



DICTIONARY OF ENERGY



SECOND EDITION

CUTLER J. CLEVELAND
CHRISTOPHER MORRIS



DICTIONARY OF Energy

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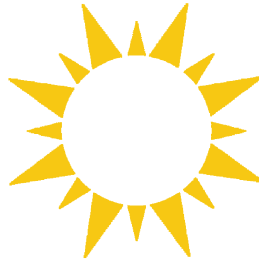
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DICTIONARY OF Energy

Second Edition

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Editors-in-Chief

Cutler J. Cleveland is Professor of Earth and Environment at Boston University, where he also is on the faculty of the Center for Energy and Environmental Studies. He is a Senior Fellow at the National Council for Science and the Environment in Washington D.C., where he serves on the Executive Board of the Council of Energy Research and Education Leaders (CEREL). Professor Cleveland also serves as Chief Education Officer at Trunity, Inc., a leading global provider of digital textbooks and eLearning solutions which is based in Portsmouth, NH. In addition to this *Dictionary of Energy*, Professor Cleveland is the author or editor of other acclaimed works on energy and environment, including the *Encyclopedia of Energy*, the *Concise Encyclopedia of the History of Energy*, the *Handbook of Energy*, and *Energy and Climate Change: A Primer*. He is co-author of *Environmental Science*, the web's first entirely electronic introductory textbook on the subject, and is also the founding Editor-in-Chief of the *Encyclopedia of Earth*, named the Best Geoscience Website by the Geoscience Information Society. Dr. Cleveland is the recipient of the Adelman-Frankel Award from the United States Association of Energy Economics for "unique and innovative contributions to the field of energy economics." He has received various other awards for his work from organizations such as the American Library Association, International Association of Energy Economics, and National Wildlife Federation, and his findings have been published in such prestigious journals as *Nature*, *Science*, *Ecological Modeling*, *Energy*, *The Energy Journal*, *The Annual Review of Energy*, *Resource and Energy Economics*, and *Ecological Economics*. His research on the valuation of ecosystem services, funded by the National Science Foundation, is highlighted in NSF's Top Discoveries series. Professor Cleveland has been a consultant to numerous private and public organizations, including the Asian Development Bank, United Nations Commission on Sustainable Development, Energy Information Administration, U.S. Environmental Protection Agency, and Charles River Associates.

Christopher Morris is owner of Morris Books, which he founded in 2004 to develop content for various publishers of academic and educational books. During his decades-long career as a professional lexicographer, he has edited thirty different dictionaries covering both general vocabulary and a variety of specific subjects. He is Editor-in-Chief of the award-winning *Academic Press Dictionary of Science and Technology*, which provides the largest resource of scientific terms yet compiled and features special essays by 120 eminent scientists, including nine Nobel laureates. During his tenure as Director of Reference Books for Academic Press USA, his group developed scholarly encyclopedias that won more than twenty major publishing awards, including American Library Association Outstanding References, Choice Magazine Outstanding Academic Books, and Library Journal Best Reference Sources. He also served as chief editor of the Macmillan school dictionary series, which includes several of the largest-selling educational dictionaries in publishing history. In addition to his work on dictionaries and encyclopedias, he has also been a textbook author and editor and has written many scientific glossaries on diverse topics such as biodiversity, ecology, endocrinology, marine mammalogy, microbiology, oncology, reproductive biology, and toxicology.

Cutler Cleveland and Christopher Morris have previously collaborated on other Elsevier works on the subject of energy, namely the *Encyclopedia of Energy* (2004), *Dictionary of Energy* (First Edition, 2006, Expanded Edition 2009), and *Handbook of Energy* (Volume One 2013, Volume Two 2014).

Subject Areas of the Dictionary

Biographies	Hydropower
Biological Energetics	Lighting
Biomass	Materials
Chemistry	Measurement
Climate Change	Mining
Coal	Nuclear
Communication	Oil and Gas
Consumption and Efficiency	Organizations
Conversion	Photovoltaic
Earth Science	Physics
Ecology	Policy
Economics and Business	Refrigeration
Electricity	Renewable/ Alternative Forms
Environment	Social Issues
Geothermal	Solar
Global Issues	Storage
Health and Safety	Sustainable Development
History	Thermodynamics
HVAC (heating/ventilation/ air conditioning)	Transportation
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Preface to the Dictionary

This Preface deals specifically with the development of the second edition of the *Dictionary of Energy*. For a more general description of the Dictionary and the philosophy on which it is based, please see the Preface to the First Edition following this section.

The first edition of the *Dictionary of Energy* was published in 2006. It developed as a result of the collaboration of the editors on an earlier Elsevier reference work, the six-volume *Encyclopedia of Energy* (2004). Each of the nearly 400 articles in that work included a short glossary of terms relating to the subject of the article. From the range of terms covered by these various glossaries, it became apparent to us that the field of energy is served by a vast vocabulary. We also ascertained that no dictionary existing at the time adequately described this vocabulary, and we set out to provide such a resource.

The entry list for the first edition of the Dictionary consisted of about 8,000 headwords and 10,000 entries in all. For this second edition, the number of terms has been greatly expanded and the Dictionary now includes about 10,000 headwords and 13,000 total entries. This total includes new entries for every one of the 40 different subject areas in the book.

The fact that a certain entry is new to this edition does not mean that it has just appeared in the language. With the exception of certain entries relating to important events (e.g., *Deepwater Horizon*, *Fukushima*), it is extremely rare for a new term to immediately show that it is significant enough to be included in this (or any other) dictionary. Terms that have recently come into common use have to go through a sort of trial period to test whether they will endure, as opposed to being used for a short time in some specific context and then fading away.

Although all subject areas of the book have new entries in this edition, these entries are not evenly distributed across all the areas. Oil and Gas has the largest

number of entries of any subject area in the Dictionary, and not surprisingly, it also has by far the largest number of new entries. It includes 175 entries not found in the first edition. This reflects several trends, such as newer extraction techniques (e.g., *fracking fluids*, *compliant-piled tower*), recently developed fields (*Marcellus Shale*, *Bakken Formation*), modern exploration technology (*geohoponoids*, *microfossils*), and industry terms that have now come into general use (*Christmas tree*, *pig*).

Other subject areas that are heavily represented by additional entries in this edition include Consumption and Efficiency, Economics and Business, Storage, and Transportation. In each case these additions are evidence of the impact that energy issues have on the given field. For example, in the case of Consumption and Efficiency, this would mainly be terms having to do with current efforts to develop more energy-efficient devices, vehicles, and buildings (e.g., *fifth fuel*, *passive house*). New entries in Economics and Business indicate the major role that energy companies and energy-related business activities play in the global economy (e.g., *carbon bubble*, *green economy*). New entries in Storage reflect advances in battery technology, as for their use to power vehicles (e.g., *charging station*). Transportation includes new entries dealing with many forms of transportation, but especially those relating to alternative forms of energy and alternative modes of transportation (e.g., *Leaf*, *Tesla*, *living street*).

In various subject areas, new entries in this edition reflect the current emphasis on renewable and alternative energy sources and technologies. Examples of this include *bioclimactic architecture*, *biofuel cell*, *geoexchange*, *molten salt storage*, and *wave energy converter*. Similarly, new entries deal with efforts to use energy in more sustainable and efficient ways, such as *eco-town*, *greenway*, and *no-till farming*.

Another source of new entries is terms dealing with the effect of energy use on the natural world, such as *ocean acidification*,

ice-albedo feedback, and *mountaintop removal mining*, or with efforts (real and potential) to mitigate such effects, such as *solar radiation management*, *carbon zero*, *biotransformation*, and *climate-neutral*. In the same vein, new entries deal with the the effects of energy use on humans, such as *energy poverty*, *food vs. fuel*, and *wind turbine syndrome*.

This second edition has been expanded not only by the addition of relatively new terms, but also by an expansion of the scope of the book to include entries that were not considered to fall within the boundaries of the first edition. A prominent example of this expansion is the category of Biographies; i.e., concise entries for people who have influenced the field of energy in some significant way. This edition includes almost 300 biographical entries that did not appear in the first edition, some of which are for contemporary figures but others for innovators of earlier times, even scholars of the ancient and medieval worlds. The principal reason for the expansion of the biographical entries is that we have now put a greater emphasis on people who influenced the development of nontraditional forms of energy, such as solar power (e.g., Felix Trombe, Frank Shuman), wind power (e.g., Marcellus Jacobs), fuel cells (e.g., Emil Baur), ocean energy (e.g., Georges Claude), hydrogen energy (e.g., Karl Kordesch) and electric/hybrid vehicles (e.g., Robert Davidson, Justus Entz).

This new edition has visual changes as well as textual ones. It has the added value of being printed in color, so that images can be shown in full color. Color is also used for display purposes, such as the special window essays, the running heads and folios (page numbers), and the special letter openers that begin each alphabetical

section. The book includes approximately 225 images, more than 75 percent of which did not appear in the first edition. These range from historic black and white photographs to schematic illustrations to contemporary color photos.

