APPENDIX TO CHAPTER 5, C

COOPERATIVE AGREEMENTS AND FEASIBILITY STUDY GRANTS FOR SYNFUELS

(Source: U.S. DOE 7/80)

COOPERATIVE AGREEMENTS

TECHNOLOGY	REQUESTED FROM DOE	DESCRIPTION/SITE
Coal Liquids		
Texas Eastern Synfuels	$24,300.00	Texas Eastern Synfuels proposes to construct a coal liquefaction facility which will produce the equivalent of 56,000 barrels of oil per day. Texas Eastern Synfuels is a joint venture of Texas Eastern Corporation, and Texas Gas Transmission Corporation. Proposed project is a Fischer Tropsch plant--like the SASOL facility in South Africa--that would convert approximately 28,000 tons per day of coal into a mixture of transportation fuels, Synthetic Natural Gas (SNG), and chemicals. Approximately 44 percent of the output is SNG (145 mmSCF/D); about 30 percent transportation fuel, and the test chemicals Site is near Hendersen, Kentucky.
High Btu Gas		
Great Plains Gasification Associates	$22,000,000	The project will employ a Lurgi pressurized, fixed bed gasification process with Lurgi methanization requiring 14,000 tons/day of lignite coal to produce 137.5 mmCF/day of synthetic gas, 98 tons of ammonia/day and 85 tons/day of sulfur. The facility will be sited in the Beulah Hazen area of Mercer County, North Dakota and has a total capital requirement of $1.5 billion

Wycoal Gas	$13,155,000	Wycoal plans to construct a facility using Lurgi and Texaco gasification units to process 16,000 tons of sub-bituminous coal daily to produce high Btu gas. All liquid by-products will also be gasified. The facility is to be located in Douglas, Wyoming. The Statement of work **proposed** will involve developing a definitive basis for plant design estimating costs, securing permits and approvals, obtaining financing and identifying long-lead delivery items. There is a market for the SNG via a pipeline system to the midwest owned by the participants. The project would produce the equivalent of 51,000 barrels of oil per day.

FEASIBILITY STUDY GRANTS

TECHNOLOGY	REQUESTED FROM DOE	DESCRIPTION/SITE
Coal Liquids		
Cook Inlet Region Anchorage, Alaska 99509	**$3,900,000**	Feasibility study of producing 54,000 barrels per day of methanol from low sulfur coal using Winkler gasifier and ICI methanol synthesis. Site: West side of Cook Inlet, Alaska
W. R. Grace Denver, Colorado 80223	$786,477	'Stage 111 of a feasibility study of a coal sourced methanol plant using a Koppers/Totzek Gasifier. Site: Moffat County, NW Colorado
Clark Oil & Refining Milwaukee, Wisconsin 53227	$4,000,000	Feasibility study of producing synthesis gas from coal, steam, oxygen & methanol from synthesis gas using a KT Gasifier, ICI & the Mobil M Process. Site: S. Illinois

ejb&a

Houston Natura Gas/Texaco Houston, Texas 77001	$3,260,000	Fourteen month feasibility study of producing fuel grade methanol from coal using Ziegler coal deposits. Site: Covent, Louisiana
AMAX, Inc. Grenwich, Connecticut	$2,190,000	Feasibility study of a coal to methanol plant producing 14,910 barrels per day using Koppers or Lurgi Gasifiers. Site: Diluth, Minnesota
Dakota Company B smark, North Dakota 58501	$4,000,000	Feasibility study for constructing an 85,000 barrel/day coal to methanol plant using Lurgi gasifier and Lurgi methanol synthesis. Site: Dunn, North Dakota
Republic of Texas Coal Co. and Mitchell Energy Corp. Houston, Texas 77002	$808,781	Feasibility study of gasification, in-situ deep Texas lignite and conversion of remaining medium BTU synthesis gas to methanol and high octane gasoline. Site: Somewhere in Texas Gulf Coast
Hampshire Energy Milwaukee, Wisconsin	$4,000,000	Ten-month feasibility study of converting 15,000 tons of coal/day to 20,000 barrels/day of gasoline * Site: Gillette, Wyoming

