Coal InThe Steam Era

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Did you know that in **1929**, the US produced 535 million tons of bituminous coal. The ICC annual report says in 1929 US Class I steam locomotives consumed 113.9 million tons of bituminous, 1.6 million tons anthracite, 2.6 billion gallons fuel oil -- and 19,499 cords of hard wood and 52,815 cords of soft wood.

Roughly 23% of the bituminous coal was used by the Class I railroads in that year.
What??? I thought there was just coal, not different types…

What are the types of coal?
There are four major types (or "ranks") of coal. **Rank refers to steps in a slow, natural process called "coalification," during which buried plant matter changes into an ever denser, drier, more carbon-rich, and harder material.** The four ranks are:

- **Anthracite**: The highest rank of coal. It is a hard, brittle, and black lustrous coal, often referred to as hard coal, containing a high percentage of fixed carbon and a low percentage of volatile matter.
- **Bituminous**: Bituminous coal is a middle rank coal between subbituminous and anthracite. Bituminous coal usually has a high heating (BTU) value and is used in electricity generation and steel making in the United States. Bituminous coal is blocky and appears shiny and smooth when you first see it, but look closer and you might see it has thin, alternating, shiny and dull layers.
- **Subbituminous**: Subbituminous coal is black in color and is mainly dull (not shiny). Subbituminous coal has low-to-moderate heating values and is mainly used in electricity generation.
- **Lignite**: Lignite coal, aka brown coal, is the lowest grade coal with the least concentration of carbon. Lignite has a low heating value and a high moisture content and is mainly used in electricity generation.

The precursor to coal is peat. Peat is a soft, organic material consisting of partly decayed plant and mineral matter. When peat is placed under high pressure and heat, it undergoes physical and chemical changes (coalification) to become coal.

COAL RANKS
Plant material --> Peat --> Lignite --> Subbituminous --> Bituminous->Anthracite -------------->
-----------Increasing heat and pressure ---------------------->
As a general rule, the harder the coal, the higher its energy value and rank. The comparative ranking of four different types of coal from the densest in carbon and energy to the least dense is as follows:

Rank	Type of Coal	Calorific Value (MJ/kg)
#1	Anthracite	30 megajoules per kilogram
#2	Bituminous	18.8–29.3 megajoules per kilogram
#3	Sub-bituminous	8.3–25 megajoules per kilogram
#4	Lignite (brown coal)	5.5–14.3 megajoules per kilogram

History of Coal
Before the eighteenth century, Britain — and the rest of Europe — had produced coal, but only in a limited quantity. Coal pits were small, and half were opencast mines (just big holes in the surface). Their market was just the local area, and their businesses were localized, usually just the sideline of a larger estate.

During the period of the industrial revolution, as demand for coal soared thanks to iron and steam, as the technology to produce coal improved and the ability to move it increased, coal experienced a massive escalation. From 1700 to 1750 production increased by 50% and nearly another 100% by 1800. During the later years of the first revolution, as steam power really took a firm grip, this rate of increase soared to 500% by 1850.

The Demand for Coal
The rising demand for coal came from many sources. As the population increased, so did the domestic market, and people in town needed coal because they weren't near to forests for wood or charcoal. More and more industries used coal as it became cheaper and thus more cost-effective than other fuels, from iron production to simply bakeries. Shortly after 1800 towns began to be lit by coal powered gas lamps, and fifty-two towns had networks of these by 1823. During the period wood became more expensive and less practical than coal, leading to a switch. In addition, in the second half of the eighteenth-century, canals, and after this, railroads made it cheaper to move greater amounts of coal, opening up wider markets. In addition, the railroads were a source of major demand. Of course, coal had to be in a position to supply this demand.

Coal and Steam
Steam had an obvious impact on the coal industry in generating vast demand: steam engines needed coal. But there were direct effects on production, as Newcomen and Savery pioneered the use of steam engines in coal mines to pump water, lift produce and provide other support. Coal mining was able to use steam to go deeper than ever before, getting more coal out of its mines and increasing production. One key factor to these engines was they could be powered by poor quality coal, so mines could use their waste in it and sell their prime material. The two industries — coal and steam — were both vital for each other and grew symbiotically.