The section entitled “Notable Quotes on Energy” was a unique feature of the first edition, one that a review of the Dictionary in *Nature* described as “a surprise and a real delight.” We have enlarged this section with 65 new quotes, from a wide range of sources such as Thomas Jefferson on climate change, Robert Goddard on rocketry, T. E. Lawrence on Iraqi oil, Chuck Yeager on breaking the sound barrier, and Edward Teller on nuclear waste. These new quotes are distributed throughout history, with about one-third of them prior to 1900, one-half from the 20th century, and the rest from the 21st, culminating with a 2012 statement by George P. Mitchell, the “father of fracking.”

I wish to thank my co-author Cutler Cleveland for the opportunity to collaborate with him once again on an energy book. This volume marks the fifth energy-related project we have undertaken for Elsevier Publishing. For this new edition we received strong support from the book development staff at Elsevier, especially sponsoring editor Candice Janco, editorial managers Sean Coombs and Carrie Bolger, and production manager Mohanambal Natarajan. Henri van Dorssen, Publisher for Energy at Elsevier UK, was the key figure in the development of the First Edition. I also would like to thank Nancy Tobin for guidance on image sources and Peter Jovanovich for initiating my involvement with scientific dictionaries.

Christopher Morris
Morris Books, Escondido, CA, USA
September 2014

Preface to the First Edition

While energy has always been a driving force in the evolution of human culture, its importance has reached new heights in the first decade of the 21st century. Due to its overarching macroeconomic importance, energy is now a precious commodity in global financial markets. Energy issues pervade global geopolitics, and will continue to do so in light of the increasing concentration of oil supplies in the Middle East coupled with rising global energy demand. Energy is central to global environmental change as emissions from energy use contribute significantly to the human component of climate change. Finally, and most importantly, access to modern energy services is a fundamental prerequisite to the alleviating the poverty from the lives of the three billion people living below subsistence level.

In education, energy is the common link between the living and non-living realms of the universe, and thus it is an integrator across all fields in science, technology, engineering, and mathematics education and research. Virtually every discipline investigates some aspect of energy, including history, anthropology, public policy, international relations, human and ecosystem health, economics, technology, physics, geology, ecology, business management, environmental science, and engineering.

The concept of energy is also applicable at all levels of formal education and lifelong learning, including many topics and tools that motivate successful learning. Kindergarten get some of their first exposure to science by learning about heat from the sun. Middle school students learn ecology by examining the flow of energy through a food chain. College students may use a physics textbook that is organized around the concept of energy, learn about international relations by studying the geopolitics of oil, or learn about the effect of taxation on human welfare by studying a tax on carbon dioxide emissions. Consumers are increasingly confronted with decisions about the cost and availability of different forms

of household energy, while diverse groups in civil society organize around political, social, and environmental ramifications of the energy system.

Despite its overarching importance, there is no coherent field of energy studies; the scientific, engineering, economic, and sociological communities share no common energy journals, conferences, or identity. There is a wealth of information about energy, but it is spread across many books, journals, websites, disciplines, ideologies, and user communities. Information about energy tends to target either a particular form of energy or a specific audience. There is no central repository of information that meets diverse user communities, and no primary machinery of communication among those communities. These characteristics of energy information define the formidable barrier to successful teaching and learning related to energy, a barrier we seek to significantly erode, if not eliminate, with the *Dictionary of Energy*.

A commonly agreed upon set of terms and definitions is essential to build communication among disparate groups, and to improving the general public's understanding of energy issues. This is especially true as new words are generated, and old ones are discarded, and as technologies, institutions, and behaviors change. An authoritative dictionary is important for an area in which identical words mean very different things. For example, "efficiency" and "elasticity" mean different things to an economist and an engineer.

The distinguishing features of the *Dictionary* are its integration of the social, natural, and engineering sciences and its breadth of coverage. It covers all academic disciplines and all the multifaceted aspects of the concept of energy. It uses an integrated approach that emphasizes not only the importance of the concept in individual disciplines, such as physics and sociology, but also how energy is used to bridge seemingly disparate fields, such as ecology and economics. The *Dictionary* covers all the environmental, engineering, and physical science topics found in

existing dictionaries. It also covers entirely new areas, such as the economic and sociological aspects of energy use, energy flows in the biological realm, methods of energy modeling and accounting, energy and materials, energy and sustainable development, energy policy, net energy analysis, and energy in world history, among others.

An interdisciplinary dictionary can never be all things to all people. Specialists may be disappointed not to find important but quite narrow terms from their field. But a number of subject-specific dictionaries exist to meet this need. This dictionary is intended to aid students, researchers and the general public in their search for words, ideas, and information about energy from outside their own areas of expertise. There is also the challenge of deciding just how much technical information a definition should include to be accurate, while at the same time being clear to non-specialists. Striking a balance between these sometimes competing ends was the most difficult challenge we faced. These compromises will without doubt not please everyone. However, the breadth and depth of this dictionary far exceed anything attempted to date on the subject of energy. We are convinced that the *Dictionary* will provide a comprehensive, organized body of knowledge for what is certain to continue as a major area of scientific study in the 21st century.

My co-editor Chris Morris added what can only be described as an uncanny combination of vision, enthusiasm, and professionalism for the project. His editorial experience with more than 20 different dictionaries on a wide variety of subjects insured the lexicographic excellence of this work. I learned an immense amount from our collaboration.

Henri van Dorssen at Elsevier was an important champion of the project from the outset, and provided outstanding editorial guidance throughout. Margo Leach and her team at Elsevier put together a highly effective and creative marketing plan. Emily Griset, Brad Strode, Noam Reuveni, Richard Weiss, Tybe Goldberg, Keith Williges, Robyn Kenney, and Alejandra Roman provided invaluable data gathering and analysis.

The Editorial Board was extremely helpful in defining subject areas and providing subject-specific guidance on many terms. The Board is an outstanding collection of scholars from the natural, social, and engineering sciences that are recognized leaders in their fields of research. To all members of our Board, I extend my thanks and congratulations.

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October, 2005

Introduction to the Use of the Dictionary

Selection

The *Dictionary of Energy*, Second Edition includes 10,000 headwords and 13,000 defined entries in all. This entry selection provides a comprehensive description of the vocabulary currently used in the context of energy.

In order for a word to qualify for inclusion in the Dictionary, it has to be either a term that is specific to one or more of the subject areas of energy covered in the book (see discussion of Subject Areas following), or it has to be a general term that has a specialized use in energy; e.g., the use of the terms *sweet* and *sour* to refer to oil and gas components. It also has to be sufficiently qualified in terms of two criteria—frequency and range. Frequency is the sheer number of times that the term occurs in the literature, and range is the variety of reputable sources in which it appears.

Sources

A dictionary of this size draws its entry list from a number of sources. Important sources for this book include other reference works in the energy field; in particular we made an exhaustive study of the vocabulary employed by the hundreds of authors who appear in Elsevier's six-volume *Encyclopedia of Energy*. We also examined existing energy dictionaries and glossaries, books on energy, scientific journals dealing with energy topics, and many energy-related Websites, both scholarly and popular. Finally, we monitored the use of energy terms in the news media, such as the *New York Times*.

Subject Areas

In the planning stage of the Dictionary project, we identified 40 different subject areas that collectively encompass the vocabulary of the energy field (See p. vii of this front matter section for a complete list of these subject areas.)

Subject areas of the Dictionary include familiar industrial forms of energy, such as Coal, Electricity, Nuclear, and Oil & Gas, and

also alternative forms such as Geothermal, Hydrogen, Solar, and Wind. Disciplines of general science that have special relevance to energy are also included, such as Chemistry, Earth Science, Physics, and Thermodynamics. Other subject areas deal with energy-related processes and functions, such as Conversion, Lighting, Mining, Refrigeration, and Transportation. In addition, the Dictionary includes subject areas that are outside the conventional realm of energy but that either impact energy use (e.g., Economics & Business, Organizations, Policy) or are impacted by it (e.g., Climate Change, Environment, Health and Safety).

Alphabetical Order

Entries in the Dictionary are arranged in alphabetical order according to standard lexicographic convention, which dictates that only the letter-by-letter spelling of a given entry is considered in alphabetization. In other words, the sequence of entries is not affected by the presence or absence of a word space or punctuation. For example note the following sequence:

acid
acid-based
acid deposition
acidolysis
acid rain

When two entries have the same spelling, the more common of the two will appear first. For example:

mill a machine or device for grinding grain . . .
mill a monetary cost and billing unit . . .

The only exception to this is when one of the terms is derived from the other; the source term then appears first. This is often the case when a common word is derived from a proper name, such as *Watt/watt* or *Curie/curie*.

