Future Impacts of Coal Distribution Constraints on Coal Cost

Students: David McCollum (dlmccollum@ucdavis.edu)

Advisor: Dr. Joan Ogden (jmogden@ucdavis.edu)

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STEPS Program

Institute of Transportation Studies

University of California, Davis

Abstract:

After years of relatively slow growth, coal is undergoing a renaissance. The Energy Information Administration (EIA) projects that the U.S. will consume more than 1,500 million tons of coal in 2030, up from about 1,100 million tons today. In addition, while EIA's estimates do not take coal-to-hydrogen production into consideration, several recent studies suggest that if the hydrogen economy ever comes to fruition coal could be a feedstock of choice, at least in the U.S. which has huge reserves of coal (~250 years' worth at current consumption rates), which are relatively cheap and easy to mine.

An increase in future coal demand fuels legitimate concerns about the impacts on global climate and regional air pollution. While carbon capture and storage is often mentioned as a solution to these two problems, another impact, often overlooked, is the possibility that the current coal distribution infrastructure may not be able to reliably deliver the additional demand. Railroads deliver about two-thirds of U.S. coal at present, but certain coal-carrying rail corridors are already up against their capacity limits. Any future demand increases will probably necessitate significant capital investment by rail companies.

This study seeks to identify existing capacity and potential constraints within the coal distribution infrastructure and to identify the costs of alleviating these constraints under several growth scenarios for coal demand. The scenarios differ based on whether or not pulverized coal (PC) or integrated gasification combined cycle (IGCC) power plants are built, as well as the amount of coal that is used to produce hydrogen for fuel cell vehicles.

Coal transportation along the nation's vast rail network is analyzed using a freight routing model that uses the Surface Transportation Board's confidential Carload Waybill Sample data as an input. For each coal demand growth scenario, we identify the rail corridors that could potentially reach their capacity limits in the future due to increasing coal traffic, and we quantify the investment that might be needed to boost the coal-carrying capacity along these lines.

Some of important questions that we have attempted to answer through this analysis include the following: (1) Will the nation's rail-coal distribution system be able to handle the future increases in coal demand that could result from traditional uses, as well as from coal-to-hydrogen production; and (2) What is the trade-off between building more efficient, albeit more expensive, IGCC power plants versus modern PC plants, if costly investments in coal transportation infrastructure can be avoided?

Coal Demand Growth Scenarios:

1. BAU1
   - Business as Usual (BAU) using projections from EIA for coal use and assuming that all coal plants—now and in the future—are pulverized coal
2. BAU2a and BAU2b
   - Same as BAU1, but assuming that all newly built coal plants will be more efficient integrated gasification combined cycle (IGCC) plants and that all old coal plants will be gradually converted to IGCC over time (i.e., same power demand as BAU1, but lower coal demand due to higher efficiency of IGCC plants)
3. BAU2 + LowH2
   - Same as BAU2b plus a low H2 demand scenario where hydrogen fuel cell vehicles make up 50% of the total vehicle market by 2050, and coal is used to produce all of the hydrogen
4. BAU2 + HighH2
   - Same as BAU2 plus a high H2 demand scenario where hydrogen fuel cell vehicles make up 100% of the total vehicle market by 2050, and coal is used to produce all of the hydrogen

Key Findings:

- Increase in coal demand -> Increase in rail transportation of coal
  - A hydrogen economy based on coal could increase demand for coal consumption and transportation in 2050 by 0 – 50% compared to a business-as-usual case w/o hydrogen.
- More efficient IGCC plants can moderately reduce coal consumption and transportation demands.
  - If old PC plants are retrofitted/repowered to IGCC, much greater reductions in coal demand can be achieved.
- Railroads could avoid significant capital investments in an IGCC future.
- We identified 42 key rail corridors (~80% of all coal transport by rail). Future coal transport along these corridors is expected to increase 35 – 95% by 2050.
- Railroad capital investments – $1.5 – $11.0 billion (in discounted 2005$) from 2004 to 2050 (includes investments in new mainline trackage, upgraded signaling systems, and new rolling stock).
- It does not seem likely that delivered prices of coal throughout the country will increase as a result of adding new rail capacity for the purpose of transporting coal.
  - Thus, higher coal cost (as a result of rail investment) should not be a barrier to a coal-based "Hydrogen Economy"

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Research Objective:

To identify existing capacity and potential constraints within the U.S. coal distribution network and to estimate the costs and coal price effects of alleviating those constraints under four growth scenarios for coal demand.

Background:

Coal Consumption/Demand

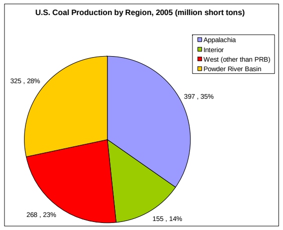
North American Coal Power Plants and Generating Units [1]

EIA Projections for Coal to 2030 [4]	2008	2030
Total Coal Demand [million tons]	1126	1545
Electric Power Coal Demand [million tons]	1033	1401
Coal's Share of Electric Generation [%]	49	55
Installed Coal Plant Capacity [GW]	311	406

- Over 600 coal plants and generating units are in operation across the U.S. [3]
- Most coal plants are situated in the Midwest, East, and Southeast.
- EIA predicts that much of new coal plant capacity will come online post-2015 [4]

