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Lignite Rides the Rails in Europe

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Lignite, or brown coal, is a globally abundant low-grade carbonaceous fuel used predominantly in certain European and eastern Mediterranean countries for electricity generation, district heating, and industrial applications. Lignite has been historically delivered to power plants near the mining site, since its relatively high moisture and low energy content were thought to make wider distribution too expensive. However, this conventional wisdom no longer holds true in Europe, where rising prices, particularly for natural gas, are increasing the radius of economical transportation. In addition to supplying local power stations, the lignite mining regions have become rail and truck depots for deliveries to widely dispersed locations that were formerly the domain of other fuels.

Europe’s largest lignite producers include Germany, Poland, Turkey, and Greece (see Figure 1 for 2013 production rates from EURACOAL).[1] Germany excavated 178 Mt in 2014,[2] affirming its rank as the world’s leading lignite miner. Greece exhibits the highest per capita usage, with more than six tonnes per year extracted for each of its 11 million inhabitants (see Figure 2). Although outranked in lignite tonnage by a few other countries, the Greek economy is crucially dependent on local energy supplies impervious to foreign exchange rates.

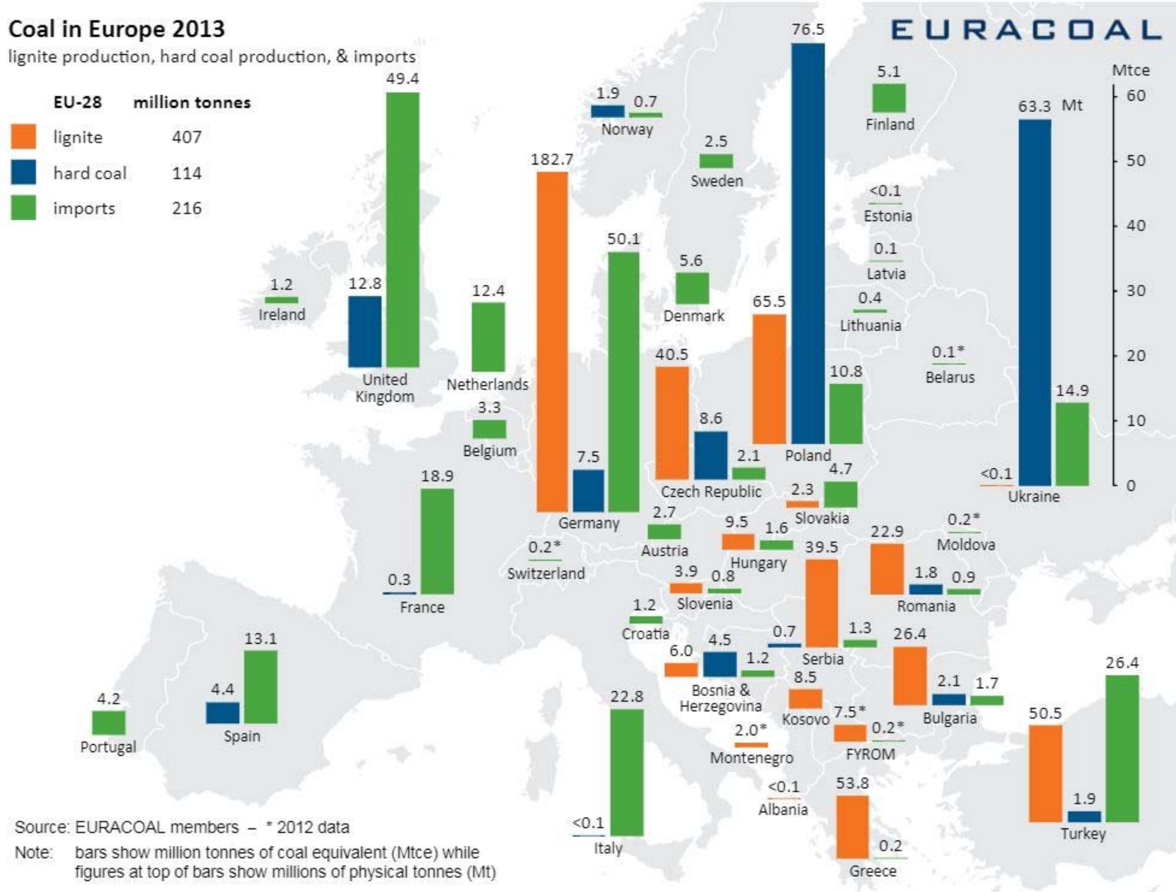

FIGURE 1. Lignite and coal production in Europe

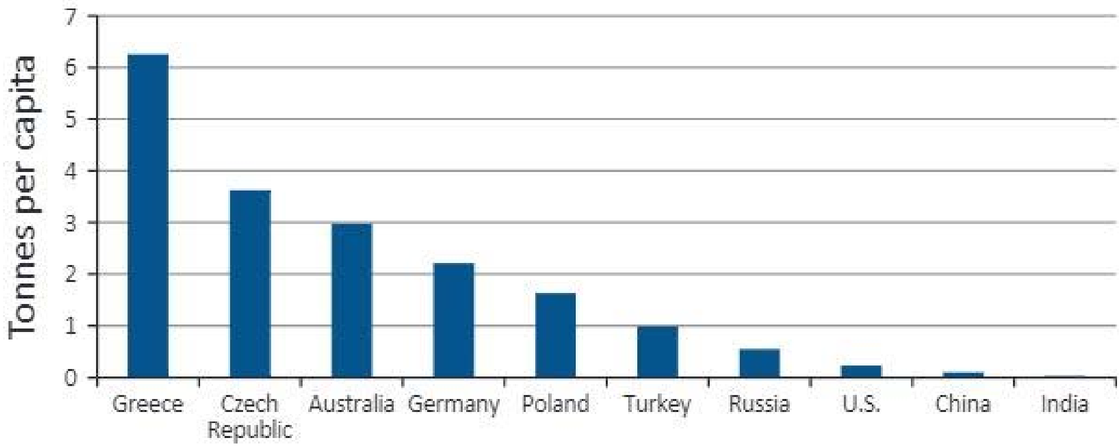

FIGURE 2. Lignite production per capita (2013–2014 figures)

The transportation of lignite enhances domestic energy security, providing a low-cost alternative to rising import dependency that currently stands at about 64% in Germany and 54% overall in the EU.[3]

European, and particularly German,[4] energy policies are directed toward the gradual replacement of large lignite-fired power plants by renewables. However, comparable transitions are not occurring with municipal heating and industrial boilers.[4] Despite reduced demand for central power generation, therefore, mining may be continued at commercially viable levels by providing greater quantities of lignite to decentralized applications.

Lignite is being transported via rail in Europe in record quantities.

THE EXPANDING DECENTRALIZED LIGNITE MARKET

The increasing diversity of lignite usage provides new perspectives for extraction, employment, and distribution despite greenhouse gas policy constraints on electricity generation. A market survey compiled by the Vattenfall subsidiary GMB in 2007[5] included 85 German municipal power and/or heating customers outside of the Rhineland mining region (dominated by RWE) that potentially could be served with transported dry lignite. An additional 250 industrial facilities were listed in the areas of energy production and mining, chemical and pharmaceutical products, plastics and textiles, paper, metal and vehicles, foodstuffs, and transportation. Thermal capacities ranged between 1 and 145 MW.