Entry Format

The typical entry in the Dictionary consists of three elements: the headword, the subject area, and the definition. Many entries also have a fourth element, the word origin (see further discussion of Word Origins below).

Reitwagen *History*. a two-wheeled vehicle built (1885) by automotive pioneer Gottlieb Daimler, employing what is considered to be the first successful version of the modern gas engine. [A German term for "riding carriage."]

Headwords

The headword, also known as the main entry or entry word, is the particular term being defined, such as *langley* in the following example. The headword appears in **boldface** and is written exactly as it would appear in print.

langley *Solar*. a measure of solar energy flux per area . . .

Thus, the headword is capitalized if it is customarily written that way in context (such as with the previous example *Reitwagen*) but terms are not artificially capitalized as a style convention.

Area Labels

The area label appears after the headword in *italics*, as an indication of the subject area in which the given term is primarily used. This does not mean it is used exclusively in this area; many terms have application in two or more areas. For example the term *pollution credit* has the area label Policy, but it also has relevance to Environment and Economics and Business.

Definitions

Definitions in the Dictionary follow the principle that a term should not be defined using terminology that is more difficult to understand than the term itself, so that the reader will not have to look up other terms in order to fully comprehend the original definition. Even beyond this, we have tried to make sure that all definitions provide scientific accuracy within a context that is concise and understandable.

Many entries in the Dictionary have more than one definition. In such cases the definitions are sequenced on the basis of which meaning is more common, more basic, or more general. For example:

particle *Physics*. **1.** any finite object that may be considered to have mass and an observable position in space. **2.** specifically, a minute subdivision of matter . . .

Word Origins

Selected entries in the Dictionary include the word origin (etymology) of the given term. The word origin indicates how this term came into existence in the English language. The word origin appears at the end of the entry and is set off by brackets. Word origins often appear when the entry word is an eponym; i.e., a term derived from a person's name. For example:

Boyden turbine *Hydropower*. a type of water turbine . . . [Developed by U.S. mechanical engineer Uriah Boyden, 1804–1879.]

Word origins also appear when the entry has an anecdotal etymology, meaning that there is some kind of background or story of interest associated with the development of the term.

Nautilus *Nuclear*. a U.S. naval vessel that was the world's first nuclear-powered submarine . . . [Named for the submarine in Jules Verne's science fiction classic *Twenty Thousand Leagues Under the Sea*.]

tsunami *Earth Science*. an ocean wave of great length and duration . . . [From a Japanese term for this; literally, "great harbor wave."]

Cross References

Many entries in the Dictionary have cross references to other entries elsewhere in the book. A cross reference is indicated by being printed in SMALL CAPITAL LETTERS. The most common type of cross reference is an alternate form of a preferred or more common term. For example:

flaming spring SEE BURNING SPRING.

Other cross references appear at the end of an entry to indicate that additional relevant information can be found under another entry.

footprint *Environment*. the impact of human activities . . . SEE ALSO CARBON FOOTPRINT; ECOLOGICAL FOOTPRINT.

A third type of cross reference appears within a definition to indicate that an important or possibly unfamiliar term is explained under its own alphabetical entry.

igneous . . . one of the three principal classifications of rocks, along with METAMORPHIC and SEDIMENTARY.

Special Essays

A distinctive component of the Dictionary is the inclusion of special essays written by scientists who are experts on the given term, such as Eugene Likens on acid rain. There are more than 100 of these essays providing detailed descriptions of key energy terms such as *alternative fuel*, *biomass*, *emergy*, *horsepower*, and *resource curse*. We refer to these as “window” essays, first because their appearance on the page gives the impression of a window (they are set off from the rest of the text in a color box), and second because they are windows in the metaphorical sense, in that they provide greater insight into the meaning of important words. (See pp. viii–xi for a table of contents for the window essays.)

Additional Features

The Dictionary also contains other material beyond the defined entries and the window essays. More than 200 entries are accompanied by illustrations. These provide visual information to supplement the textual information in the definition, and their captions also give greater detail about the term in question. At the end of the Dictionary following the letter ‘Z,’ a special section appears entitled “Notable Quotes on Energy.” This is a collection of significant or memorable statements that relate in some way to the theme of energy. The quotes are arranged chronologically, beginning with the Bible and the ancient Greeks and continuing up to the present day.

Common Abbreviations in Energy Usage

A	ampere	kVa	kilovolt-ampere
Å	angstrom	kW	kilowatt
A-h	ampere-hour	kWh	kilowatt-hour
amu	atomic mass unit	kWp	kilowatt peak
API	American Petroleum Institute	L	liter
atm	(standard) atmosphere	lb	pound
AU	astronomical unit	lx	lux
bbl	barrel (42 U.S. gallons)	lm	lumen
bq	becquerel	m	meter
Btu (BTU)	British thermal unit	m ²	square meter
C	Celsius (centigrade)	m ³	cubic meter
C	coulomb	M	mega (million)
cal	calorie	mcf	thousand cubic feet
cd	candela	MeV	million electron volts
CDD	cooling degree-day	mg	milligram
Ci	curie	mi	mile
cm	centimeter	min	minute
CFS	cubic feet per second	MJ	megajoule
d	day	mm	millimeter
EMU	electromagnetic unit	MPa	megapascal
ESU	electrostatic unit	mpg (MPG)	miles per gallon
eV	electron volt	mT	metric ton
F	Fahrenheit	MW	megawatt
F	farad	MWe	megawatt electric
ft	foot (feet)	MWh	megawatt-hour
ft ²	square foot	Mx	maxwell
ft ³	cubic foot	N	newton
g	gram	nm	nanometer
gal	gallon	Nm	newton-meter
gr	grain	Ω	ohm
Gy	gray	Oe	oersted
h	hour	oz	ounce
H	henry	Pa	pascal
ha	hectare	psi	pounds per square inch
HDD	heating degree-day	Q	quintillion Btu (10 ¹⁸ Btu)
hp	horsepower	quad	quadrillion Btu (10 ¹⁵ Btu)
Hz	hertz	R	Rankine
in	inch	R	roentgen
J	joule	rad	radiation (absorbed dose)
k	kilo (thousand)	rem	roentgen equivalent man
K	Kelvin	s	second
kcal	kilocalorie	S	siemens
kg	kilogram	Sv	sievert
kJ	kilojoule	t (T)	ton (tonne)
km	kilometer	T	tesla
kPa	kilopascal	toe	tons of oil equivalent
ktoe	thousand tons of oil equivalent	V	volt
		W	watt
		yd	yard

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A ampere.

ab- *Electricity.* a prefix indicating electromagnetic units of the centimeter-gram-second system; e.g., abohm, abvolt.

abandoned *Mining.* describing an excavation that is deserted and in which no further mining is intended. Thus, **abandonment, abandoned working** or **mine**.

abatement *Environment.* a reduction in the amount of pollution generated, or in the effects of pollution.

abatement cost *Economics & Business.* the cost of reducing emissions from some established reference level.

Abbot, Charles Greeley 1872–1973, U.S. scientist who advanced solar energy technology through his invention or improvement of various solar-powered devices; e.g., a highly efficient solar boiler.

Abdel Aziz 1906–1975, king of Saudi Arabia from 1964 to 1975. He ruled in a period when the Arab oil exporting nations gained increasing control over the world oil market, and was seen as a major force behind the oil embargo against the U.S. in 1973, which helped produce the first oil price shock.

Abercrombie, James S. 1891–1975, U.S. inventor who with colleague Harry Cameron developed the first successful oil well blowout preventer, thus providing the means to prevent the uncontrolled gushers that had previously plagued the industry.

aberration *Physics.* an apparent displacement in the position of a celestial object, due to the time it takes for light from the object to reach an earthbound observer and to the orbital motion of the earth during that time.

