



NON-ENERGY USES OF COAL

The combustion of coal for power and heat generation is predicted to gradually reduce as nations seek to lower CO₂ emissions. This study examines alternative uses for coal that range from large-scale processes treating raw lignite to novel small-scale applications associated with high tech industries. The coal to chemicals industry is the fourth largest consumer of coal, after the power, steel and cement sectors. Coal tar pitch and coal gasification yield a wide range of established chemical products. Other commercial uses for coal include the synthesis of activated carbon, carbon fibre, composite materials, and carbon electrodes. Recent innovative technologies include the development of high value nanomaterials, the novel extraction of key rare earth elements from coal and lignite modified for agricultural purposes.

COAL TO CHEMICALS

The coal tar industry operates worldwide and converts the by-products of coal coking to a host of common chemicals, pharmaceuticals, dyes and preservatives. Although the demand for them is increasing, the feedstock supply is shrinking due to contraction in blast steel manufacture. Also, the tar industry must respond to growing concern over the environmental impact of polyaromatic products.

Coal gasification to polymers, based in China, has an increasing share of the overall polymer market. The industry benefits from low feed cost but has more complex production methods. The process has greater CO₂ emissions than equivalent gas polymerisation, and so, coal-to-chemicals looks to be an early adopter of carbon capture (CCUS).

MINERALS FROM COAL

Growing demand for rare earth elements (REE) which are critical to the deployment of renewable energy and transport electrification has led to a new initiative to extract REE minerals directly from coal. Unique to the coal industry, waste streams and lignite resources can be relatively rich in REE and offer an alternative resource to the restricted supply from conventional ore mining. Initial REE recovery targets in the US funded programme have been exceeded. The removal of heavy metals from coal waste streams may offer substantial environmental benefits at coal mining sites.

PITCH CARBON FIBRE

Carbon fibre is a high performance, weight saving structural material with properties superior to either aluminium or specialised steels. Although expensive, carbon fibre is ideally suited to specialised engineering applications within the aviation, aerospace, and motor sport sectors. Carbon fibre produced from coal pitch is an alternative to the more common polyacrylonitrile (PAN) fibre derived from petroleum feedstocks. Production of pitch derived fibre is technically harder, but manufacture in the USA and Japan has recently doubled to 10,000 t/y. High quality pitch fibre is deployed in space craft materials and can exhibit exceptional thermal conductivity properties.

ALTERNATE USES FOR LIGNITE

The international trend to withdraw from lignite power generation is due to its relatively high CO₂ emissions. The impact on countries such as Australia may mean that there is a risk that lignite could become a stranded energy resource.

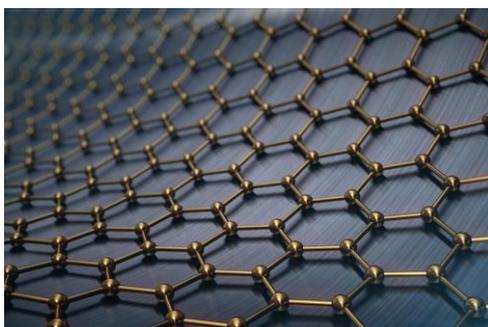
Desertification and rising demand for food may increase demand for agricultural products. New lignite processing techniques involving air or microbial treatment can provide humic products capable of enhancing soil fertility. A substantial application rate is required, making this a potential high-volume lignite market.

Gasification of lignite to hydrogen gas transforms low quality coal into a carbon-free fuel. Initial technical developments in Australia are testing oxidation, shift and capture technology, ultimately intended to form part of Japan's hydrogen economy transition. The project will also examine the safe and economical transport of hydrogen, either cryogenically or using ammonia as an intermediate hydrogen carrier.

ACTIVATED CARBON FOR GAS AND LIQUID PURIFICATION

A rising demand for activated carbon products is due to the role it plays in water recycling, natural gas purification, mercury emission control, together with the potential to act as a CO₂ capture agent. Activated carbon is produced in a mild coking process, with production currently over 1 Mt/y.

NANOMATERIALS



3-D illustration of a graphene layer showing hexagonal form

An increasingly important if low-volume use of coal carbon is the synthesis of nanomaterials to form polymer composites, energy storage devices, novel electrodes, catalysts, and specialist coatings. Carbon nanotubes (CNT) and graphene are typically produced by methane vapour deposition or graphite exfoliation techniques. However, a new electrochemical method can directly convert raw coal to produce graphene sheets, and selected coals can be processed to extract graphene dots for the latest display technologies.

FUTURE FOR COAL PRODUCTS

Non-energy uses of coal are growing in all sectors and cumulatively the total requirement for coal feedstocks exceeds 100 Mt/y. The increasing electrification of energy and transport depends upon specialist products (carbon fibre, nanomaterials, REE) which can be obtained from coal. The nanomaterials sector is a valuable niche market that is rapidly expanding. The manufacture of graphene directly from coal is potentially a breakthrough technology providing coal sourced materials for the latest IT applications.

Rare earth elements are a valuable commodity, essential to aerospace development, but there is growing concern over limited economical supplies that are predominantly obtained from China. The US coal to REE programme offers an alternate source with positive environmental benefits.

Lignite resources, formerly used in local power plants, may be harnessed for agricultural humic products to counter the increasing crisis of land desertification. Alternately, lignite is under investigation as a source of carbon free fuel in pursuit of the Japanese hydrogen economy.

The IEA Clean Coal Centre is a technology collaboration programme mandated by the International Energy Agency (IEA). We provide independent information and analysis on all coal-related trends compatible with the UN Sustainable Development Goals. Each executive summary is based on a detailed study which is available separately from www.iea-coal.org. This is a summary of the report Non-energy uses of coal by Dr Ian Reid, CCC/291, ISBN 978-92-9029-614-0, 90 pp, November 2018