Coal and Iron
Darby was the first person to use coke – a form of processed coal – to smelt iron in 1709. This advance spread slowly, largely due to the cost of coal. Other developments in iron followed, and these also used coal. As the prices of this material fell, so iron became the major coal user, increasing demand for the substance vastly, and the two industries mutually stimulated each other. England pioneered iron tramways, which enabled coal to be moved more easily, whether in mines or on route to buyers. Iron was also needed for coal using and facilitating steam engines.

Coal and Transport
There are also close links between coal and transport, as the former needs a strong transport network able to move bulky goods. The roads in Britain before 1750 were very poor, and it was hard to move large, heavy goods. Ships were able to take coal from port to port, but this was still a limiting factor, and rivers were often of little use due to their natural flows. However, once transport improved during the industrial revolution, coal could reach greater markets and expand, and this came first in the form of canals, which could be purpose-built and move large quantities of heavy material. Canals halved the transport costs of coal compared to the packhorse.

Other canals soon followed, many built by coal mine owners. There were problems, as canals were slow, and iron trackways still had to be used in places.

Trevithick built the first moving steam engine in 1801, and one of his partners was a coal mine owner searching for cheaper and faster transport. Not only did this invention pull large quantities of coal quickly, but it also used it for fuel, for iron rails, and for building. As railways spread, so the coal industry was stimulated with railway coal use rising.

COAL-BURNING

Compared to coal, wood is a bulky, primitive fuel with a low calorific value. In the nineteenth century one ton of soft coal was considered equal to 13/4 cords of wood, or, roughly figuring wood at 3,000 pounds per cord, 2,000 pounds of coal equaled 5,250 pounds of wood.

The greater heating value of coal over wood was well understood by engineers at the beginning of the railroad era. Contrary to present erroneous beliefs that wood was the only fuel considered at the time, a surprising number of our first railways initially experimented with coal-burning locomotives, turning to wood only as a last resort. In 1828 the Delaware and Hudson planned to use coal-burning engines for two reasons: one, it was a coal carrier; two, the several locomotives imported for that service—the *Stourbridge Lion* among them— were copied from British colliery locomotives, which had always burned coal. The failure of this pioneering steam railroad venture was attributable to weak tracks rather than to the use of coal as fuel. The Baltimore and Ohio's first experimental locomotive, the Tom Thumb, burned anthracite successfully; the road then specified that all engines entering its 1831 locomotive contest must use the same fuel. In later years this road was a leader in the development and use of coal-burning locomotives. The early attempts to introduce coal-burning locomotives were a failure. A small number of "coalers" continued to work, but, in general, early American roads were powered almost exclusively by wood-burners. The chief difficulty was an inability to burn coal. The blame falls directly on the type of coal available. Only **anthracite**, or as it was first known, "**stone coal**," was mined in this country before about 1840. It was a difficult fuel to burn, particularly in the small locomotive fireboxes of that time. In addition, it was a slow-burning fuel and was therefore particularly unsuited to the needs of the locomotive, where rapid combustion was essential for a rapid production of steam. Had soft coal been more commonly available in the 1830's, it is likely that successful coal-burners would have been developed many years earlier.

The high price and limited supply of coal in this period were other factors that discouraged an early introduction of coal burning locomotives. Coal cost from $7.00 to $10.00 per ton in the 1830's. The big mines were located in eastern and central Pennsylvania. Transportation costs considerably boosted the price per ton for roads outside this area. As other coal fields opened, particularly the Maryland, West Virginia, and southern Illinois deposits, railroads in these areas were encouraged to adopt coal. But few of these fields were in production before 1850; some were not in full operation until many years later. Anthracite fields, which had been commercially worked before any locomotives were employed in this country, did not achieve large production until after 1840. Only after that time did coal become an important American fuel. Industry, in general, was slow to adopt coal; thus, railroads were not alone in their slow acceptance of this fuel.

As production in the old fields grew, new fields opened, and railroads could reach the mines and offer cheap transportation; coal prices accordingly showed a steady decline as the nineteenth century passed. By the mid-1850's coal was down to about $3.00 per ton, and in 1862 the Baltimore and Ohio was able to get coal at 75 cents a ton because of the many mines along its route. It was this decline in coal prices, rather than the dramatic increase in wood prices, that brought about the great conversion in locomotive fuel.

