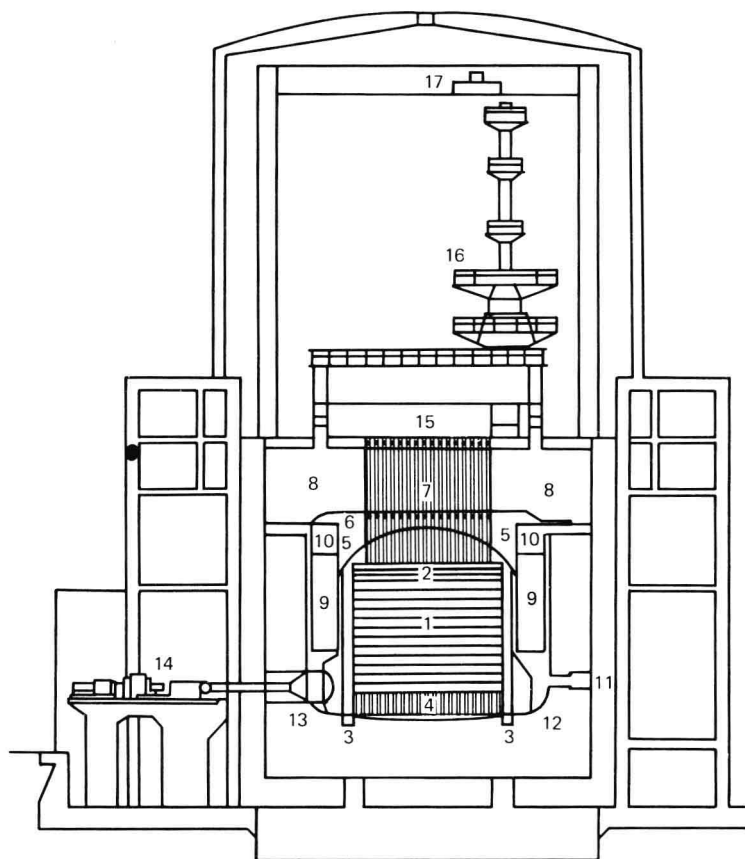
**Advanced gas-cooled reactor (AGR)** An improved design of *nuclear reactor*, compared with its predecessor of Magnox design. As in the Magnox reactor, the heat of fission is removed from the reacting core by circulating carbon dioxide under pressure through it and passing this coolant gas through a boiler; graphite is also used as a moderator. The fuel elements, however, are made not of metallic uranium in a magnesium can, but of uranium oxide in a stainless steel can. This enables the heat of fission to be removed at a higher temperature in the coolant gas, and higher steam temperatures and pressures in the boilers can be achieved. The reactor shell may be protected from excessive heat by the use of a 'hot box' or heat exchanger, the gases only coming into contact with the shell after being in contact with the heat exchanger. Dungeness 'B' nuclear power station is of AGR design. *See Figure A.1.*

**Adventitious ash** Incombustible materials such as shale, clay, *pyrites*, *ankerite*, dirt from earthy or stony bands in coal seams, and fragments of stone from the roof or floor of a seam, which are found in *run-of-mine coal*. During mechanical cleaning, much of the adventitious material can be removed. *See ash; inherent ash.*

**Advisory Council on Energy Conservation (ACEC)** An advisory body responsible to the UK *Department of Energy* to assist in the formulation of plans for energy conservation. An ACEC report on energy conservation was published by the Department of Energy in 1975. The report made recommendations on ways of saving energy through prices policy, education and training, and policies relating to transport and building regulations.

**Advisory Council on Research and Development for Fuel and Power (ACORD)** An advisory body responsible to the UK *Department of Energy* to assist in the formulation of future plans for research and development in the energy technologies. A discussion document, *Energy R & D in the United Kingdom*, was released in 1978.