High Btu Gas

Crow Tribe of Indians Washington, D.C. 20036	$2,729,393	Nine month feasibility study, High Btu Gas (Lurgi Process - SNG) at Crow Reservation, MT. Site: East of Billings, MT.
Texas Eastern Synfuels, Inc. Houston, Texas 77001	$3,018,000	Nine month feasibility study, High Btu Gas (Lurgi Process - SNG, Methanol) at San Juan County, New Mexico. Site: East of Navajo Indian Reservation

Low/Medium Btu Gas

Florida Power St.Petersburg, Florida 33733	$1,380,796	Twelve month feasibility study of Medium Btu Gas Combined cycle. Site: Pinellas Courty, Florida
General Refractories Bala Cynwyd, PA. 19004	$922,555	Nine month feasibility study of low Btu Industrial Fuel Gas. Site: Florence, Kentucky
Central Maine Power Augusta, Maine 04336	$3,624,558	Fifteen month feasibility study of combined cycle, medium Btu gas at Sears Island, ME. (Process: Texaco Gasifier) Site: Waldo County, Maine
EG&G Wesley, Massachusetts 02181	$4,000,000	Feasibility study for a medium Btu gasification facility producing combined cycle power and methanol. Choice or process technologies between Koppers-Totzek or Slagging Lurgi. Site: Fall River, Massachusetts
Philadelphia Gas Works Philadelphia, PA 19102	$1,168,108	Twelve month feasibility study of medium Btu gas (Process: TRD). Site: Philadelphia, Pernsylvania
Celanese Corp Dallas, Texas 75247	No cost	Feasibility study to determine the technical and economic viability of developing a carbon monoxide and hydrogen syngas from either a high Btu coal or a Texas lignite. Site: Near Bishop, Texas
Union Carbide/Linde Division Tonawanda, New York 14150	$3,945,676	Eighteen-month feasibility study of low/Medium Btu Gas. Site: Texas City, Houston, Texas

Oil Shale

Gary Energy Corp. Fruita, Colorado 81521	$3,009,399	Feasibility study for upgrading crude oil shale to gasoline jet fuels, DFO and residual using UOP hydro-processing & hydro-cracking. Site: Fruita, Colorado
Transco Energy Co. Houston, Texas	$3,778,267	Eighteen month feasibility of 2000 BPD (or larger) module of a 50,000 BPD plant. Site: Lewis County, Kentucky

Tar Sands

Natomas Energy Co. San Francisco, California 94108	$357,511	Eight-month feasibility study of extracting 20,000 barrels/day of oil from domestic tar sands - Bitumen. Site: Site may be in Utah or California
Standard Oil of Indiana Chicago, Illinois 60601	$0	Feasibility study of a 5000 barrel/day Tar Sands Bitumen facility. Site: Sunnyside, Utah

Unconventional Gas

Acruex Corporation Mt. View, California 94-42	$440,261	Feasibility study of anaerobic digestion of sewer water to obtain methane. Site: Possibly Oakland, California
Seneca Indian Nation Salamarca, New York 14779	$896,638	Feasibility study of the recovery of natural gas from Devonian Shales - vertical wells. Methane from Devonian Shale. Site: Salamanca, New York

Republic of Texas Coal Co. and Mitchell Energy Corp. Houston, Texas 77002		Feasibility study of gasification, in-situ deep Texas lignite and conversion of remaining medium Btu synthesis gas to methanol and high octane gasoline. Site: Calvert, Robertson County, Texas
Mountain Fuel Supply Co. Salt Lake City, Utah 84139	$1,810,762	Two-year feasibility study of unconventional natural gas in the Pinedale field. Product is natural gas and condensate. Site: Sublette County, Wyoming
Peat		
Minnesota Gas Co. Minneapolis, Minnesota 55402	$3,996,554	Nineteen month feasibility study for the production of high Btu substitute natural gas from peat. Site: Minnesota
Shale Liquid Upgrading		
Union Oil Energy Mining Los Angeles, CA 90017	$4,000,000	Feasibility study for operation of a 10,000 BPD upgrading plant producing premium quality syncrude. Site: Grand Valley, Colorado

