Anthracite Market Survey

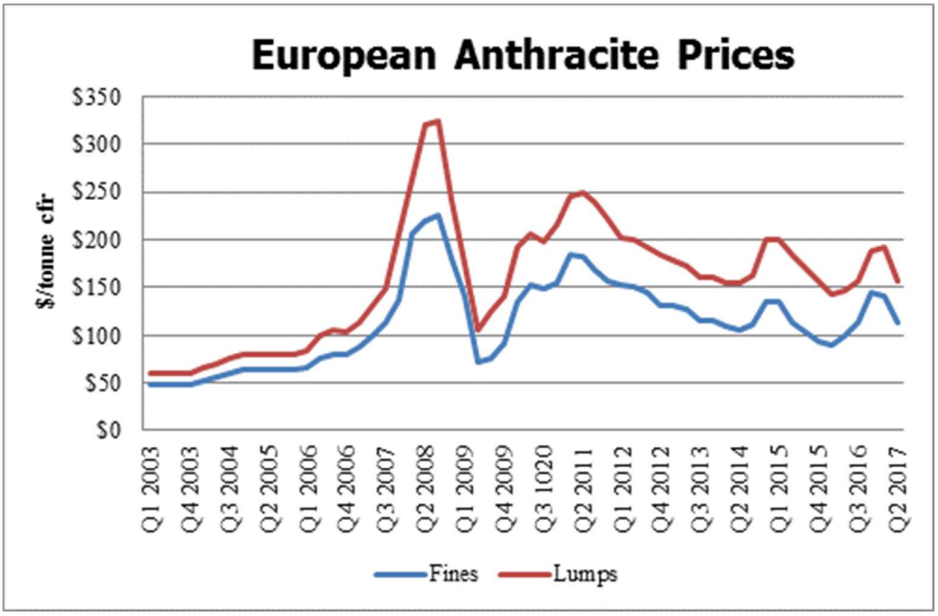
June 2017

Key Points

- **Anthracite is low-volatile (<10%), high fixed-carbon (>80%) coal used in various industrial and other applications, as well as for power generation in specially equipped plants.** The anthracite market divides primarily into applications needing sized lumps and those for fines (<10mm typically). Anthracite lumps are used as a reductant in various industrial processes, as well as a household fuel. It has been successfully introduced as a low-cost replacement for metallurgical coke. The main application for anthracite fines is as a fuel in ore sintering and pelletizing applications alongside other carbon materials including coke breeze. The anthracite and coke markets are closely linked due to the nature of their applications. There are also "niche" applications for anthracite requiring specific sizing and quality.

- **Mining of high-quality anthracite occurs primarily in China, Russia, South Africa, Ukraine, the United States and Vietnam.** Production remains some western European countries for power generation but is unlikely to survive beyond next year. In terms of trade, Russia has become the dominant supplier to world markets over the past few years. In Asia, Russia has progressively replaced China and Vietnam as the primary supplier. With conflict disrupting production in eastern Ukraine since 2014, Russia has made inroads into the European market.

- The high prices for coke for much of the 2000s decade led to its substitution in some areas by anthracite as well as by other carbon materials. It is unclear how much replacement of coke is left for the future. Reporting prices for anthracite is complicated by the range of grades and sizes available, but "Resource-Net" has successfully tracked the European market for high-quality lumps and fines for more than ten years, as shown below. There was a substantial run-up in prices in 2007-08 and again in 2011. Since then, pricing has been on a lower level due declining demand in Europe and the slow world economy, plus adequate supply.



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About Resource-Net

Andrew Jones is an independent analyst and researcher on the mineral commodity markets. He established Resource-Net in Brussels, Belgium in 1999. Resource-Net's main interest lies in metallurgical reductants, producing regular research on the global markets for:

- Metallurgical and foundry coke;
- Anthracite for reduction applications, metallurgical coke replacements;
- Metallurgical coal.

Resource-Net's approach to commodity research can be summarized as follows:

- We obtain price and market information via informal contacts with industry players;
- Global network of contacts in all sectors of the industry - producers, traders and consumers;
- Extensive data-base of information on the commodity markets;
- Rigorous analysis of relevant statistical data on production, exports and imports.

Andrew Jones has more than 20 years of professional experience, acquired mainly in commodity market research and analysis. Professional qualifications include an honours degree in metallurgy from the University of Sheffield and a Masters Degree in Multinational Commerce from Boston University Brussels.

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Definition of Anthracite

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Definition of Anthracite

Anthracite is a naturally occurring carbonaceous material that represents the highest level of non-metamorphic coalification (transformation to coal). Anthracite was formed by the compression of geologically preserved organic residue of primordial swamps.