AB₅ *Storage.* a range of metal alloys (e.g., LaNi₅) capable of undergoing a reversible hydrogen absorption-desorption reaction as a nickel-metal hydride battery is charged and discharged, respectively.

abiogenic *Earth Science.* not resulting from the activities of living organisms.

abiogenic formation *Earth Science.* the formation of hydrocarbon deposits by non-biological means (see next).

abiogenic theory *Oil & Gas.* the theory that hydrocarbon deposits have a (mainly) non-biological origin. According to this, such materials became trapped far below the earth's crust when the basic structure of the planet evolved, and have subsequently migrated into reservoirs and to the surface through openings in the earth's crust. Contrasted with the more generally accepted BIOGENIC THEORY that hydrocarbon deposits derive from the remains of living organisms.

abiotic *Environment.* relating to or caused by nonliving environmental factors, such as light, temperature, water, soil, pH, salinity, and atmospheric gases.

ablative fast pyrolysis *Biomass.* a form of pyrolysis technology to produce energy from biomass, in which the speed of biomass decomposition is increased by applying pressure through the use of a centrifugal or mechanical force, e.g., a hot rotating plate.

abrasion (abrasive) drilling *Oil & Gas.* a rotary oil-drilling method in which abrasive material under pressure rotates while being pressed against the rock.

absolute advantage *Economics & Business.* the ability of a country, individual, company, or region to produce more of a good or service with the same amount of resources, or the same amount of a good or service with fewer resources, than the cost at which any other comparable entity produces that good or service. See also COMPARATIVE ADVANTAGE.

absolute entropy *Thermodynamics.* the entropy of a substance existing at a temperature of absolute zero (0 degrees

Kelvin); any pure substance can be assumed to have an entropy of zero at this point.

absolute expansion *Thermodynamics.* the true expansion of a liquid with a change in temperature, allowing for the expansion of the container holding the liquid in calculating this measurement.

absolute humidity *Earth Science.* a statement of humidity that describes the mass of water vapor present in relation to the unit volume of space that it occupies; usually expressed in grams per cubic meter.

absolute permeability *Oil & Gas.* a measurement of the ability of a fluid, such as oil, gas, or water, to flow through a rock formation when the formation is at complete saturation.

absolute pressure *Measurement.* the total pressure of a gas system measured with respect to a pure vacuum (zero pressure).

absolute temperature scale *Measurement.* a temperature scale whose zero point corresponds to absolute zero (see next), such as the Kelvin scale or Rankine scale. Thus, **absolute temperature**.

absolute zero *Measurement.* the zero point on a temperature scale of ideal gases, denoted by 0°K on the Kelvin scale (or 0°R on the Rankine scale), -273°C on the Celsius scale, or -459°F on the Fahrenheit scale. At a condition of absolute zero, all molecular motion (in the classical sense of motion) is assumed to stop.

absorb *Chemistry.* to take up or receive matter; undergo a process of absorption. Thus, **absorbent**.

absorbance *Physics.* the ability of a medium to absorb radiation, which depends on temperature and wavelength; expressed as the negative common logarithm of the transmittance (ratio of transmitted energy to incident energy).

absorbed dose *Nuclear.* the amount of energy from ionizing radiation that is absorbed by a unit mass of any material; it is expressed in grays or rads. One gray is defined as one joule per kilogram; one rad is defined as 100 ergs per gram.

absorbed (absorptive) glass mat see AGM BATTERY.

absorber *Solar.* 1. a material or device that absorbs solar radiation. 2. *Photovoltaic.* the material that readily absorbs photons to generate charge carriers (free electrons or holes).

absorber plate *Solar.* a metal sheet in a flat plate solar collector whose primary function is to maximize the transfer of solar radiation reaching it through the glazing to the heat transfer fluid.

absorptance *Solar.* the ratio between the radiation absorbed by a surface (absorber) and the total amount of solar radiation striking the surface.

absorptiometer *Measurement.* a device used to measure the ability of a sample substance to absorb a given material.

absorption *Chemistry.* 1. the process by which a liquid or gas is drawn into the permeable pores of a solid material. 2. the action of energy or matter penetrating or being assimilated into a body of matter with no reflection or emission.

absorption band *Earth Science.* a spectral region in which the absorption coefficient reaches a relative maximum, by virtue of the physical properties of the matter in which the absorption process takes place; used in the study of the Earth's energy budget.

absorption chiller *Refrigeration.* a device that transfers thermal energy from a heat source to a heat sink through an absorbent fluid and a refrigerant. Most commercial absorption chillers use lithium bromide (a salt) and water as the fluid pair, with lithium bromide being the absorbent and water the refrigerant.

absorption coefficient 1. *Measurement.* a measure of the amount of incident energy that is absorbed per unit distance or unit mass of a substance. 2. *Solar.* the factor by which photons are absorbed as they travel a unit distance through a material.

absorption cycle *Refrigeration.* a process within a refrigeration system during which the primary fluid (the refrigerant)

and the secondary fluid (the absorbent) mix after the refrigerant leaves the evaporator. Thus, **absorption refrigeration**, **absorption cooling**.

absorption enhanced reforming *Conversion.* a thermochemical conversion process in which the separation of carbon dioxide is realized by using a sorbent material within a gasifier or a steam reformer.

absorption loss *Physics.* the part of transmission loss caused by the dissipation or conversion of electrical, electromagnetic, or acoustic energy into other forms of energy as a result of its interaction with a material medium.

absorption peak *Physics.* **1.** the wavelength or frequency at which a particular substance absorbs the most power (or, where the attenuation of the propagated signal is the greatest) whenever the substance is bombarded or irradiated with audio, electromagnetic, or light waves. **2.** *Communication.* the specific wavelength at which a particular impurity absorbs the most power, i.e., causes a maximum attenuation of propagated light waves.

absorption spectroscopy *Chemistry.* a technique for determining the concentration and structure of a substance, by measuring the amount of electromagnetic radiation that the sample absorbs at various wavelengths.

absorptive glass mat battery see AGM BATTERY.

absorptivity *Thermodynamics.* the ratio of the energy absorbed by a body to the total energy incident upon the same body.

abutment *Mining.* the part of a mine structure that directly receives thrust or pressure, as from an arch or vault.

AC alternating current.

acceleration *Physics.* the rate of change in velocity with respect to time.

accelerator *Transportation.* **1.** a pedal or lever designed to control the speed of an engine by actuating the carburetor throttle valve or fuel-injection control.

2. Nuclear. short for PARTICLE ACCELERATOR; i.e., a device used to produce high-energy, high-speed beams of charged particles.

accelerometer *Measurement.* an instrument used to measure and record acceleration in a given direction, as in an aircraft or a spacecraft.

accent light(ing) *Lighting.* light that illuminates specific features of a room or building, as for enhanced light, aesthetic purposes, safety, and so on.

acceptor *Chemistry.* **1.** a molecule, or part of a molecule's structure, that accepts an electron pair from a donor. **2. Photovoltaics.** a dopant material, such as boron, having fewer outer shell electrons than required in an otherwise balanced crystal structure, providing a hole that can accept a free electron; this is an important attribute of photovoltaic materials.

accessed *Coal.* describing a coal resource that has been prepared for mining.

accessible *Coal.* describing a coal resource for which there are no land-use restrictions and for which it can be assumed that ownership or leaseholds will be obtainable for mining. Thus, **accessibility**, **accessible resources**, **accessible (reserve) base**.

access to safe water *Global Issues.* **1.** the fact of having a reasonable means of obtaining safe water, either treated water (e.g., a municipal water supply) or clean untreated water from springs, wells, and so on. **2.** a measure of the percentage of a given population having such access.

accident see NUCLEAR ACCIDENT.

acclimation temperature *Biological Energetics.* the ambient temperature that an organism has become accustomed to by a period of constant exposure to this condition over time.

account of others *Oil & Gas.* an industry term for deliveries of natural gas to customers by transporters that do not own the gas but deliver it for others for a fee.

accumulated dose *Health & Safety.* a total dose resulting from repeated exposure to a toxic substance or radiation.

accumulation *Oil & Gas.* one or more reservoirs of petroleum that have distinct trap, charge, and reservoir characteristics; this may encompass several fields or be equivalent to a single field.

accumulator *Refrigeration.* **1.** a device that prevents liquid from entering the suction of the compressor in a refrigeration cycle. **2. Storage.** any device that can be employed to store energy, such as a rechargeable battery.

accumulator battery *Storage.* a term for any battery that stores (accumulates) energy in chemical form and discharges it as electrical energy.

AC/DC alternating current/direct current.

ACEEE American Council for an Energy-Efficient Economy (est. 1980), a nonprofit organization influential in advancing energy efficiency as a means of promoting both economic prosperity and environmental protection.

acetylene *Chemistry.* C_2H_2 , an odorless, colorless gas obtained from limestone and coal; its combustion in pure oxygen produces the highest achievable flame temperature, over $3300^{\circ}C$, releasing 11,800 J/g. A widely used welding fuel that also has been used in illumination and in the synthesis of industrial compounds.

acetylene black *Materials.* a special type of carbon black made by the controlled combustion of acetylene in air under pressure.

Acheson furnace *Conversion.* a type of electric furnace used for the production of graphite, in which the heating temperature can be increased to near $3000^{\circ}C$ for completion of the graphitization process. [Named for U.S. chemist Edward Goodrich Acheson, 1856–1931.]