The railroads closest to and serving anthracite coal mining areas were basically:

Central Railroad of New Jersey
Delaware Lackawanna & Western Railroad
Lehigh Valley Railroad
Reading Company
Lehigh and New England
Lehigh and Hudson River Railroad

also to some extent: Delaware & Hudson, New York, Ontario & Western, New York, Susquehanna & Western, Erie. For the anthracite mining areas of NE PA.

Most other coal was bituminous elsewhere in the country, some very few burned lignite, and some of course, oil.

The Baltimore and Ohio Railroad showed a strong interest in coal burning from its earliest years and was the only major American line to operate coal burning locomotives continuously in the last century. Before 1840 **anthracite** was imported from Pennsylvania at $8.00 a ton. After the road reached the soft-coal fields of western Maryland in 1840, **bituminous coal** was adopted. In the next year, half of the road's power burned coal exclusively while a few engines burned a mixture of wood and coal.

The fuel question followed a similar pattern in the Midwest. The Chicago, Burlington and Quincy was one of the first midwestern railroads to convert. It acquired its first coal-burner in 1855 after reaching the southern Illinois coal fields. The next year, eleven coal engines were in service; in 1859 twenty-five were on the road. The conversion was accelerated by the purchase of coal mines so that by 1868 all of its engines were burning coal. The Illinois Central began experiments with coal-burning locomotives in 1855. At first, poor local coal dampened prospects for an early conversion, but, despite this difficulty, over half of the road's engines were coal-burners by 1861. Five years later only 5 of 151 engines were wood-burners. Not all railroads in this area found native coal satisfactory, and the Galena and Chicago Union's report of 1863, while admitting that wood prices were prohibitive, stated that coal was no ready solution.

The conversion of locomotive fuel from wood to coal may be summarized as follows: The early interest in coal-burning resulted in no substantial use; only a few coal-field lines regularly employed this fuel. By the 1850's a renewed and substantial interest in coal-burning was thwarted by the mistaken belief that revolutionary changes in firebox design were necessary. It was quickly established that fireboxes of ordinary construction were capable of successful coal-burning, and by the late 1850's several important railroads had adopted coal. During the 1860's and 1870's coal was accepted as the best fuel for locomotives, and all major railroads began abandoning wood. By 1880 more than 90 per cent of railway fuel was coal.

By the 1930s, Class 1 steam engines would burn 44 tons of coal and use 2,880 gallons of water per hour.

Coke
Coking coal, also known as metallurgical coal, has low sulfur and phosphorus content and can withstand high heat. Coking coal is fed into ovens and subjected to oxygen-free pyrolysis, a process that heats the coal to approximately 1,100 degrees Celsius, melting it and driving off any volatile compounds and impurities to leave pure carbon. The hot, purified, liquefied carbon solidifies into lumps called "coke" that can be fed into a blast furnace along with iron ore and limestone to produce steel. While in England, the use of coke was being pushed due to the amount of smoke, soot and pollution produced by coal and wood, it never caught on in the US.

Note: The Big Boy locomotives of UP used **bituminous coal** from the UP owned mines in Wyoming. Here are some details: The centipede-style tender was supported by 14 wheels, each 42 in (1.07 m) tall. The first four wheels made up the leading truck, and the 10 trailing wheels were mounted directly to the tender. The tender originally carried 56,000 lbs. (25,401 kg) of coal in a front compartment. In the late 1940s, 10 in (254 mm) tall steel sideboards were added to the top of the coal compartment. The sideboards enabled an additional 8,000 lbs. (3,629 kg) of coal to be loaded, increasing the tender’s capacity to 64,000 lbs. (29,030 kg). A rear compartment held 24,000 gallons (90,850 L) of water for the -1 class and 25,000 gallons (94,635 L) of water for the -2 class. At full steam, a Big Boy engine would consume the tender’s coal and water supply in two hours, but a proper facility could replenish the coal and water in eight minutes.

Sources:

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