IEA CLEAN COAL CENTRE profiles

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Operating experience of low grade fuels in circulating fluidised bed combustion (CFBC) boilers

Although subject to sometimes quite considerable short-term variations, the long term trend for the price of coal, along with other primary energy resources, is upwards. In addition, the need to protect the environment has resulted in a reduction in low-cost disposal routes for many waste materials (eg coal processing wastes and sewage sludge) and this has provided a driver to develop alternative ways of dealing with these arisings. Finally, the growth in the use of carbon-neutral renewable technologies has spurred interest in the use of biomass for energy production; on a stand-alone basis and in combination with coal.

Low grade fuels evaluated for energy production		
Agricultural	Peach wood	Paper sludge
	Pear wood	Oil soaked clay
Alfalfa seed straw	Peat	PET/Glycol liquid
Almond brush	Pecan shells	Petroleum tanker sludge
Almond shells	Pistachio shells	Petroleum coke
Almond wood	Pistachio wood	Polyolefins
Apple wood	Plum wood	Sontara
Apricot wood	Poultry derived fuel	Tyre derived fuel
Barley straw	Prune pits	Unburned fuel
Bean straw	Prune wood	
Cherry pits	Race track shavings	**Municipal waste**
Chicken litter	Race track straw	
Citrus trees	Rice hulls	Refused derived fuel
Coffee grounds	Rice straw	Wastewater treatment sludge
Corn cobs	Safflower stalks	
Corn kernels	Sunflower hulls	**Wood**
Corn stalks	Swine solids	
Cotton gin wastes	Tobacco sludges	Bark
Cotton seed hulls	Tomato pomace	Hardwoods
Cotton stalks	Walnut shells	Railroad ties
Cow manure	Walnut wood	Saw dust
Cubed garlic	Wheat midds	Softwoods
Fig culls	Wheat straw	Zinc borate OSB waste
Fig wood		Board plan waste
Garlic and onion skins	**Industrial waste**	Planer shavings
Grape canes		Slander dust
Grape pomace	Grease, scum and screenings	Slash
Grape scaffolds	Cardboard sludge	Urban wood waste
Grass straw	Auto shredded residue	Woodex pellets
Lignin cake	Cellulose absorbent	
Manure + wheat straw	Carpet scraps	**Fossil fuels, etc**
Nectarine wood	Char	Anthracite
Oat straw	Cellulose acetate	Coal dust
Olive pits	Distillation bottoms	Subbituminous
Orange peel and pulp	Charcoal	Bituminous
Paunch manure	Hospital waste	Lignite
Peach pits	Dried paper sludge	Sulphite liquor

IEA Clean Coal Centre is a collaborative project of member countries of the International Energy Agency (IEA) to provide information about and analysis of coal technology, supply and use. IEA Clean Coal Centre has contracting parties and sponsors from: Australia, Austria, China, the European Commission, Germany, India, Italy, Japan, New Zealand, Poland, Russia, South Africa, Thailand, the UK and the USA.

Each issue of **Profiles** is based on a detailed study undertaken by IEA Clean Coal Centre, the full report of which is available separately. This particular issue of Profiles is based on the report:

Operating experience of low grade fuels in circulating fluidised bed combustion (CFBC) boilers

Ian Barnes

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This report is free to organisations in member countries, £100 to organisations in non-member countries for six months after publication, and free thereafter.

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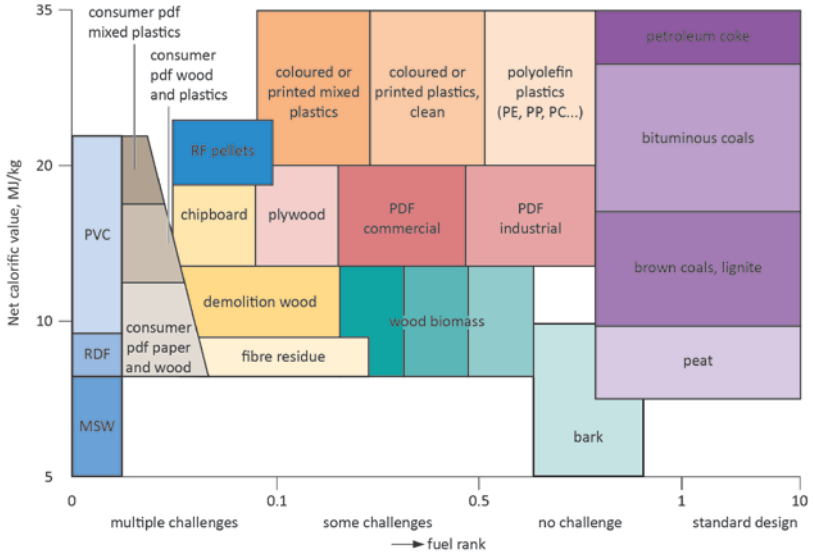
These three factors are largely responsible for the use of the so-called 'low grade fuels' for energy generation singly, and in combination with coal. The term 'low grade fuels' is generally used to describe materials that have an energy content that may be recovered by direct (eg combustion) or indirect (eg gasification) processes, but where that energy content is significantly lower than the range expressed in normal fossil fuels (oil, gas and coal). The lower energy content may be a consequence of low inherent potential in the organic material, or by the 'dilution' of the carbonaceous material by mineral matter and water. Additionally, the fuel may be considered low grade by virtue of having high concentrations of pollutant precursors such as sulphur. That said, some low grade fuels, such as waste plastics, may have an intrinsically high energy content although they are most frequently encountered in a diluted form such as in refuse-derived fuel. Low grade fuels may be attractive for a number of reasons particularly in having a sufficiently low cost that justifies their use. Also, they may also otherwise be considered as waste materials that have a relatively high disposal cost and this cost can be offset or eliminated by using that waste for energy generation.

The utilisation of low grade fuels has been investigated in several coal utilisation systems, but one particular technology stands out as being particularly well suited to using these fuels; circulating fluidised bed combustion (CFBC). CFBC plant have evolved from earlier bubbling bed fluidised bed combustion technology where primary combustion air is injected from beneath a bed of fuel suspending the particles and giving them fluid-like flow properties. In bubbling fluidised beds low fluidising air velocities are employed to prevent fine particles from being carried out of the bed, but circulating fluidised beds use higher fluidising air velocities which entrain particles throughout the boiler. The flue gases are fed into solid separators (typically cyclones) that return solid bed and ash to the lowest part of the combustor and thus prevent unburnt fuel from leaving the furnace. This creates a recycle loop through which fuel particles can pass 10 to 50 times until complete combustion is achieved. The prolonged combustion time results in much lower temperatures (800–900°C) than those found in pulverised coal combustion-based systems.

Despite the clear advantages of CFBC is utilising low grade fuels, different fuels present challenges to the technology. The benefits of using these fuels must be weighed carefully against the plant design and operating practice modifications, the recoverable energy content of the fuel and the cost of that fuel. These sometimes conflicting requirements are summarised in the figure below.



A categorisation of fuels according to the challenges with respect to CFBC boiler design

Different manufacturers have tackled these issues to ensure the availability of reliable plant with considerable success. This report on which this profile is based sets out examples of the range of low value fuels, their reserves and properties, with particular emphasis on coal-derived materials, the issues for CFBC plant in utilising these fuels and selected examples of manufacturer and operator experience with purpose built, or modified CFBC plant. Finally an up-do-date global inventory of CFBC plants using a range of low value fuels is presented.