Achnacarry agreement *History.* a cartel agreement reached by major international oil companies in 1928 at Achnacarry Castle in Scotland, to control the downstream marketing of oil and divide it according to market shares existing at that time.

acid *Chemistry.* a general term for compounds that when dissolved in water

increase the concentration of hydrogen ions (H^+). Acids are proton donors and have a pH less than 7. Thus, **acidizing**.

acid-based *Storage.* describing batteries that use an acid such as sulfuric acid as the major component of the electrolyte; e.g., automobile batteries.

acid deposition *Environment.* the environmental deposit of acidic or acidifying components from the atmosphere by rain or other precipitation (cloud droplets, fog, snow, or hail); precipitation that has an excessive concentration of sulfuric or nitric acids, as a result of chemical pollution of the atmosphere from such sources as automobile exhausts and the industrial burning of coal or oil. Generally defined as any precipitation with a pH of less than 5.6. Also known as ACID RAIN or ACID PRECIPITATION.

acid fracturing *Oil & Gas.* a method to stimulate oil production in which an acid-in-oil emulsion is used to fracture and dissolve carbonate reservoirs; called **acid-frac** for short.

acid gas *Chemistry.* a term for any of the acidic constituents of natural gas, such as hydrogen sulfide or carbon dioxide.

acid hydrolysis see ACIDOLYSIS.

acidification *Chemistry.* **1.** the process of becoming more acidic, or of being converted into an acid. Thus, **acidify**. **2.** see OCEAN ACIDIFICATION.

acid mine drainage (AMD) *Mining.* drainage with a pH of 2.0 to 4.5 from mines and mine wastes, especially coal mines, resulting from the oxidation of sulfides exposed during mining, which produces sulfuric acid and sulfate salts. The acid dissolves minerals in the rocks, causing the water (**acid mine water**) to have elevated concentrations of sulfate and dissolved iron. The low pH water can harm aquatic ecosystems and degrade aquifers.

acidolysis *Chemistry.* acid hydrolysis; the decomposition of a molecule with the addition of the elements of an acid to the molecule.

acid precipitation another term for ACID DEPOSITION.




acid rain Acid rain is a popular term for the atmospheric deposition of acidified rain, snow, sleet, hail, acidifying gases and particles, as well as acidified fog and cloud water. The increased acidity of these depositions, primarily from the strong acids, sulfuric and nitric, is generated as a by-product from the combustion of fossil fuels. The heating of homes, using electricity, and driving vehicles, all rely primarily on fossil fuel energy. When fossil fuels are combusted, acid-forming nitrogen and sulfur oxides are released to the atmosphere. These compounds are transformed in the atmosphere, often traveling thousands of kilometers from their original source, and then fall out on land and water surfaces as acid rain. As a result, pollutants from power plants in New Jersey or Michigan can impact pristine forests or lakes

in undeveloped parts of New Hampshire or Maine. Acid rain was discovered in 1963 in North America at the Hubbard Brook Experimental Forest in the White Mountains of New Hampshire, in rain that was some 100 times more acidic than unpolluted rain. Innovations for reducing fossil fuel emissions, such as scrubbers in tall smoke stacks on power plants and factories, catalytic converters on automobiles, and use of low-sulfur coal, have been employed to reduce emissions of SO_2 and NO_x . As a result of increasing global economies, fossil fuel combustion is increasing around the world, with concomitant spread of acid rain.

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acid rain *Environment.* the popular term for ACID DEPOSITION; i.e., rain or other precipitation that has an excessive concentration of sulfuric or nitric acids.  See above.



acid rain Effects of acid rain on trees.

acid rock drainage (ARD) *Materials.* a similar process to ACID MINE DRAINAGE, in which the condition results from pyrite exposure that is not mining-related.

acid snow see ACID DEPOSITION.

acid stratification *Storage.* a phenomenon in lead-acid cells, in which high-density sulfuric acid is produced in the

plates during charging, and under the action of gravity tends to fall to the lower part of the cell.

acid treatment *Oil & Gas.* a method to stimulate production from a well in which an acid is injected into a carbonate formation and then dissolves the reservoir rock. Also known as **acidizing** or **acid job**.

acid wash *Oil & Gas.* an operation and maintenance procedure to improve production from an oil or gas well, in which acid is pumped into the well tubing to remove scalings and other contaminants from the well.

acoustic *Physics.* 1. having to do with sound or the study of sound. 2. *Materials.* describing a material intended to absorb sound. Thus, **acoustic ceiling**, **acoustic insulation**, and so on. Also, **acoustical**.

acoustical engineering *Consumption & Efficiency.* the study of the practical applications of sound and the control of sound and vibration, as in structural design.

acoustical logging *Oil & Gas.* a determination of the physical properties or dimensions of a borehole by acoustical means.

acoustics *Physics.* the scientific study of sound, including its production, propagation, and effects.

acoustic wave *Physics.* a longitudinal wave that consists of a sequence of pressure pulses or elastic displacements of the material in which the wave propagates. In gases, it consists of a sequence of compressions (dense gas) and rarefactions (less dense gas) traveling through the gas. In liquids, it consists of a sequence of combined elastic deformation and compression waves, and in solids it consists of a sequence of elastic compression and expansion waves.

acousto-optics *Physics.* the study of the interactions between acoustic waves and light waves in a material medium.

acquisition costs *Economics & Business.* direct and indirect costs incurred to acquire legal rights to extract natural resources. Direct costs include costs incurred to obtain options to lease or purchase mineral rights and costs incurred for the actual leasing or purchasing of the rights. Indirect costs include brokers' commissions and expenses, recording and filing fees, and legal services for examination of title and documents.

acre-foot *Hydropower.* the volume of water covering one acre to a depth of one foot; used to describe a quantity of storage in a reservoir, lake, and so on.

actinide *Chemistry.* a classification for any of the heavy radioactive metallic elements having atomic numbers in the range from 90 (thorium) to 103 (lawrencium); actinium (89) is sometimes also included. Thus, **actinide series**.

actinium *Chemistry.* a radioactive chemical element having the symbol Ac, the atomic number 89, an atomic weight (in its most stable isotope) of 227, and a half-life of 21.7 years, with a melting point of 1050°C and a boiling point of about 320°C; a rare silvery-white metal found in compound form in uranium ores or obtained from radium by neutron bombardment.

actinometer *Solar.* an instrument used to measure direct radiation from the sun.

activated alumina *Materials.* a highly porous type of aluminum oxide that readily absorbs moisture and odors, used

in the petroleum industry, refrigeration, and water purification.

activated carbon *Biomass.* a highly porous form of carbon, typically from wood, lignite, coal, or coconut shell; widely used as a filtration medium; e.g., to remove taste and odor from water by adsorbing organic compounds. Also known as **activated charcoal**.

activated carbon injection *Environment.* a technology employed to remove mercury from emissions at coal-fired power plants.

activated shelf life *Storage.* the length of time (at a specified temperature) that a charged battery can be stored before its capacity falls to an unusable level.

activated sludge *Environment.* the semi-liquid, microbe-rich sediment that is added to secondary-stage sewage material in the activated-sludge process (see next).

activated-sludge process *Environment.* a widely used process for sewage treatment that raises the level of biological activity by increasing the contact between the wastewater and the actively growing microorganisms. Thus, **activated-sludge effluent**.

activation *Nuclear.* the creation of a radioactive element from a stable one by the absorption of neutrons or protons, occurring when a particle interacts with an atomic nucleus, shifting the nucleus into an unstable state and causing it to become radioactive.

activation analysis *Nuclear.* a method for identifying and measuring chemical elements in a sample of material that is made radioactive. Newly formed radioactive atoms in the sample then give off characteristic radiations indicating what kinds of atoms are present, and how many.

activation energy *Chemistry.* 1. the energy needed to initiate a chemical reaction. 2. *Nuclear.* specifically, the minimum energy that a system must acquire before a nuclear reaction can occur.

activation enthalpy *Thermodynamics.* the internal energy contribution to the free energy barrier that an atom in a metastable position must surmount in order

to participate in a thermally activated process.

activation entropy *Thermodynamics.* the entropic contribution to the free energy barrier that an atom in a metastable position must surmount in order to participate in a thermally activated process.

activation overpotential *Storage.* overpotential that results from the restrictions imposed by the kinetics of charge transfer at the electrode-electrolyte interface.

activation product *Nuclear.* a radioactive isotope of an element (e.g., in the steel of a reactor core) that has been created by neutron bombardment.

active capacity *Hydropower.* a reservoir's capacity normally usable for storage and regulation of inflows to meet operating requirements for power and other uses.

active carbon another term for ACTIVATED CARBON.

active conservation capacity *Hydropower.* a reservoir's capacity assigned to regulate reservoir inflow for power, irrigation, municipal and industrial use, fish and wildlife, navigation, recreation, water quality, and other purposes. Also, **active storage**.

active cooling *HVAC.* 1. the cooling of a space by means of a conventional compressor-driven air conditioning system, as opposed to PASSIVE COOLING by non-mechanical means. 2. *Nuclear.* the cooling of a reactor in case of an emergency by moving water past the core or by some other intentional process, as opposed to PASSIVE COOLING by means of natural forces such as gravity and convection. 3. see ACTIVE SOLAR COOLING.

active earth pressure *Hydropower.* the actual amount of pressure that is exerted permanently by soil against a dam, retaining wall, or other such structure.

