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AN OPTIMAL MODEL

OF GLOBAL THERMAL COAL TRADE

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Introduction

While one would be hard pressed to glean positive news regarding the coal industry's future from the popular media and even from some trade publications, recent research suggests that the future may not be so bleak. In fact, according to the International Energy Agency (IEA):

- Electricity will be the fastest growing component of the global energy mix over the next two decades; and
- Coal will remain the predominant fuel for electric generation.
[1]

These simple statements presage continued growth in global coal demand, the need for new projects to satisfy both this growing demand and to replace depleting reserves, and continued growth in the global coal trade. Other authoritative sources, including the BP 2014 World Energy Outlook, come to similar conclusions regarding coal's future.

With regard to steam coal, IEA, under its New Policies (Base Case) Scenario, projects average annual growth of slightly over 0.8% per year over the 2012 – 2035 period. Under this scenario, global steam coal growth would average about 56 MM tonnes

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per year and total steam coal demand would approach 7.4 billion tonnes by 2035. IEA's projections for steam coal under its Current Policies Scenario are considerably more robust. Under this scenario, IEA projects annual growth of about 1.75% per year, equivalent to annual growth of about 132 MM tonnes per year, and total global steam coal demand of approximately 9.2 billion tonnes per year by 2035.

The IEA projects even higher growth rates for inter-regional steam coal trade. Over the 2012 – 2035 period, the IEA projects that in its New Policies

(Base Case) Scenario, inter-regional coal trade will grow from roughly 960 MM tonnes in 2012 to about 1,320 MM tonnes in 2035, an overall growth rate of about 1.4% p.a. In the Current Policies Scenario, inter-regional coal trade volumes grow at about 2.7% p.a. over the period, nearly double the rate in the New Policies Scenario, ultimately reaching about 1,827 MM tonnes in 2035.

Problem Statement

While this growth obviously requires substantial new coal mine development and infrastructure, the likely sources of additional coal are far less readily apparent. Not all coal is suitable or available in all markets. While the overall market is global, it retains significant regional characteristics. As the market evolves, traditional supply patterns will likely also change. For example, diversion of South African coal to Asian markets will open opportunities for other producers to supply South Africa's traditional markets in Europe. In general, the global steam coal trade is a complex and volatile business. The complexities include site specific supply and demand, coal specifications (both for suppliers and consumers), coal export and import terminal capacity and capability, coal pricing, and vessel rates, among other factors.

Given these complexities, what trade patterns make the most economic sense? Which trade patterns are most economically efficient? Which trade patterns are economically vulnerable? As inter-regional steam coal trade volumes increase, what projects in what regions are most likely to satisfy increased demand? RPMGlobal set out to develop a tool to help industry answer these fundamental questions.

Development of an Optimal Model

In order to address this problem, RPMGlobal developed a mathematical model of the global thermal coal trade known as a constrained network model. This cost optimization model consists of a series of sources from which coals can enter the network (analogous to export terminals), arcs over which the coals can flow, and a number of sinks (analogous to import terminals or other demand nodes). Costs are assigned to each source and each arc and the model minimizes the total cost of sending sufficient supplies of appropriate quality to satisfy the requirements of all the demand nodes, subject to meeting coal quality and numerous other constraints necessary to accurately reflect the complexities of the global market.

In developing this model, RPMGlobal did not set out to replicate actual coal trade. Instead, RPMGlobal's objective was to minimize overall quality adjusted costs. In so doing, and by comparing model results to actual coal trade patterns, RPMGlobal was able to identify both economically robust and economically vulnerable trade patterns. Also, RPMGlobal did not set out to forecast thermal coal supply and demand. Rather, this tool optimizes shipments to various demand nodes given coal volume, coal quality, and other constraints.

Model Variables

RPMGlobal incorporated the following variables and parameters into this cost minimization model:

1. Total seaborne steam coal demand: Based on IEA data and other sources, the RPMGlobal model included approximately 1.23 billion tonnes of total demand. This total included both inter-country and intra-country demand.

2. Import facilities: The model incorporates about 180 coal import terminal facilities with total capacity of 1.5 billion tonnes per year. In addition to terminal capacity, RPMGlobal also incorporated vessel capability, i.e., the size of vessel each facility could accept, largely based on draft, for each facility.

3. Coal consumer quality specifications: RPMGlobal also incorporated coal quality specifications at each terminal. The model incorporates specifications for calorific value (CV), ash, and sulphur 2. RPMGlobal also included an "on/off" switch for blending at each demand node, which governs whether the model could blend coals with different qualities to achieve an overall specification or whether every coal imported at that facility must individually meet the overall spec. The model also specifies how many coals and the minimum volume of any one coal that can be used in a blend.