Main characteristics are: low volatile matter, by strict definition less than 10% (dry basis); fixed carbon normally >80%; high hardness (low grindability); and high calorific value. However, only anthracite lumps with less than 5-6% volatiles can be marketed as metallurgical coke replacements, either partial or total.

Some countries also report so-called "semi-anthracite" as "full anthracite" in production and trade data, this category having volatile content 12-15% and fixed carbon <80%. These grades are typically sold into low-volatile PCI (pulverized coal injection) and power-generation markets.

Definition of Anthracite (cont'd)

Vitrinite reflectance is the main method for classifying coal ranks as shown.

Vitrinite is one of the primary components of coals. It is a type of maceral, i.e. the organic component of coal, analogous to the minerals contained in rock. Vitrinite has a shiny appearance, resembling glass.

The higher Vitrinite content of a coal => higher the degree of transformation => higher the rank of the coal.

	Vitrinite Reflectance	***Applications***
Low-Rank Coal *Lignite ("brown coal"),* *Sub-Bituminous*	Less than 0.5%	Power generation
Medium-Rank Coal *Bituminous*	0.5% to 2.0%	Pulverized coal injection in the iron blast furnace Coke production
High-Rank Coal *Anthracite*	2.0% to 6.0%	Coke replacement Pulverized coal injection

(From International Standard ISO11760 (Classification of coals), 2005)

Definition of Anthracite (cont'd)

Market Research on Anthracite

Compared to other commodities, the anthracite market is **difficult to characterize** for various reasons:

- Lack of agreement of what constitutes "anthracite" around the world: grades of up to 12-13% volatiles (or even higher) are sometimes included; classically, it should be less than 10%. Then, there has been discussion of "high-grade" and "ultra high grade" anthracite in some presentations and reports, but no universal standards exist.

- National production data, when available, can include both washed and un-washed product (even run-of-mine sometimes) in the same number; so that globally we are often not comparing like with like. Sometimes, material recovered from old dumps is also included. **We normally report "saleable product" i.e. the state in which it is dispatched to the customer – this may sometimes include un-washed product.**

- Trade data from country to country are not consistent in what they include in customs category 2101 1100 (for "Anthracite Coal"). We try to eliminate figures under this code that we believe to be clear errors in reporting (for example, we take out any reference to Australia as an anthracite source, as it produces only semi-anthracite not full anthracite).

- A general reluctance by the industry to give out information on production, pricing and applications.

Anthracite Applications & Specifications (cont'd)

End-use Market / Typical Specification	Market Characteristics
Fines Markets (cont'd):	
Ore Pelletizing: Sizing: 0/50mm Ash Content: 17-21% max Volatile Matter: 10-13% max Fixed Carbon: 68-72% min Sulphur: 1.0% max Grindability (HGI): 50 min	Anthracite fines can be employed as fuel in iron-ore pelletizing - but only for hematite and mixed ores, not for magnetite. The pellet process consists of grinding, thickening, balling then firing. In the process, 14 kg of anthracite per tonne is needed. Coke breeze, petroleum coke and natural gas can all be used as alternatives to anthracite in pelletizing. However, anthracite is typically the preferred fuel. For the pellet producers that are not also steelmakers, it is cheaper than buying coke breeze. Petroleum coke can present problems due to oil contamination. And solid fuels are preferred to natural gas due to their lower combustion rate enabling improved process control. The volatile content (10-13%) indicates a semi-anthracitic grade rather than of "true" anthracite. The specification is set low in order keep the costs at a minimum. Brazil's pellet production makes use of low-grade raw materials in order to compensate for high freight costs to the consumers. Sizing is not critical as the coal is ground before use. Recent investments in iron-ore pellet capacity using anthracite or other carbon sources have been centred in Brazil and India, as well as Oman latterly. **Vale**, together with **Samarco** – its joint venture with BHP Billiton - has 86m tpy of pelletizing capacity at five sites in Brazil. Three of Vale's plants were closed in 2012 due to the poor market; one may restart next year. A major accident halted production at Samarco in 2015, and there is no date for restart yet. South Africa is Vale's leading source for anthracite. Vale produced a total of 48m tonnes in 2016 from its plants in Brazil and Oman, which have a total capacity of 95m tpy (including Samarco). *(Cont'd)*

World Anthracite Production (cont'd)