COOPERATIVE AGREEMENTS

TECHNOLOGY	REQUEST C FROM DOE	DESCR PT ON/SITE
Unconven ional Gas		
U.S. Steel Corporation	$600,000	U.S. Steel Corporation proposes to build a collection and compression system to capture methane from a mine pre-drainage program. The gas, currently being vented, will be injected into an interstate pipel ne system for sale. The project will produce the equ valent of 200 barrels of oil per day. Site s Oak Grove, Alabama.
Coal Oil Mixture		
Bankl ck Corporatio	$989,500	Banklick Corporation proposes to design and construct a Coal Mining Mixture (COM) preparation plant on a site on Blount Island, Florida owned by the Jacksonville Port Authority and to market the products. In this proposal, the approach is to first grind the coal, then mix it with oil and pulverize the result, and, finally, to mix the product more thoroughly using ultrasonic agitators. A COM prep plant is relativley simple and, in addition to the above equipment, cons sts of coal storage and handling equipment (including a coal pile), oil and COM piping and storage hardware, and associated hardware. Coal would be delivered by rail. The project will produce 6,000 barrels per day.

GLOSSARY (Courtesy: Coal Liquefaction Quarterly Report, U.S. DoE, May 1979)

absorptio an imprecise term suggesting the taking up of one substance by another by either a physical process or a chemical combination.

acceptor — calcined carbonate that absorbs carbon dioxide evolved during gasification. liberating heat.

acid gas removal — the process of selectively removing hydrogen sulfide and carbon dioxide from a gas stream.

activated carbon — carbon obtained by carbonization in the absence of air, preferably in a vacuum; has the property of absorbing large quantities of gases. solvent vapors; used also for clarifying liquids.

diabatic — any process where heat is neither given off nor absorbed.

dsorption — the process by which the surface of a solid or liquid attracts and holds any atom. molecule. or ion from a solution or gas with which it is in contact.

gglomerate — assemblage of ash particles rigidly joined together. as by partial fusion (sintering).

nttmcits coal — hard coal containing 86 to 98 percent fixed car- " bon and small percentages of volatile material and ash.

API — American Petroleum institute.

API gravity— a scale adopted by the API for measuring the density - of oils; $^{\circ}API = \frac{141.5}{\text{Specific gravity. } 60^{\circ}F/60^{\circ}F} - 131.5$

romatic hydrocarbon — a cyclic hydrocarbon containing one or more six-carbon (benzene) rings.

sh — solid residue remaining after the combustion of coal.

ASTM — American Society for Testing Materials.

autoclave – a vessel, constructed of thick-walled steel for carrying out chemical reactions under high pressures and temperatures.

bench-scale. unit — a small-scale laboratory unit for testing process concepts and operating parameters as a first step in the evaluation of a process.

. binder — carbon products. tars. etc.. used to impart cohesion to the body to be formed: a coai-extract binder may be used to prepare formed-coke pellets from non-coking coals.

bituminous coal — a broad class of coals containing 46 to 86 percent fixed carbon and 20 to 40 percent volatile matter.

blow down— periodic or continuous removal of water from a boiler to prevent accumulation of solids.

bottoming cycle~ — the lower temperature thermodynamic power cycle of a combined-cycle system.

Btu — British thermal unit. the quantity of energy required to raise the temperature of one pound of water one degree Fahrenheit.