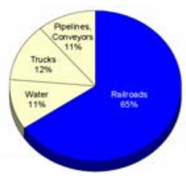
Coal Production/Supply

U.S. Coal-Producing Regions with Average Heat and Sulfur Contents of Coal [2]



Coal Transportation

Coal is the largest single commodity carried by Class I railroads: 43% of total tonnage, 24% of total carloads, and 20% of total revenue [7]



U.S. Coal Shipments to Final Destination by Mode, 2003 [6]

U.S. Class I Railroad Network and Coal-Producing Regions [2]

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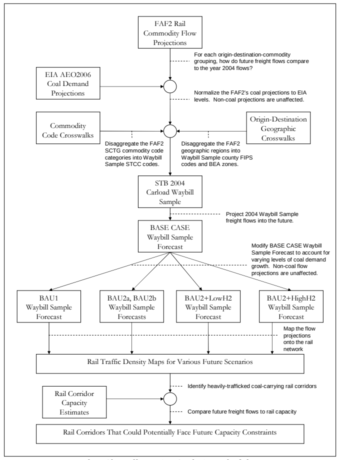
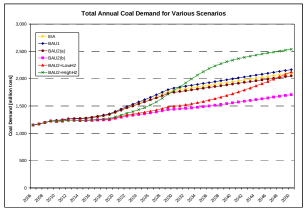
Analysis Methodology:

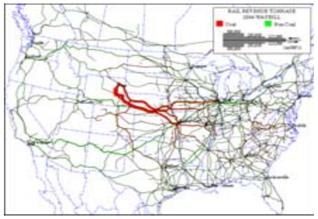
1. Estimate total national coal demand for each scenario on an annual basis
2. Estimate coal and non-coal rail traffic flows for each scenario in 2030 and 2050
   1. Use Surface Transportation Board's 2004 Confidential Carload Waybill Sample for base values
   2. Project future flows by modifying base year values in Waybill Sample per projections of Freight Analysis Framework 2 study (U.S. DOT FHWA) and estimates of total national coal demand
3. Load the railroad network with coal and non-coal rail traffic flows (i.e., trip assignment)
   1. Use ALK, Inc.'s railroad routing model
4. Identify the most heavily trafficked coal-carrying rail routes
5. Estimate current carrying capacity of important coal routes
6. Quantify investment in infrastructure (trackage, signaling systems, rolling stock) needed to boost capacity to future traffic levels
7. Calculate incremental costs of capacity enhancements and compare to historical costs
8. Identify rail routes that might be forced to increase rates in the future as a result of capital investments



Flow Chart Illustrating Analysis Methodology

Modeling Results:





Traffic Flows on the Railroad Network in the Base Year 2004

Rail routes where coal transportation rates may be forced to increase

Total Incremental Cost Estimates for All Routes

Scenario	Incremental Capacity Costs [1] (discounted billion $) [2], [3]		Incremental Rolling Stock Costs [4] (discounted billion $)		Capital Costs for Coal Power and Coal-to-Hydrogen Plants (discounted billion $)
	CTC	PTC	CTC	PTC	
BAU1	2.25 – 5.34	1.58 – 3.72	2.72 – 4.74	2.76 – 5.05	54
BAU2a	1.88 – 4.45	1.28 – 3.02	2.37 – 4.21	2.40 – 4.43	59
BAU2b	0.64 – 1.48	0.53 – 1.24	1.05 – 2.05	0.98 – 2.02	140
BAU2b+LowH2	1.00 – 2.30	0.76 – 1.73	1.44 – 2.61	1.40 – 2.63	147
BAU2b+HighH2	2.28 – 5.33	1.61 – 3.73	2.84 – 4.93	2.88 – 5.23	166

These costs reflect the addition of:
- **Several thousand additional miles of mainline trackage and CTC/PTC signaling**
- **Several thousand new locomotives**
- **Tens of thousands of new coal-rail cars**

[1] "Incremental Capacity Costs" refer to the capital costs associated with upgrading signal systems and adding new mainline trackage from 2004 to 2050.
[2] The discount rate is assumed to be in the range of 7 – 12% and is varied during Monte Carlo simulation.
[3] A range is given for each cost estimate to reflect the multiple costing methodologies and variable input assumptions used in this study.
[4] Incremental Rolling Stock Costs" refer to the capital costs associated with investing in new locomotives and coal rail cars from 2004 to 2050.

References:

[1] Global Energy Decisions, 2006, Boulder, CO, Energy Velocity Suite software product.

[2] National Coal Council (NCC), 2006, "Coal: America's Energy Future", Volume 1, http://nationalcoalcouncil.org/report/NCCReportVol1.pdf, Accessed on July 31, 2006.

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[5] National Mining Association, 2006, "Most Requested Statistics - U.S. Coal Industry", http://www.nma.org/pdf/c_most_requested.pdf, Accessed on July 31, 2006.

[6] Hamberger, Edward, 2005, "Statement of Edward R. Hamberger, President and Chief Executive Officer, Association of American Railroads", Conference on the Future of Coal, U.S. Senate Committee on Energy and Natural Resources, March 10, http://energy.senate.gov/public/_files/Question4SelectedParticipantSubmittals.doc, Accessed on August 17, 2006.

[7] Association of American Railroads (AAR), 2006, "Railroads and Coal", http://www.aar.org, Accessed on August 15, 2006.

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