active-energy meter *Measurement.* a measuring device that displays the amount of energy being imported to a system at any given time; can have household, industrial, or commercial applications.

active material *Storage.* describing a material that reacts chemically to produce electric energy when a battery discharges, and which is restored to its original state during the charge.

active power *Electricity.* the real power supplied by a generator set to the electrical load; it does the work of heating, turning motor shafts, and so on; measured in watts.

active solar cooling *Solar.* the converse of active solar heating; the use of the sun's radiant energy to power a cooling appliance.

active solar heat(ing) *Solar.* a solar energy system that uses mechanical devices and an external energy source in addition to solar energy, to collect, store, and distribute thermal (heat) energy. Thus, **active solar energy**, **active solar heater**, **active solar system**, and so on. Compare PASSIVE SOLAR HEAT.

active transport *Biological Energetics.* an energy-expending mechanism by which a cell moves a chemical across the cell membrane from a point of lower concentration to a point of higher concentration, against the diffusion gradient.

activity short for RADIOACTIVITY.

actual emissions intensity *Climate Change.* a ratio of the amount of emitted greenhouse gas over the associated production of common units of economic output.

actuator *Conversion.* any device that is moved a predetermined distance to operate or control another mechanical device; e.g., a controlled motor that converts voltage or current into a mechanical output.

acute exposure *Health & Safety.* a short interval of usually heavy exposure to radiation or a toxic substance; exposure received within a short period of time.

acute radiation syndrome *Health & Safety.* a syndrome resulting from a whole-body dose of ionizing radiation in excess of 1 gray, and characterized by multiple symptoms such as diarrhea, vomiting, fever, and bleeding. Given a sufficiently large dose, death may result

within hours or weeks of exposure. Also, **acute radiation exposure**.

acute respiratory infection (ARI) *Health & Safety*. the rapid onset of an infection of any part of the respiratory tract, usually classified as either an **upper respiratory infection (URI)**, which involves the ears, nose, throat, or sinuses, or a **lower respiratory infection (LRI)**, involving the trachea, bronchial tubes, and the lungs themselves.

acute toxicity *Health & Safety*. a toxic reaction that occurs over a relatively short period of time, directly following exposure to a single, typically large dose of the toxic substance. Similarly, **acute health effect**.

Adair, Paul (Red) 1915–2004, U.S. engineer known for his ability to control spectacular oil well blowouts and fires, noted especially for his efforts during the Persian Gulf War, when he and his teams extinguished oil well fires ignited by Saddam Hussein's troops.

Adams, William active mid to late 19th century, British government official based in India, noted for several major advances in the use of solar energy, including the first book on the subject (1878), the construction of a large-scale heating system in Bombay, India, employing a bank of mirrors to concentrate the sun's radiation, and a system at the mouth of the Red Sea that concentrated solar energy to distill seawater into freshwater.

Adams, William Grylls 1836–1915, English scientist who played an important role in the discovery of the photoelectric effect, through his discovery (with colleague Richard Evans Day) that the solid material selenium produces electricity when exposed to light.

adaptation *Ecology*. 1. a particular developmental, behavioral, anatomical, or physiological modification in a population of organisms, based on genetic changes and occurring as a result of natural selection. 2. the general capacity of a species to undergo evolutionary change and thus enhance its ability to survive. 3. *Climate Change*. the fact or policy of making adjustments

in practices, structures, or systems in response to projected or actual changes in climate, such as the protection of coastal areas from sea-level rise.

Adaptation Fund *Climate Change*. a financial instrument under the United Nations Framework Convention on Climate Change (UNFCCC) to finance adaptation projects and programs in developing countries that are parties to the Kyoto Protocol.

adatom *Storage*. an atom adsorbed on the surface of an electrode.

addiction *Social Issues*. a term often used by critics to characterize America's extensive use of fossil fuels, comparing this to an addict's compulsive use of a drug.

additionality *Consumption & Efficiency*. an energy efficiency improvement above that required by building codes and efficiency standards.

additive *Materials*. 1. any substance that is added to another substance, usually in a small quantity, in order to produce a desired effect in the primary substance. 2. a chemical compound added to gasoline to improve performance; e.g., to reduce engine knock or emissions.

Adelman, Morris 1917–2014, U.S. economist noted for his founding work in the economics of oil supply and the world oil market. Central to his work is the premise that oil is a commodity like any other; i.e., that it should not have a special status as a depleting resource or an increasing-cost good.

Adelman's rule *Economics & Business*. a practical approach to valuing oil reserves based on current prices and extraction costs; the principle that the in situ value (V) of an oil reserve (R) can be reasonably approximated by the formula $V = 1/2 (p - c)R$, where p is the price of oil and c is the unit cost of extraction.

adenosine triphosphate (ATP) *Biological Energetics*. an energy-bearing molecule formed during light reactions through the phosphorylation of adenosine diphosphate. The energy in ATP is the primary energy source for most biological reactions.

Ader, Clement 1841–1926, French engineer noted for his pioneering work in aviation. In 1886 he built the Éole, a bat-like machine run by a lightweight steam engine that drove a four-blade propeller. In 1890 a second version of the Éole was built, which managed to take off into the sky and fly a distance of more than 40 yards.

adhesion *Materials.* 1. a static attractive force at the contacting surface between two bodies of different substances in contact with each other. 2. the sticking together of structural parts by means of cement or glue.

adiabatic *Thermodynamics.* 1. without loss or gain of heat. 2. specifically, describing a process (e.g., the expansion of a gas) in which there is no transfer of heat into or out of the system in question. Thus, **adiabatic process**, **adiabatic temperature change**, and so on. Compare **DIABATIC**.

adiabatically *Thermodynamics.* occurring in a manner that does not involve a loss or gain of heat.

adiabatic envelope *Thermodynamics.* a surface surrounding a thermodynamic system across which there is no heat transfer; disturbances to the envelope can only be made by long-range forces or by motion of part of the envelope.

adiabatic flame temperature *Thermodynamics.* the temperature of the products in a combustion process that takes place with no heat transfer and no energy exchange; this is the maximum possible temperature for these products.

adiabatic (lapse) rate *Earth Science.* the rate at which temperature decreases as a mass of air rises, or increases as the air falls.

adiant exposure *Solar.* radiant energy incident on a unit surface over some specified time period; the units are joules per square meter.

adit *Mining.* a level, or nearly level, access passage from the surface of a mine, used to excavate or drain the main tunnel.

adjustable speed drive *Conversion.* a type of equipment used to control the

speed of machinery. Such drives reduce energy use by ensuring that the motor's speed is properly matched to the load placed on the motor.

admittance *Electricity.* the measure of how readily an alternating current flows through a circuit; the reciprocal of impedance.

adsorber *Environment.* 1. a material or device that adsorbs; i.e., that will take up and hold a substance on its surface. 2. specifically, an emissions control device that removes volatile organic compounds from a gas stream by means of attachment onto a solid matrix such as activated carbon.

adsorption *Chemistry.* the adhesion of the molecules of gases, dissolved substances, or liquids to the surface of solids or liquids with which they are in contact; distinguished from **ABSORPTION**, a process in which one substance actually penetrates into the inner structure of the other. Thus, **adsorb**, **adsorbent**.

adsorption isotherm *Chemistry.* an equation describing how the surface coverage of an adsorbate depends on its Gibbs free energy of adsorption, precursor and product concentrations, and electrochemical potential.

ADT average daily traffic.

ad valorem *Economics & Business.* per unit of value (i.e., divided by the price); many states and federal governments tax energy extraction in this manner. Thus, **ad valorem tax**.

advanced gas-cooled reactor (AGR) *Nuclear.* a type of graphite-moderated power reactor that uses helium as a coolant and graphite as a moderator, operating at substantial temperatures.

advanced metering infrastructure (AMI) *Electricity.* a system of measuring electrical usage that provides immediate information to the utility about demand and to the consumer about pricing, with the intent of maintaining a stable load on the grid and shifting energy consumption to off-peak periods.

Advanced Research Projects Agency see ARPA.

advanced vehicle technology (AVT)

Renewable/Alternative. the engineering and design processes that (will) lead to vehicles with high energy efficiencies and low emissions, such as direct-injection, hybrid electric, fuel cell, and battery-powered electric vehicle systems, as well as improved materials and vehicle design.

advance mining *Mining.* a system of mining in which the service roadways move forward along with the working face, as opposed to being formed beforehand (RETREAT MINING).

advection *Earth Science.* the horizontal transport of air along the earth's surface, felt as the wind. It transfers temperature, humidity, and other atmospheric characteristics from one region to another.

adverse hydro *Hydropower.* describing conditions that are unfavorable to the generation of hydropower; e.g., low rainfall or snowfall, lack of runoff from higher elevations.

AEC Atomic Energy Commission.