BTX— benzene. toluene. xylene; aromaticc hydrocarbons.

caking — the softening and agglomerartion of coal as a result of the application of heat.

calcination — the process of heating a solid to a high temperature to cause the decomposition of hydrates and carbonates.

calorific value— the quantity of heat obtaincd by the complete combustion of a unit mass of a fuel under prescribed conditions.

carbon fiber – fine filaments of carbon about eight microns in diameter which are used in composite materials. being bound with resins.

carbonization — destructive heating of carbonaceous substances wit h the production of a solid. porous residue or coke. and the evolution of a number of volatile products. For coal. There are two principal classes of carbonization. high-temperature coking (about 900" C) and low-temperature carbonation (about 700° C).

catalyst — a substance that accelerates the rate of a chemical reaction without itself undergoing a permanent chemical change.

centrifuge — an apparatus rotating at high speed which utilizes the centrifugal force generated to separate materials of different densities. e.g.. undissolved residue from coal solution in the SRC process.

char — the solid residue remaining alter the removal of moisture and volatile matter from coal.

Claus process— industrial method of obtaining elemental sulfur through the partial oxidation of gaseous hydrogen sulfide in air followed by catalytic conversion to molten sulfur.

coal — a readily combustible rock containing more than 50 weight percent and more than 70 volume percent of carbonaceous material including inherent moisture. formed from compaction and induration of variously altered plant remains similar to those in peat.

coalification — metamorphosis of vegetable debris into coal.

coke — strong porous residue cons] sting of carbon and mineral ash formed when bituminous coal is heated in a limited air supply or in the absence of air. Coke may, also be formed by thermal decomposition of petroleum residues.

coke breeze — the fine screenings from crushed co kc usually passing a 1 2 inch or 3 *4* inch screen opening.

combined cycle — two sequentai thermodynamic power conversion systems operating at different temperatures.

combustion gas — gas formed by the combustion of coal. e.g.. burning.

combustor — a vessel in which combustion taken place

coupon — a polished metal strip used to measure the rate 01 corrosion of the metal in a specific gaseous or liquid environment.

cracking — the partial decomposition of h l~h-m~)lecuiar-weight organic compounds into lower-molecular-weight compounds. generally as a result of high temperatures

crude *gas* — impure gas produced in a gasifier

culm — the waste or slack from anthracite mines or preparation plans consisting of fine coal, coal dust. and dirt.

cyclone separator – essentially a settling chamber to separate solid panicles from a gas. in which gravitational acceleration is replaced by centrifugal acceleration.

degasification — a process for removing nat urally occurring methane from coal seams.

delayed cokinq — a process wherein coal is subjected to a long period of carbonization at moderate temperatures to form coke.

demineralization –- removal of mineral matter (ash) from coal by solvent extraction. usually under hydrogen atmosphere.

depolymerization — the change of a large molecule into simpler molecules usually accompanied by the substitution of hydrogen for oxygen in the molecular structure.

destructive distillation — the distillation of coal accompanied by Its thermal decomposition.

desulfurization — the removal of sulfur from hydrocarbonaceous substances by chemical reactions.

devolatization — the removal of a portortion of the volatile matter from medium- and high-voiatile coals.

diatomaceous earth — a yellow. white. or light-gray, siliceous porous deposit made up of opaline shells of diatoms: used as a filter aid. paint filler, adsorbent. abrasive. and thermal insulator. Also known as kieselguhr.

diatomite — See Diatomaceous Earth.

dissolution — the taking up of a substance by a liquid with the formation of a homogeneous solution.

distillation — a process of vaporizing a liquid and condensing the vapor by cooling: used for separating liquids into various fractions according to their boiling points or boiling ranges.

dotomite~ — a carbonate of calcium and magnesium having the chemical formula $CaMg(CO_3)_2$

Dowtherm — trademark for a series of eutectic mixtures of diphenyl oxide and dlphenyl used as high-temperature heat-transfer fluids.

● bullated bed — gas containing a relatively small proportion of suspended solids. bubbles through a higher density fluidized phase with the result that the system takes on the appearance of a boiling liquid.

economizer — beat exchanging mechanism for recovering heat from flue gases.

effluent gas — gas given off from a process vessel.

etutriation — the preferential removal of the small constituents of a mixture of solid particles by a stream of high-velocity gas.