CIS	Mine Capacity Million tonnes - a	Comments
Russia	16.80	There is production in several regions: ➢ *Rostov in the eastern Donbass* – Russia's traditional anthracite-mining area, but production has been in steep decline in recent years. ➢ *Novosibirsk region* – Siberian Anthracite has mined here since the 1990s, joined by Vostok Coal from 2015. ➢ *Kuznetsk basin, Kemerovo region* – the producer is Mechel from the Krasnogorsk mine. ➢ *Taimyr peninsula, Krasnoyarsk* – Vostok Coal started another mine here in 2016. The Rostov region of the eastern Donbass has been the historical centre of Russian anthracite mining, much of it used for power production rather than industrial processes. Here is the same body that is mined in eastern Ukraine. Production has shifted to mines in Siberia over the past decade, however. From 9-10m tpy in the late 1990s, it has declined to less than half this level currently. Joining Mechel and Siberian Anthracite, Vostok Coal has started two mines at separate locations in Siberia in the last two years. Russian total production was 12.8m tonnes in 2016, down from 12.9m tonnes in the previous year. Offsetting more production at Siberian and the Vostok start-ups was lower production by Mechel and in the Rostov region. One the major producers in the Rostov went bankrupt in 2016. Some of the washing capacity there has been occupied with processing anthracite from Ukraine over the past year or so.

a – Saleable product, end 2016

World Anthracite Trade (cont'd)

Exporter	Volume Exported - a, Million tonnes			Comments (main markets, end-use industries)
	2014	2015	2016	
South Africa	2.1	1.6	1.9	Most exports are fines for Brazilian iron-ore pelletizing. They have been as high as 0.9-1.0m tpy, but in 2016 exports declined to 0.6m tonnes due to the Samarco accident and the closure of some Vale plants. A number of producers – Aviemore, Petmin, Vaalkrantz, ZAC - supply this market via **Glencore**. India is another significant market for fines. Since 2014, the overall volume has been sustained due to exports of high-ash anthracite for power generation in South Korea, Ukraine and Vietnam. This product is extracted from discarded material. Until about 2009, there were significant exports of sized anthracite to markets such as Belgium, Ireland, Spain, Turkey and the UK. These were for the domestic heating market. Exports of lumps are now rare, with probably only **ZAC** having the quality required. Until 2016, the major anthracite producers held an allocation at the privately owned Richards Bay Coal Terminal (RBCT) under the "Quattro" scheme for smaller, emerging mining companies. The anthracite stockpile was constraining Quattro's throughput, so this trade was moved to the Multi-Purpose Terminal (owned by state company Transnet) in 2016. RBCT is generally more efficient and lower in cost that the Transnet ports. Exporters also use the Dry Bulk Terminal (also Transnet) at Richards Bay from where **Petmin** ships its fines. **Jindal Africa** and **Osho** (both Indian-owned) also ship from here.

(Cont'd)

a – Sourced from Department of Mineral Resources, South Africa

Anthracite Demand (cont'd)

North America	Anthracite Demand, Million tonnes			Comments
	2014	2015	2016	
United States	1.64	1.81	1.20	Large quantities (4-5m tpy) of stockpiled coal-waste material ("culm") are burnt in ten co-generation plants equipped with CFB technology (excluded from demand estimates). Due to the low gas prices, most have shut down or operate for part of the year only. Unlike in many other anthracite areas around the world, there is no large-scale dedicated power plant in Pennsylvania. The steel industry uses anthracite in EAFs, but there is no use for ore-sintering at the integrated steel sites. Other uses are in home and commercial heating (20% of total demand), and filtration (3-4%). The few submerged-arc furnace smelters in the US (calcium carbide, manganese alloys) do not use anthracite. All soda ash production in the US is mined rather than produced via the synthetic route. There is some use as coke replacement in sugar-beet refining. In 2010, leading "mini-mill" group **Steel Dynamics** started producing iron "nuggets" at majority owned Mesabi Nugget plant in Minnesota; the innovative direct-reduction (DR) process used anthracite fines. Due to low iron prices, it was idled in 2015. It has an existing DR plant, **Iron Dynamics**, in Indiana, also using anthracite. In 2014, **Magnetation** commissioned a 3m tpy iron-ore pellet plant in Indiana. Potentially, it would consume up to 40,000 tpy of anthracite, most probably sourced domestically. It entered bankruptcy in 2015 and stopped production the following year. **Asbury Carbons** and **Hickman Williams** are drying anthracite for steel applications. Demand is met primarily by mine production in Pennsylvania. Imports have been lower since 2012 and were just 70,000 tonnes last year. US demand for anthracite has increased by an average of 2% per year over the past decade.
Total North America	**2.12**	**2.23**	**1.60**	

Demand estimates are compiled on "apparent basis" i.e. production + imports – exports.