AEEI *Economics & Business.* autonomous energy efficiency index; the rate at which the economy becomes less energy intensive, with the price of energy remaining constant relative to the prices of other inputs. This indicates productivity improvements in energy use that are not caused by increases in energy prices.

aeolian *Wind.* having to do with the wind; produced or affected by the action of winds.

aeolipile *History.* an ancient device operating on steam power, developed about 2000 years ago, reportedly by the Greek scholar HERO of Alexandria; considered the earliest working steam engine and a predecessor to modern jet engines. It is described as a sealed, water-filled boiler mounted over a source of heat; as the water turned to steam it rose into a hollow sphere above. The steam would then escape from two curved outlet tubes on

the sphere, causing it to rotate. [From a Greek term for "wind ball".]

Aepinus, Franz 1724–1802, German scientist who conducted important early studies in electricity and magnetism, which led him to reject then-current mechanical theories of electricity and support Benjamin Franklin's one-fluid theory.

AER all-electric range.

aerate *Physics.* to expose a substance to air or another gas, e.g., the passing of air through a liquid substance, or the process of air entering the soil. Thus, **aeration**.

aeration cell *Electricity.* a device that generates electromotive force across electrodes that are made of the same material but located in different concentrations of dissolved air.

aerator *Consumption & Efficiency.* 1. a device used to aerate a substance or medium; i.e., expose it to air or another gas. 2. specifically, a device installed in a faucet or showerhead to add air to the water flow, thus maintaining an effective spray while reducing overall water consumption.

Aermotor *Wind.* the most common form of American farm windmill, distinguished by a self-oiling system in which all the working parts are continuously lubricated; introduced in 1915 and still widely used today. [Developed by the Aermotor Company of Chicago, an early (1888) producer of farm windmills.]

aerobe *Biological Energetics.* an organism, especially a bacterium, that requires atmospheric oxygen to live. Contrasted with an ANAEROBE, which does not require oxygen.

aerobic *Biological Energetics.* requiring or occurring in the presence of oxygen (O₂). Thus, **aerobic bacteria**, **aerobic metabolism**.

aerobic fermentation *Conversion.* any fermentation process that requires the presence of oxygen.

aerobic respiration *Biological Energetics.* respiration in which molecular oxygen is consumed through its use as a terminal electron acceptor, and which produces carbon dioxide and water.

aeroderivative *Conversion.* an aviation propulsion gas turbine (jet engine) used in a nonaviation application (e.g., an electric power plant) to provide shaft power.

aerodynamic drag *Physics.* the opposing force encountered by a body moving relative to a fluid; e.g., an aircraft in flight displacing the air in its path.

aerodynamics *Physics.* **1.** the scientific study of gases in motion and the forces that affect this motion. **2.** specifically, the study of the effects of air in motion on an object; either objects moving through air, such as aircraft or automobiles, or stationary objects affected by moving air, such as bridges or tall buildings.

aerogel *Materials.* a low-density, foamy solid-state material derived from jelly-like materials (gel) in which the liquid component is replaced with gas.

aerogenerator *Wind.* a device that generates electricity from the kinetic energy produced by wind.

aeromechanics *Physics.* the scientific study of air and other gases in motion or in equilibrium, including the two distinct branches of aerodynamics and aerostatics.

aerometer *Measurement.* an instrument used to measure the weight or density of air and other gases.

aeronautics *Transportation.* the science and technology of flight, especially the design, construction, and operation of aircraft.

aerosol *Environment.* **1.** the suspension in a gaseous medium of very fine particles of a solid or of droplets of a liquid. Fog, smoke, and volcanic dust are examples of aerosols in the atmosphere. **2.** the particles themselves.

aerosol optical depth (AOD) *Environment.* a measure of how much light airborne particles prevent from passing through a column of atmosphere; aerosols tend to

absorb or reflect incoming sunlight, thus reducing visibility and increasing optical depth.

aerosol propellant *Environment.* a liquefied gas that is used as the driving force to expel a liquid from a container, such as an aerosol spray from a can; e.g., hair spray, deodorants, spray paints, or various household cleaning products.

aerospace *Transportation.* a collective term for activities involving flight either in the atmosphere or in space.

aerostat *Transportation.* a lighter-than-air vehicle, such as a balloon or dirigible.

aerostatics *Physics.* **1.** the scientific study of air and other gases in equilibrium, and of bodies suspended or moving within such gases. **2.** the study of lighter-than-air aircraft.

aerothermodynamics *Thermodynamics.* **1.** a branch of thermodynamics that studies the effects of heating and the dynamics of gases. **2.** the analysis of aerodynamic phenomena at high gas speeds, incorporating the essential thermodynamic properties of the gas.

aesthetic impact *Social Issues.* the effect that a change in land use has or would have on the visual appeal or other aesthetic qualities of the given setting; e.g., the aesthetic impact of a wind farm placed on a hillside or offshore location.

aestivation another spelling of ESTIVATION.

AFC alkaline fuel cell.

afforestation *Environment.* a direct, human-induced conversion to forest of land that had not been forested for a significant preceding period of time, through planting, seeding, or the human-induced promotion of natural seed sources.

Aframax *Transportation.* an ocean-going crude oil tanker vessel of intermediate size, usually between 80,000 and 119,000 deadweight tons.

AFRA-NEST African Network for Education in Nuclear Science and Technology.

AFSE Association for Applied Solar Energy.

afterburner *Transportation*. 1. an auxiliary combustion chamber placed behind a jet engine turbine to gain extra thrust by injecting additional fuel into the turbine's hot exhaust gases. 2. *Environment*. a catalytic or thermal combustion device used to control air contaminant emissions.

aftercooling *Nuclear*. the cooling of a nuclear reactor after it has been shut down.

afterdamp *Mining*. the residue mixture of gases in a mine following a mine fire or an explosion of firedamp.

afterheat *Nuclear*. heat that is liberated by the decay of radioactive materials in a reactor that has been shut down.

aftermarket conversion *Renewable/Alternative*. the alteration of a standard factory-produced vehicle having a conventional fuel system, by adding equipment that enables the vehicle to operate on alternative fuel. Thus, **aftermarket converted vehicle**.

aftertreatment *Transportation*. a method of controlling emissions from internal combustion engines by applying pollution control technologies to the engine exhaust stage (as opposed to treatments applied during the intake or combustion stages).

AFUE annual fuel utilization efficiency.

AFV alternative fuel vehicle; see ALTERNATIVE FUEL.

Agassiz, Louis 1807–1873, Swiss scientist who was the first to recognize (1837) that the earth's earlier history included an ice age with much colder conditions than the climate of his own time, thus establishing the existence of the phenomenon of climate change.

Agenda 21 *Sustainable Development*. 1. a comprehensive plan of action to be taken globally in the interest of sustainable development, agreed upon at the Earth Summit in Rio de Janeiro, Brazil in 1992. Major issues of environment and development were examined, including resource management, poverty, population, and human health. 2. any of various local programs modeled after this initiative. [So called because it is described as a plan for the 21st century.]

Agent Orange *Health & Safety*. a toxic chemical agent used as a herbicide; investigated for possible health effect in humans. See TCDD.

agglomerate *Materials*. 1. a mass or cluster of fine particles, gathered together in a body of larger size than the original particles, but not in a coherent pattern. 2. of materials, to become grouped together in this manner. Thus, **agglomerated, agglomeration**.

agglomerating character *Coal*. a classification for coal based on its caking properties; coals are considered **agglomerating** if the coke button remaining from a test for volatile matter will support a weight of 500 grams without pulverizing, or if the button swells or has a porous cell structure.

aggregate intensity *Economics & Business*. the ratio of total energy use to total output measured at a comprehensive level, as for an entire industry or a national economy; e.g., the ratio of energy use to gross domestic product for a nation.

aggregator *Economics & Business*. an entity that assembles customers into a buying group for the purchase of a commodity service such as electricity.

AGM battery *Storage*. absorbed glass mat battery; a type of sealed lead-acid battery in which the electrolyte is absorbed in a matrix of glass fibers, which holds the electrolyte next to the plate, and immobilizes it to prevent spills. AGM batteries tend to have good power characteristics and low internal resistance.

agrarianization *Ecology*. the establishment of agriculture; the formation and spread of a system structured around the domestication of plants and animals.

agribusiness *Economics & Business*. 1. those aspects of agriculture involving issues of finance, sales, marketing, and the like. 2. larger corporate entities of agriculture as opposed to smaller family-run operations; e.g., Archer Daniels Midland corporation.