● ndoth_mic reactton — a process in which heat is absorbed.

● rtthdpy change — the increase or decrease in heat content of a substance or system which accompanies its change from one state to another under constant pressure.

● ntrmncd bed (flow) — a bed in which solid particles are suspended in a moving fluid and are continuously carried over in the effluent stream.

eutectic — that combination of two or more components which produces the lowest melting temperature.

● xotttermte reaction — a process in which heat is liberated.

extraction — a method of separation in which a solid or solution is contacted with a liquid solvent (the two being essentially mutually Insoluble) to transfer components into the solvent.

● xtractlve coking — similar to delayed coking process. with the emphasis on high tar yieids to produce liquids.

filter aid — finely divided solids used to increase efficiency of filtering.

filter cake -- the moist residue remaining from the filtration of a slurry to produce a clean filtrate.

filtrate — a liquid free of solid matter after having passed through a filter.

filtration — the separation of solids from liquids by passing the mixture through a suitable medium. e.g.. cloth, paper. diatonaccous earth.

Fischer assay — method for determining the tar and light oil yields from coal or oil shale: conducted in a retort under an inert atmosphere with a presribed increase in temperature to 500°C.

Fischer-Tropsch catatyst — catalysts developed for the catalytic synthesis of liquid fuels from coal-derived svnthesis gas; catalysts contain principay iron. cobalt. nickel. or ruthenium.

Fischer-Tropsch process — method of hydrogenating mlxtures of carbon monoxide and hydrogen produced from coal. lignite. or natural gas by means of steam. at 1-10 atmospheres and 360-410°F to yield liquid and gaseous fuels. and a wide spectrum of industrial chemicals.

fixed-bed -- stationary solid particles in intimate contact with fluid passing through them.

fixed carbon — the solid residue. other than ash. obtained by destructive distillation; determined by definite prescribed methods.

flash carbonization — a carbonization process characterized by short residence times of coal in the reactor to optimize tar yields.

ftue gas— gaseous combustion products.

fluidization (dense phase) — the turbulent motion of solid particles in a fluid stream; the particles arc close enough as to interact and give the appearance of a boiling liquid.

fluidization (entrained) — gas-solid contacting process in which a bed of finely divided solid particles is lifted and agitated by a rising stream of gas.

fluidized-bed — assemblage of small solid panicles maintained in balanced suspension against gravity by the upward motion of a gas.

fly ash— a fine ash from the pulverized urned in power station boilers. or entrained ash carried over from a gasifier.

fractionation — distillation process for the separation of the various components of liquid mixtures.

freeboard — the space in a fluidized-bed reactor between the top of the bed and the top of the reactor.

free swelling index — a standard test that indicates the caking characteristics of coal when burned as a fuel.

Friedel-Crafts reaction — a substitution reaction. catalyzed by aluminum chloride in which an alkyl R-) or acyl (RCO-) group replaces a hydrogen atom of an aromatic nucleus to produce a hydrocarbon or a ketone.

fuel cell — a galvanic cell in which the chemical energy of a conventional fuel is utilized to produce electricity.

fuel gas — low heating value (150-350 BTU, scf) product generally utilized on sitc for power generation or industrial use.

gasification of coal — the conversion of solid coal into a gaseous form by various chemical reactions with steam.

gasifier — a vessel in which gasification occurs. usually utilizing fluidized-bed. fixed-bed. or entrained-bed units.

he@ capacity— quantity of heat required to raise the temperature of one pound of a substance one degree Fahrenheit.

high-Btu gas— a gas having a heating value of 900 to 1,000 Btu per standard cubic foot. which approaches the value for natural gas.

higher-heating value (HHV) — tl۲ heat liberated during a combustion process in which the product water vapor is condensed to a liquid and the heat of condensation is recovered.

hydroclone — a small cyclone extractor for removal of suspended solids from a flowing liquid by means of the centrifugal form set up when the liquid is made to flow through a tight conical vortex.