4. Export terminals: The model incorporates 75 coal export terminals or regions. Again, each of these facilities has unique steam coal capacity, draft, and vessel capabilities. Total capacity of these 75 terminals approached 2.0 billion tonnes per year.

5. Coal Availability, Specifications, and Prices: RPMGlobal identified 37 different coals that could be shipped through these 75 terminals. In addition to coal quality specifications, each coal also had a specified volumetric constraint, which in many cases was different than terminal capacity. Total coal availability was about 1.7 billion tonnes. Each coal had a price at each export terminal, generally based on mid-2013 market conditions.

6. Vessel Types and Rates: RPMGlobal's Base Case model incorporates three types of vessels: Handymax (with a capacity of 40,000 tonnes), Panamax (with capacity of 70,000 tonnes) and Cape (with capacity of 175,000 tonnes). For evaluation of the potential impact of the Panama Canal expansion discussed further below, RPMGlobal added a fourth class of vessel, Post-Panamax (with capacity of 130,000 tonnes).

For each of these classes of vessels, RPMGlobal developed estimates of shipping rates for each origin/destination pair, generally based on mid-2013 market conditions.

Results

Figure 1 below is a simplified illustration of actual 2012 thermal coal flows 3, with the thickness of the lines representing the volumes over the various paths 4. Traditional thermal coal trade patterns, such as South African coal to Europe, Australian coal to northern Asia, and Indonesian coal to India and Southern China are apparent. Figure 2 is a simplified representation of the results of the RPMGlobal optimization model.

Figure 1

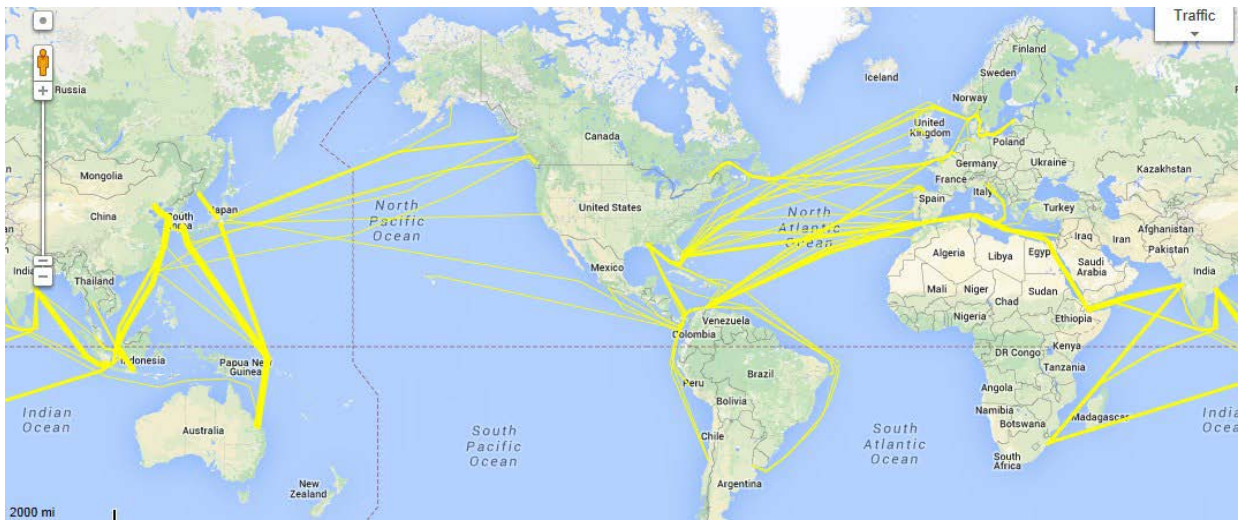

Figure 2

Obvious differences between model results and actual 2012 shipments include:

- Domestic Chinese shipments from Qinhuangdao aredramatically reduced, as Indonesian and even South African coals prove more economical at southern Chinese import terminals;
- The traditional movement of South African coal to Europe disappears. Instead, all coal from Richards Bay and neighboring Mozambique heads to India, China, and other Asian markets;
- The South African coal shipments to Europe and the Mediterranean are replaced by increased volumes of Russian (from Baltic, White Sea, and Black Sea sources) U.S. Gulf Coast, and East Coast coals.