**Aerated burner** A *gas burner* in which the gas induces primary air immediately before the burner ports. *See bunsen burner.*



*Figure A.1* Dungeness 'B' nuclear power station

- |                                    |                       |
|------------------------------------|-----------------------|
| 1. Core and reflector              | 9. Boiler             |
| 2. Top shield                      | 10. Steam outlet      |
| 3. Side shield                     | 11. Feed water inlet  |
| 4. Support structure               | 12. Plenum chamber    |
| 5. Pressure cylinder               | 13. Circulator        |
| 6. Thermal insulation              | 14. Circulator drive  |
| 7. Fuelling and control standpipes | 15. Charge face       |
| 8. Concrete pressure vessel        | 16. Fuelling machine  |
|                                    | 17. Charge face crane |

(Source: Central Electricity Generating Board, London)

**Dungeness 'B' Nuclear Power Station: operating data**

Net electrical output	1200 MW
Gross generation	1320 MW
Number of reactors	2
Number of turbo-generators	2
Overall station efficiency	41.5%
Type of fuel	$36 \times 0.57$ in pin clusters
Number of fuel elements in stringer	8
Mean fuel rating for reactor	9.5 MW/tonneU
Initial enrichment	1.47/1.76%
Feed enrichment	1.99/2.42%
Refuelling	continuous on load with axial shuffle
Lattice pitch	15.5 in
Lattice geometry	square
Active core height	27 ft
Active core diameter	31 ft
Total number of channels	465
Number of fuel channels at equilibrium	412
Channel gas inlet temperature	320° C (608° F)
Channel gas outlet temperature	675° C (1247° F)
Peak can temperature	800° C (1472° F)
Circulator outlet pressure	450 lbf/in <sup>2</sup> abs
Number of circulators per reactor	4
Type of circulator	centrifugal
Circulator speed	1500 rev/min
Speed variation	fluid drive coupling
Circulator drive	synchronous motor
Circulator installed power, each	16 500 hp
Type of boiler	once-through
Steam pressure	2315 lbf/in <sup>2</sup> abs
Steam temperature	565° C (1050° F)
Steam flow	3.7 M lb/h
Reheat pressure	556 lbf/in <sup>2</sup> abs
Reheat temperature	565° C (1050° F)
Condenser vacuum	28.9 inHg
Cooling water inlet temperature	14° C (57° F)



**Aerated test burner** A test burner designed to provide a rapid appreciation of gas quality; it measures the amount of air required to give a stable, well-defined, blue inner cone. The *ATB Number* is the extent to which the air inlet shutter is opened to give the standard size of inner cone.

**Aerodynamics** A branch of dynamics that deals with the motion of air and other gases, and the forces acting upon bodies passing through them—particularly aircraft, missiles and rockets.

**Aerosol** A particle of solid or liquid matter of such small size that it can remain suspended in the atmosphere for a long period of time; aerosols diffuse light, and the larger particles settle out on horizontal surfaces or cling to vertical surfaces. All air contains aerosols, the larger particles, above 5  $\mu\text{m}$  in size, being filtered out in the nose or bronchia. The smaller particles, below 5  $\mu\text{m}$  in size, pass into the lungs; they may be expelled immediately or retained for varying periods of time. Aerosols are classified into smoke, fumes, dust and mists.

**After-burner** A burner located in the exit gases from a combustion process, providing sufficient heat to destroy smoke and odours.

**After-heat** In respect of a *nuclear reactor*, heat produced by the decay of the fission products in the fuel elements, after the reactor has been shut down.

**Agglomeration** The clustering or adhering together of a number of small particles to form a larger single entity or 'agglomerate'. Agglomeration has been associated with small particles in chimney-stacks.

**Air** See *atmosphere; excess air; nitrogen; oxygen; primary air; secondary air; tertiary air; theoretical air*.

**Air-assisted pressure jet burner** A type of *pressure jet burner* in which low-pressure air is utilised to assist atomisation, provide directional stability and promote primary zone turbulence. See *oil burner*.

**Air blanketing** An accumulation of air in a heat exchanger or other vessel which impedes or prevents the transfer of heat.

**Air count** The determination of the amount of radioactivity in a standard volume of air; in one method the prescribed volume of air is drawn through a filter paper on which the radioactive solids are deposited.

**Air director** See *air register*.

**Air-dried coal** Coal exposed to the atmosphere in a dry well-ventilated place, protected against the weather, so that it loses by evaporation most of its free or surface moisture. Coal is analysed in this condition to give the percentages of *inherent moisture, volatile matter, fixed carbon* and *ash*. See *free moisture; proximate analysis; ultimate analysis*.

**Air filter** A device for removing particulate matter from an air