hydrocoking — coking of tars. SRC. etc.. under hydrogenating conditions to form liquid products.

hydrocracking — the combination of cracking and hydrogenation of organic compounds.

hydrogasification — gasification that involves the direct reaction of fuels with hydrogen 10 optimize formation of methane.

hydrogenation — chemical reactions involving the addition of gaseous hydrogen to a substance in the presence of a catalyst under high temperatures and pressures.

hydrogen donor solvent — solvent. such as anthracene oil tetralin (tetrahydronaphthalene), decalin. etc.. which transfers hydro-

gen to coal constituents causing depolymerization and consequent conversion to liquid products of lower boiling range which are then dissolved by the solvent.

hydrotreating — a process to catalytically stabilize petroleum *or* other liquid hydrocarbon products and or remove objectionable elements from products or feedstocks by reacting them with hydrogen.

Ideal gas— any gas whose equation of state is expressed by the ideal gas law, namely PV = nRT where P is the pressure. V is the volume. R is the gas constant. T is the absolute temperature, and n = number of moles.

Ignition temperature— the minimum temperature necessary to initiate self-sustained combustion of a substance.

Industrial gas — see fuel gas.

Inerts— constituents of a coal which decrease its efficiency in usc. e.g.. mineral matter (ash) and moisture in fuel for combustion.

In situ— in its original place. underground gasification of coal scam.

intermediate-Btu synthesis gas product with a higher heating value between 350 and 500 Btu per standard cubic foot.

Ignite— brownish-black coal containing 65-72 percent carbon on a mineral-matter-free basis. with a rank between peat and subbituminous coal.

limestone— sedimentary rock containing 50 percent carbonate (CO_3) of lime or magnesia. Chemical formula (for calcite limestone) is $CaCO_3$

liquefaction— conversion of a solid to a liquid: with coal. this appears to involve the thermal fracture of carbon-carbon and carbon-oxygen bonds, forming free radicals. These radicals abstract hydrogen atoms yielding low molecular weight gaseous and condensed aromatic liquids.

liquefied patroleum gas (LPG)— those hydrocarbons that have a vapor pressure (at 70°F) slightly above atmospheric (such as propane and butane): kept in liquid form under a pressure higher than 1 atm.

lock hopper — a mechanical device that permits the introduction of a solid into an environment of different pressure.

low-Btu gas — a gas having a heating value up to 350 Btu per standard cubic foot.

lower heating value — the heat liberated by a combustion process assuming that none of the water vapor resulting from the process is condensed, so that its latent heat is not available.

MAF— moisure and ash-free; a term that relates to the organic fraction in coal.

mesh — measure of fineness of a screen. e.g.. a MO-mesh sieve has 400 openings per linear inch.

methanation – the production of methane (CH_4) from carbon monoxide or dioxide and hydrogen.

methane a CH_4, a colorless. odorless. and tasteless gas. lighter than air; the chief component of natural gas.

methane — methanol alcohol. CH_3OH.

micron — a unit of length equal to one millionth of a meter: 10^{-6} meter.

moving bed — particlized solids in a process vessel that are circulated (moved) either mechanically or by gravity flow.

natural gas — naturally occurring gas extracted from sedimental structures consisting mainly of methane and having a higher heating value of approximately 1,050 Btu per standard cubic foot.

noncoking coal — a coal that does not form coke under normal coking conditions.

olefinic hydrocarbon — a class of unsaturated hydrocarbons containing one or more double bonds and having the general chemical formula C_nH_{2n}

open cycle — a thermodynamic power cycee in which the working fluid passes through the system only once and is then exhausted to the atmosphere.

peat— an unconsolidated. hydrophilic. yellowish-brown to brownish-black. carbonaceous sediment. formed by accumulation of partially fragmented and decomposed plant remains in swamps and marshes which retains more than 75 percent inherent moisture and less than 12 percent mineral matter in saturated natural deposits.

petrochemicals— those derived from crude oil or natural gas. or their coal-derived substitutes: they include light hydrocarbons such as butylene. ethylene and propylene. the raw materials for the production of plastics by polymerization.