Anthracite Demand (cont'd)

Apparent Demand by Country

Million tonnes	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	% Avge Ann Ch 07-16
Europe	**22.19**	**22.04**	**18.75**	**18.85**	**17.29**	**15.83**	**12.15**	**11.60**	**10.11**	**9.10**	***-9.9%***
Austria	0.02	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	*-14.5%*
Belgium	0.34	0.43	0.52	0.79	0.97	0.78	0.47	0.29	0.55	0.54	*0.3%*
Bosnia & Herzogovina	0.01	0.01	0.00	0.03	0.03	0.05	0.06	0.10	0.05	0.06	*20.6%*
Bulgaria	2.24	2.84	1.94	1.86	2.20	1.13	0.73	0.84	0.29	0.27	*-19.2%*
Czech Rep	0.05	0.04	0.02	0.02	0.10	0.12	0.18	0.09	0.09	0.08	*11.2%*
Denmark	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*-41.9%*
Finland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	*46.5%*
France	2.10	2.25	1.35	1.40	0.84	1.24	0.90	0.83	0.91	0.41	*-14.0%*
Germany	3.14	2.67	2.70	3.17	2.51	2.58	2.08	2.03	1.74	1.79	*-6.3%*
Hungary	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*-17.0%*
Ireland	0.03	0.04	0.05	0.07	0.04	0.03	0.04	0.04	0.02	0.03	*-4.7%*
Italy	0.41	0.49	0.21	0.41	0.39	0.27	0.16	0.20	0.16	0.21	*-10.4%*
Moldova	0.13	0.13	0.17	0.06	0.21	0.14	0.22	0.10	0.10	0.06	*-3.4%*
Netherlands	0.17	0.11	0.02	0.06	0.17	0.26	0.15	0.10	0.08	0.14	*1.8%*
Norway	0.08	0.08	0.05	0.08	0.08	0.08	0.07	0.08	0.11	0.10	*3.8%*
Poland	0.45	0.55	0.31	0.58	0.58	0.41	0.38	0.32	0.27	0.29	*-6.0%*
Portugal	0.04	0.05	0.03	0.02	0.03	0.04	0.03	0.01	0.01	0.01	*-14.0%*
Romania	0.07	0.11	0.06	0.07	0.15	0.14	0.14	0.13	0.11	0.15	*6.9%*
Slovakia	0.18	0.26	0.26	0.29	0.71	0.64	0.50	0.61	0.39	0.19	*5.0%*
Spain	11.67	10.74	9.89	8.91	7.11	6.32	4.59	4.19	3.78	3.14	*-14.4%*
Sweden	0.03	0.03	0.01	0.03	0.03	0.03	0.03	0.03	0.02	0.03	*2.1%*
United Kingdom	1.05	1.18	1.11	0.98	1.13	1.57	1.39	1.61	1.41	1.58	*4.9%*
CIS	**15.90**	**13.82**	**13.50**	**9.50**	**12.27**	**13.84**	**15.68**	**17.13**	**10.87**	**13.06**	***-0.4%***
Belarus	0.01	0.02	0.03	0.04	0.05	0.05	0.05	0.06	0.05	0.05	*10.6%*
Kazakhstan	0.24	0.24	0.25	0.11	0.22	0.21	0.23	0.14	0.52	0.20	*3.8%*
Russia	6.47	4.99	5.96	3.93	3.82	4.41	5.81	4.95	3.73	4.96	*-2.6%*
Ukraine	9.18	8.58	7.26	5.43	8.19	9.17	9.59	11.99	6.58	7.85	*0.8%*
North America	**1.93**	**1.91**	**1.96**	**1.86**	**2.48**	**2.54**	**2.02**	**2.12**	**2.23**	**1.60**	***0.2%***
Canada	0.56	0.49	0.28	0.31	0.50	0.51	0.36	0.34	0.29	0.26	*-5.8%*
Mexico	0.13	0.13	0.12	0.12	0.16	0.17	0.18	0.15	0.14	0.15	*2.3%*
United States	1.25	1.29	1.55	1.42	1.83	1.86	1.48	1.64	1.81	1.20	*1.5%*
Latin America	**1.48**	**1.53**	**0.78**	**1.34**	**2.01**	**1.48**	**1.51**	**1.48**	**1.48**	**1.13**	***0.0%***
Brazil	1.41	1.45	0.72	1.28	1.95	1.41	1.40	1.38	1.40	1.07	*-0.1%*
Peru	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	*0.0%*
Venezuela	0.03	0.03	0.00	0.01	0.01	0.02	0.06	0.05	0.03	0.01	*5.8%*

(Cont'd)