Construction and infrastructure are already established market sectors for transported lignite. The RWE subsidiary Rheinbraun Brennstoff (93.6 Mt in 2014) supplies three million tonnes of dry pulverized lignite (LEP) annually to over 600 asphalt-mixing installations throughout Europe.[6] Large-volume shipments are also made to cement plants located at limestone formations between the Ruhr industrial region and the Alps. The Swiss Siggenthal cement factory north of Zürich receives two trainloads (1500 tonnes) of lignite per week from the Rhineland—a distance of 600 km.[7] This direct route is preferable to loading Rotterdam coal from Rhine River barges in the city of Basel 60 km away, demonstrating that European lignite can offer competitive advantages over seaborne imports at distant locations.

In Lusatia southeast of Berlin, Vattenfall Europe Mining (61.8 Mt) supplies various grades of pulverized lignite to 10 municipal power plants, which often cogenerate heat and power (CHP).[8] The eastern German MIBRAG Mining Corporation (20.9 Mt) delivers lignite 40 km via rail from its Profen surface mine to the Schkopau CHP plant (2×450 MW_e) where it is used for both chemical production and railway electrical power generation (16 ⅔ Hz). Additional lignite deliveries have more recently been made, using 25-tonne trucks, from the company's second United Schleehain mine to Profen for railway distribution.

MIBRAG is the primary lignite supplier for six power plants located between 40 and 402 rail kilometers from the Profen loading terminal. In addition, three sugar factories and one production facility for biofuels are served over distances of up to 120 km.

Smaller industrial customers also rely on transported lignite. For example, a power plant operated by Allessa Chemie using pulverized lignite recently entered service at Fechenheim east of Frankfurt, Germany. A similar facility will be completed next year by the WeylChem chemical company in nearby Griesheim. This plant will be capable of firing lignite, natural gas, or "white powder", an inexpensive biomass substitute. Three truckloads of finely pulverized lignite per day will be supplied from the Rhineland about 200 km northwest near Cologne, with ash returned for mining reclamation.

An electronic capacity control limits both plants to 19.5 MW operation, alleviating the need to purchase EU Allowances (EUA) for emissions trading. Public hearings are also required only for capacities exceeding 50 MW, and environmental impact assessments per Directive 2014/52/EU above 300 MW.