phenols— a group of aromatic compounds having the hydroxyl (OH) group directly attached to the benzene ring.

pilot plant — chemical process plant containing all the processes of a commercial unit, but on a smaller scale. for the purpose of studying the technical and economic feasibility of the process.

pipeline gas— a methane-rich gas that conforms to certain standards and has a higher heating value between 950 and 1.050 Btu per standard cubic foot.

plenum chamber — an enclosed space through which air is forced for slow distribution through ducts.

present — layer of suitable filtering medium. e.g.. diatomaceous earth. laid down on a rotary filter cloth prior to operation.

prilling tower— a tower that produces small solid agglomerates by spraying a liquid solution in the top and blowing air up from the bottom.

process development unit - a system used to study the effects of process variables on performance: sized between a bench-scale unit and a pilot plant.

proximate analysis— analysis of coal based on the percentages 01 moisture, volatile matter. fixed carbon (by difference). and asn. using prescribed methods. Reported on different bases. such as as-received (or as-fired), dry, mIncral-matter-free (mmf), and dry mineral- matter-free (dmmf).

purification — removal of a wide range of impurities present in gases from coal gasification.

pyrolysis — thermal decomposition of organic compounds in the absence of oxygen.

quenching — cooling by immersion in oil. water bath. or water spray.

Raney nickel catalyst — specially prepared nickel catalyst used in the hydrogenation of organic materals and the methanation of synthesis gas to methane.

raw gas— see crude gas.

reactivity — susceptibility to chemical change: for example, in coal liquefaction. the reactivity of the coal for conversion to liquid products is a function of the coal rank. among other things.

reactor — vessel in which coal-conversion reactions take place.

Rectisol process— a process for the purification of coal-gasification gas based on the capability of cold methanol to absorb all gas impurities in a single step: gas naphtha. unsaturated hydrocarbons. sulfur compounds. hydrogen cyanide. and carbon dioxide are removed from the gas stream by the methanol at temperatures below O°C.

reducing gas — a gas which, at high temperatures, lowers the state of oxidation of other chemicals.

reforming processes — a group of proprietary processes in which low-grade or low molecular weight hydrocarbons are catalytically converted to higher grade or higher molecular weight materials: also applies to the endothemic reforming of methane. for the production of hydrogen, by the reaction of methane and steam in the presence of nickel catalysts.

refractory — a material capable of withstanding extremely high temperatures and having a relatively low thermal conductivity}'.

residence time — *time* spent by a typical particle in a particular zone.

saturated **hydrocarbon** — a carbon-hydrogen compound with all carbon bonds filled; that is. there are no double or triple bonds as in olefins and acetylenes.

scrubber — apparatus in which a gas stream is freed of tar. ammonia. and hydrogen sulfide.

seam coal — coal which is intermediate in rank between bituminous coal and anthracite: contains 8 to 22 percent volatile matter and from 9 I to 93 percent carbon.

semi- water gas — a mixture of carbon monoxide. carbon dioxide. hydrogen. and nitrogen. obtained by passing an air-stream mixture through a hot bed of coke. having a higher heating value of about 120 Btu per standard cubic foot.

sensible heat— that heat which results in only the elevation of the temperature of a substance with no phase changes.

shift conversin — process for the production of gas with a desired carbon monoxide content from crude gases derived from coal gasification; carbon monoxide-rich gas is saturated with steam and passed through a Catalytic reactor where the carbon monoxide reacts with steam to produce hydrogen and carbon dioxide. the latter being subsequently removed in a scrubber employing a suitable sorbent.

sintering — the agglomeration of solids at temperatures below their melting point, usually as a consequence of heat and pressure.

slag — molten coal ash composed primarily of silica, alumina iron oxides. and calcium and magnesium oxides.

slurry — a suspension of pulverized solid in a liquid.

solvation — the assocation or combination of molecules of solvent with solute ions or molecules.