Agricola, Georgias (Georg Bauer), 1494–1555, German scientist, regarded as the founder of the science of metallurgy

and credited with the first published use of the term *petroleum*. He also provided some of the earliest detailed accounts of the use of water power in mining and metallurgy.

agricultural energetics *Biological Energetics*. 1. the various forms of energy involved in the process of agriculture, either as inputs (e.g., human labor, animal power, electricity) or as useful output (e.g., food, manure). 2. specifically, the relationship between energy in the form of food produced and the energy input required to achieve this production.

agricultural residue *Biomass*. a fuel source composed of plant parts, primarily stalks and leaves, that are not harvested for use as food or fiber; e.g., corn stalks and husks, wheat straw, or rice straw.

Agricultural Revolution *History*. a term for the period in history beginning shortly before the Industrial Revolution, when significant improvements in agricultural production were achieved through such means as land reform, crop rotation, livestock improvements, and technological innovation (e.g., improved plows).

agricultural waste *Environment*. a general term for waste materials generated by farming activities, including both natural (organic) and non-natural refuse and residues.

agriculture *Consumption & Efficiency*. the process, business, or science of producing food, feed, fiber and other desired products by the cultivation of certain plants and the raising of domesticated animals (livestock). ☀ See next column.

agrobusiness see AGRIBUSINESS.

agroecology *Ecology*. 1. the study of the relationship between an agricultural system and its surrounding environment. 2. the application of principles of ecology to plan and manage agricultural systems in a sustainable manner.

agroecosystem *Ecology*. the biotic and abiotic components of an agricultural system, including not only the livestock and cultivated crops but also, for



agriculture Humans began to cultivate their food crops about 10,000 years ago. Prior to that time, hunter-gatherers secured their food as they traveled in the nearby environment. When they observed some of the grains left behind at their campsites sprouting and growing to harvest, they began to cultivate these grains. From these humble beginnings agriculture began. Slash and burn, an early type of crop culture remains today a truly sustainable agriculture, one that is independent of fossil energy. In such a system, about 10 hectares of productive land is held in fallow for each planted hectare. With this rotation system, a hectare is planted once in 20 years, allowing the soil to reaccumulate vital plant nutrients. Although the practice requires large acreages and large labor inputs, the crop yields are adequate. For example, corn with ample rainfall can yield about 2000 kg/ha. Over time human labor in agriculture has decreased because of the use of animals and finally with machinery powered by fossil fuel. Currently plentiful and economical fossil energy supports an era of machinery and agricultural chemicals. Now about 1000 liters of oil equivalents are used to produce a hectare of corn with a yield of 9000 kg/ha. One-third of this energy is used to replace labor, one-third for fertilizers, and one-third for others. Worldwide more than 99.7% of human food (calories) comes from the land. Serious environmental impacts, such as soil erosion, water runoff and pesticide pollution, result from fossil-fuel intensive agriculture. A critical need exists to assess fossil energy limits, the sustainability of agriculture, and the food needs of a rapidly growing world population.

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example, the water supply, other plant and animal species, soil characteristics, climate, and human inputs.

agroforestry *Ecology*. the practice of growing a combination of forest growth products and agricultural crops on the same area of land.

agro-industry *Economics & Business*. 1. the industry involved with the supply,

processing, and distribution of agricultural products. **2.** agriculture as practiced on a large scale by corporate enterprises. Thus, **agro-industrial**.

AHU air-handling unit. See AIR HANDLER.

agronomy *Consumption & Efficiency.* the scientific study of agricultural crops and soils. Thus, **agronomist**.

AIM Action Impact Matrix.

AIP American Institute of Physics.

air *Chemistry.* the invisible, odorless, and tasteless mixture of gases forming the earth's atmosphere. At normal sea-level pressure, dry air consists of (percentage by volume) nitrogen 78%, oxygen 20.95%, argon 0.93%, carbon dioxide 0.033% (currently; thought to be increasing), neon 0.0018%, helium 0.0005%, methane 0.0002%, krypton 0.0001%, and smaller amounts of nitrous oxide, hydrogen, xenon, and ozone.

AIR air-injection reactor.

air basin *Environment.* a defined land area that has generally the same quality and properties of air, because of similar meteorologic and geographic conditions throughout the area; a geographic unit used in the regulation of air pollution and air quality.

air battery *Storage.* a type of battery having an electric storage cell (**air cell**) in which one electrode is activated chemically by the oxygen in the ambient air.

airblast or air blast *Mining.* **1.** the air-borne shock wave or noise created by an explosion. **2.** a method of blasting that employs a jet of compressed air at very high pressure. Also, **air blasting**.

airborne fraction *Climate Change.* the portion of carbon dioxide that remains in the atmosphere after its release from energy consumption and land-use activities, as opposed to the portion absorbed by plants and oceans.

air brake *Transportation.* a mechanism operated by compressed air acting on a piston, used to stop or slow a moving element, as in a motor vehicle.

air-breathing *Transportation.* describing an engine or vehicle that operates on the basis of utilizing air for combustion.

air change *HVAC.* the amount of air required to completely replace the air in a room or building (as opposed to simply recirculating it).

air change efficiency *HVAC.* a measure of how quickly the air in a given space (a room or building) is completely replaced.

air change rate *HVAC.* the replacement of a quantity of air in a given space within a certain period of time, typically expressed in units per hour; e.g., if a building has one air change per hour, this is equivalent to all of the air in the building being replaced in that time.

air cleaner see AIR FILTER.

air conditioner *HVAC.* **1.** any device that modifies or controls one or more aspects of air, such as its temperature, relative humidity, purity, or motion. **2.** such a device used in a building, room, vehicle, or other enclosed area to maintain the air therein at a comfortably cool and dry level.

air conditioning *HVAC.* the simultaneous control of the temperature, relative humidity, purity, and flow of the air in a given enclosed space, as required either for the thermal comfort of people who live or work in the respective space, or for specified technological prescriptions. This can involve either cooling or heating of air, but in popular use is assumed to refer only to cooling.

air conditioning intensity *HVAC.* the ratio of air-conditioning consumption or expenditures to square footage of cooled floor space and cooling degree-days (base 65°F); it provides a way to compare different types of housing units and households by controlling for differences in housing unit size and weather conditions.

air-conditioning ton see REFRIGERATION TON.

air-cooled *Transportation.* describing an engine that is cooled by a stream of air rather than by water or another liquid coolant.

aircraft *Transportation.* any weight-bearing vehicle designed for navigation in the air, supported by the action of air upon its surfaces or by the vehicle's own buoyancy.

air curtain *Consumption & Efficiency.* a continuous broad stream of high-velocity, temperature-controlled air that is circulated across an opening, in order to reduce airflow in or out of the space, minimize heat loss or gain, contain a fluid (e.g., an oil spill), and so on.

airbox *Coal.* a system for breaking down coal through the use of compressed-air blasting.

air drilling *Mining.* a form of drilling in which compressed air or gas is the circulation medium; used in coal mining, and also in petroleum extraction instead of mud drilling because of its greater speed.

air dry *Biomass.* the state of dryness of a quantity of biomass at equilibrium with the water content in the surrounding atmosphere. The actual water content will depend upon the relative humidity and temperature of the surrounding atmosphere.

air exchange see AIR CHANGE.

air exfiltration see EXFILTRATION.

air film *Consumption & Efficiency.* a layer of still air adjacent to a surface, providing some thermal resistance.

air filter *Consumption & Efficiency.* a device attached to an air intake mechanism to remove solid impurities from an airstream; may be used with ventilating mechanisms or to prevent pollutants from entering an instrument or engine.

airflow *Measurement.* a rate of movement for air, computed by volume or mass for a certain time unit.

airfoil *Transportation.* a body, part, or surface designed to provide a useful reaction on itself, such as lift or thrust, during motion through the air.

air-fuel ratio *Consumption & Efficiency.* the relative amounts of fuel and air in a combustion chamber; a method of expressing the composition of a mixture of fuel and air by the measurement of

either weight or volume. Thus, **air-fuel mixture**.

air handler *HVAC.* the interior of an air-conditioning system that contains the blower, cooling (evaporator) coil, and heater. Also, **air-handling unit**.

air-injection reactor (AIR) *Transportation.* a system installed in an automotive engine to mix fresh air with exhaust gases in the exhaust manifold, causing reaction with any escaped and unburned or partially burned fuel from the cylinders.

air lock or airlock *HVAC.* a compartment that serves to control air exchange into or out of a conditioned space.

air mass *Solar.* a measure of how far light travels through the earth's atmosphere. One air mass, or AM1, is the thickness of the earth's atmosphere. Air mass zero (AM0) describes solar irradiance in space, i.e., radiation not attenuated at all by the atmosphere. The power density of AM1 light is about 100 mW/cm²; the power density of AM0 light is about 136 mW/cm².

air pollution *Environment.* a general term for the discharge or release of harmful or unwanted substances to the atmosphere; the extraction, processing, and use of energy, particularly fossil fuels, is a major source of such releases. Thus, **air pollutant**.



air pollution *Polluted air hovers over midtown Manhattan, New York City in the late 1960s, an era of more relaxed emission standards.*