LIGNITE CHARACTERISTICS

Lignite properties that are relevant to fuel usage, such as combustion heat, water, and ash, vary according to local geological conditions. Table 1 indicates the essential parameters of German lignite extracted by surface mining in the regions shown in Figure 3. The average calorific value of German lignite (*Braunkohle*) lies between 7.8 MJ/kg, which is the lowest grade in the Rhineland and in Lusatia, and up to 11.3 MJ/kg in Middle Germany near Leipzig.[9] This soft (*weich*) brown coal exhibits high water content along with appreciable quantities of sulfur and ash, particularly in certain eastern German deposits.

TABLE 1. German-mined lignite parameters

Production Region	*Calorific Value MJ/kg*	*Water %*	*Sulfur %*	*Ash %*
Rhineland	7.8–10.5	50–60	0.15–0.5	2–8
Lusatia	7.8–9.5	48–58	0.3–1.5	2.5–16
Middle Germany	9.0–11.3	49–53	1.5–2.1	6.5–10

Some Polish lignite is similar to Lusatian quality in seams that extend beneath the Oder River. The calorific value of higher density Czech brown coal (*hnedé uhlí)* south of the nearby Ore Mountain range in North Bohemia, however, lies between 11.6–20.56 MJ/kg. The respective grades of hard lignite comprise both dull brown coal (*matt*) and shiny brown coal (*lesk*) that may resemble black coal (černé uhlí). Lignite rail distribution is essential for maintaining widely employed district heating services in the Czech Republic. However, Germany remains particularly active in developing the decentralized lignite market in order to diffuse mining risks ensuing from the national energy transition (*Energiewende*).

FIGURE 3. Lignite-producing regions in Germany

The lignite shipped by rail is graded according to individual plant requirements. Since crude lignite is permeated with mining groundwater, and thus the pressure at the bottom of a stockpile will be higher, it may be delivered several times a week to reduce the possibility of spontaneous combustion in large stockpiles.[10] Any moisture lost during transport can actually upgrade fuel quality. For instance, imported Middle German lignite has been rated at 12 MJ/kg in the Czech Republic, several percent higher than mining specifications.[11]

Alternately, dried pulverized lignite (*Braunkohlenstaub* BKS, alternatively LEP or LignoPlus) with double the calorific value of 21–22.2 MJ/kg has a residual water content of only 10.5–11%, improving combustion characteristics and reducing freight volumes. For this grade of lignite, railway container cars or silo trucks (for smaller quantities) are used for transport.

Germany's three miners also manufacture lignite briquettes with similar thermal characteristics for traveling grate furnaces and heating stoves. MIBRAG briquettes are pressed from low-sulfur RWE lignite delivered from the Rhineland. The Czech Republic has been importing 0.14 Mt of briquettes annually for the heating market.

Sifted lignite is delivered in Germany for circulating fluidized bed boilers with about 19 MJ/kg and 19% water content.

LIGNITE ECONOMICS AND PROCESSING

The manageable costs of lignite production are prerequisite to long-term contracts for distribution and use. Although mine-mouth prices for German lignite have risen from about €4/MWh_{th} (per 3.6 GJ, roughly one third tonne) at the turn of the century to currently around €6/MW_{th}, adjusted for calorific value and sulfur content, the continuing low cost is largely impervious to global energy markets. The effective fuel price at the most efficient (43%) plants is about €1.5 cents/kWh generated electrical power.

All grades of crude and processed lignite are considerably less expensive than natural gas, which is traded in Europe at over €20/MWh_{th} (US$7/MMBtu). The price difference between lignite and natural gas does not include the additional benefits of reliable supply and energy security provided by domestic lignite. Thus, a number of relatively new gas plants are being retired in Germany due to rising fuel costs and declining yearly demand.

Naturally, moving lignite by rail increases the overall cost of utilization. Total charges for fuel, rolling stock, dispatching, and personnel easily make rail transport more expensive than the mined value of the lignite. Compared with the U.S., railroad costs per tonne·km are four times higher in Europe, while revenues are only twice as high.[12] This can be partly attributed to the fact that passenger trains service accounts for 79% of the distance traveled on the European rail network (2007 data), which may put freight trains at a scheduling disadvantage. Even so, the total cost of the transported lignite is sufficiently low to make it a viable endeavor.

A typical gravity-dumping railcar used for lignite transport with loading capacity of over 60 tonnes.

The EcoTransIT website permits transport energy expenditures to be calculated between European cities with rail connections.[13] A diesel freight train requires roughly three liters of fuel per double kilometer. The energy expended for electric traction is similar when power generation losses are included. In all calculated cases, rail transport energy constitutes less than 1% of the delivered lignite energy content. Thus, from the standpoint of required fuel expenditures, the shipment of lignite by rail remains uncritical.

LIGNITE'S TRANSITION

Transported lignite is of growing importance in many parts of Europe. Smaller regional lignite power plants can supply both district heat and the grid power needed to offset varying renewable generation. Transported lignite provides municipal utilities and industrial parks with highly competitive fuel costs, durable supply reliability, and commensurate energy security. At a time when natural gas power plants in Europe can lack financial backing, lignite is taking to the rails in quantities previously unimaginable.

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