solvent — that component of a solution which is present in excess: liquid used to dissolve a substance.

solvent extractIon — selective solution of coal constituents from finely divided coal particles into a suitable solvent after intimate mixing, usually at high temperatures and pressures in the presence of hydrogen, with or without a catalyst. followed by phase separation.

solvent refined coal (SRC) — a coal extract derived by solvent extraction; a brittle. vitreous solid (m.p. 300° F to 400° F) containing about 0.1 percent ash and about 10 percent of the sulfur in the original coal feedstock; calorific value is about 16.000 Btu per pound: may be used as a clean fuel for power generation by combustion: utilized for the production of h:gh-grade metallurgical coke. anode carbon. and activated carbon by coking. or hydrogenated to produce synthetic crude oil.

space Velocity — volume of a gas (measured at standard temperature and pressure) or liquid passing through a given volume of catalyst in a unit time.

spacific gravity — ratio of the weight of any volume of a substance to the weight of an equal volume of water at 4°C.

specific heat — heat capacity of a substance as compared with the heat capacity of an equal weight of water.

standard **cubic fool {SCF)** — the volume of a gas at standard conditions of temperature and pressure. The American Gas Association uses moisture-free gas at 60° F and 30 inches of mercury (i .0037 atm) as Its standard conditions. The pressure standard IS not universal in the gas Industry: 14.7 psia (1 .000 atm) and 14.4 psia (0.980 atm) are also used. The scientific community uses 32° F and ! atm as standard conditions.

stoichometry — the definite proportions in which molecules react chemically to form new molecules.

stripping — the removal of the more volatile components from a liquid mixture of compounds.

subbituminous coal — the rank of coal between bituminous and lignite. classified by ASTM as having a range of heating values between 8.300 and i 1.000 Btu per pound on a moist mineral-matter-free basis.

substitute natural gas (SNG) — a gas produced from coal. oil sands. or oil shale conforming to natural gas standards.

Superficial velocity — the linear velocity of a fluid flowing through a bed of solid particles calculated as though the particles were not present.

superheater – a heat exchanger ,which adds heat to the saturated steam leaving a boiler.

syncrude — synthetic crude oil: oil produced by the hydrogenation of coal.. coal extracts. oil sands. or oil shale. which is similar to petroleum crude.

synthesia gas — a mixture of hydrogen and carbon monoxide which can be reacted to yield a hydrocarbon.

tail gas — a gas issuing from a gas-treatment unit which may be recycled to the process or exhausted.

tar (coal) — a dark brown or black. viscous, combustible liquid formed by the destructive distillation of coai.

therm — a unit of heat used as a basis for the sale of natural gas; equal to 100.000 Btu.

topping cycle — the higher temperature thermodynamic power cycle of a combined-cycle system.

turndown ratio- the minimum ratio of actual flow rate to design flowrate at which a process unit can be operated.

ultimate analysis — the determination by prescribed method of carbon and hydrogcn in the material as found in the gaseous products of its complete combustion. the determination of sulfur. nitrogen. and ash in the material as a whole and the estimation of oxygen by difference: may be reported on different bases. such as as-received (or as-fired). dry.. mineral-matter-free (mmf). and dry mlnerai-matter-free (dmmf).

Venturi **scrubber**— a gas cleaning device which involves the injection of water into a stream of dust-laden gas flowing at a high velocity through a contracted portion of a duct. thus transferring the dust particles to the water droplets which are subsequently removed.

volatile matter — those constituents of coal, exclusive of moisture. that are liberated from a sample when heated to 1750° F for seven minutes in the absence of oxygen.

water gas— gas produced by the reaction of carbon (in coal or coke) and *steam* to *yield* mixtures of carbon monoxide and hydrogen: similar to synthesis gas.

water gas shift — the reaction between water vapor and carbon monoxide to produce hydrogen and carbon dioxide or the reverse: $CO + H.O \rightleftarrows H: + CO_2$.

working fluid — a gas stream which directly does work. e.g.. powering a gas turbine.

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