In addition to these changes evident in Figure 2, the RPMGlobal optimization model also showed:

- Ports on the west coast of North America operated at capacity, suggesting that North American coals are competitive, particularly in northeast Asian markets. This bodes well for the various port projects currently in permitting or construction phases.

- Substantial shipments of Atlantic Basin coal to India, in large part for quality purposes.

Analytic Capability

As mentioned at the outset, RPMGlobal developed this model as a tool to help industry understand the dynamics of the global thermal coal trade.

Specific potential uses include:

- Investment analysis: The RPMGlobal Global Thermal Coal Optimization Model is ideally suited for analysis of new mining and port capacity. The model can be modified to add new sources and the coal availability, specifications, and pricing at the new sources, to determine whether investment in new projects is likely to succeed.

- Scenario analysis: The model is ideally suited for scenario analysis. By changing model assumptions, the user can analyze the impact of various new scenarios. A (non-exhaustive) list of potential applications includes changes in coal demand, changes in production capacity, taxes or bans on lower quality coal, more lenient specifications or installation of blending capability, and the impact of currency fluctuations.

- Shadow pricing: Another very useful model output is so-called "shadow prices". A shadow price (or cost) is the price at which a coal not currently in the optimal solution can enter the solution. For example, recent criticisms of Galilee Basin coal development projects have focused on whether coal prices will be sufficiently robust to support the requisite multi-billion dollar investment[5]. The model can help in two related analyses. First, as noted above, production from the Galilee Basin can be added to the model at a price necessary to profitably develop the resource. The model will then show whether (or not) this coal enters the solution and at what volumes. Secondly, to the extent that the model does not use the Galilee supply capability, the model can develop the price at which it becomes competitive.

- Diversification and other purchasing strategies: An optimization model such as the RPMGlobal Global Thermal Coal Optimization Model will go "all-in" on supply patterns that minimize total cost. In the real world, however, there are numerous valid reasons why a coal consumer would choose not to purchase 100% of its coal from a single supplier or source. This model can help purchasers analyze this issue. Which alternative sources are most economically logical? How do coal quality parameters from an alternate source affect purchases from the low cost source?

- Non-intuitive market opportunities: One of the major outcomes of RPMGlobal's Base Case was the attractiveness of low ash Atlantic Basin coals in the Indian market. What other non-intuitive market opportunities may become available as supply, demand, and other factors change? The RPMGlobal Global Thermal Coal Optimization Model can help analyze this question of fundamental importance.

A Case Study: Panama Canal Expansion

As mentioned at the outset, RPMGlobal developed this model as a tool to help industry understand the dynamics of the global thermal coal trade. RPMGlobal used the Global Thermal Coal Optimization Model to analyze the impact of the Panama Canal Expansion on the global thermal coal trade.

Following expansion of the Panama Canal, now scheduled for completion in early 2016, industry analysts envision a new class of vessel, so-called "Post -panamax" or "Baby Cape" with nominal capacity of 130,000 tonnes. Some of these analysts have suggested that the canal expansion, combined with presumably lower freight rates for the larger Baby Cape vessels, will facilitate substantial penetration of Atlantic Basin coals into Asian markets previously served primarily by Pacific Basin coal origins 6.

The RPMGlobal Global Thermal Coal Optimization Model allows testing of this hypothesis. RPMGlobal relaxed the current maximum vessel capacity that could traverse the canal from 70,000 tonnes to 130,000 tonnes and developed freight rates for these new vessels. In order to isolate the impact of canal expansion, RPMGlobal made no other changes to the model, i.e., no changes to supply and demand volumes, no changes to port capabilities and capacities, coal availability, coal pricing, etc.

Under these circumstances, this analysis is a zero-sum game: Any gains by Atlantic Basin suppliers must be exactly offset with losses from traditional Pacific Basin suppliers. Who would the winners and losers be? In the RPMGlobal Base Case, total coal volume through the Panama Canal was 18.45 MM tonnes 7. Under the Post-panamax Case, total coal volumes increased a relatively modest 6.7%, to 19.675 MM tonnes. Although there are a number of changes in origins and destinations as well as other complex and more detailed nuances, the bottom line is that changes to the global thermal coal market resulting from the expansion of the Panama Canal will be relatively modest.

Conclusion

RPMGlobal set out to develop this model to help answer fundamental questions about the most economic trade patterns and to better understand the dynamics of global thermal coal trade. Potential uses for this model have been outlined in this article and while this is not a commercial offering from RPMGlobal, our experts are able to work with clients to use this model as a basis for further analysis.