SCENARIO ANAL1YSES AND DATA CONSIDERATIONS IN AN INTEGRATED, INTERNATIONAL OIL AND GAS TRANSPORTATION NETWORK MODEL

Tuncay Alparslan, U.S. Energy Information Administration, (202) 586-3138, tuncay.alparslan@eia.gov
Samantha Calkins, U.S. Energy Information Administration, (202) 586-0595, samantha.calkins@eia.gov
Peter Gross, U.S. Energy Information Administration, (202) 586-8822, peter.gross@eia.gov
David Manowitz, U.S. Energy Information Administration, (202) 586-2815, david.manowitz@eia.gov

Section 1: Overview

The U.S. Energy Information Administration (EIA) in its International Energy Outlook 2017 (IEO2017) projects China's pipeline and LNG imports of natural gas, as well as the share of imported gas from Russia, to increase. This reference case projection assumes continual improvement in known technologies based on current trends. To account for some of the uncertainty in the markets, EIA also considers side cases for high and low economic growth, and high and low oil price. But how would the projections be affected if Russia decided to increase tariffs to China or if there was a change in the geopolitics of the region? What if future LNG demand was more weighted towards oil-linked contracts as opposed to growing reliance on spot markets? EIA's present models are unable to respond to such scenarios. To improve its analytic capabilities, EIA is currently upgrading its World Energy Projections Plus (WEPS+) model, the primary modelling tool for its projections for international energy markets. These efforts include overhauling how WEPS+ handles the global hydrocarbon supply via a new upstream oil and gas resource model, a new conversion (i.e., petroleum refinery) model, and a logistics model. Combined, these three models make up the new Global Hydrocarbon Supply Model (GHySMo). Data preparation and scenario analysis for the logistics model, which optimizes the transportation and delivery of crude oil, natural gas, and petroleum products, is the focus of this abstract. Preliminary analysis of data and specific scenarios, such as the threshold effects on natural gas imports due to increased transportation cost from Russia to China, are presented.

Section 2: Methods

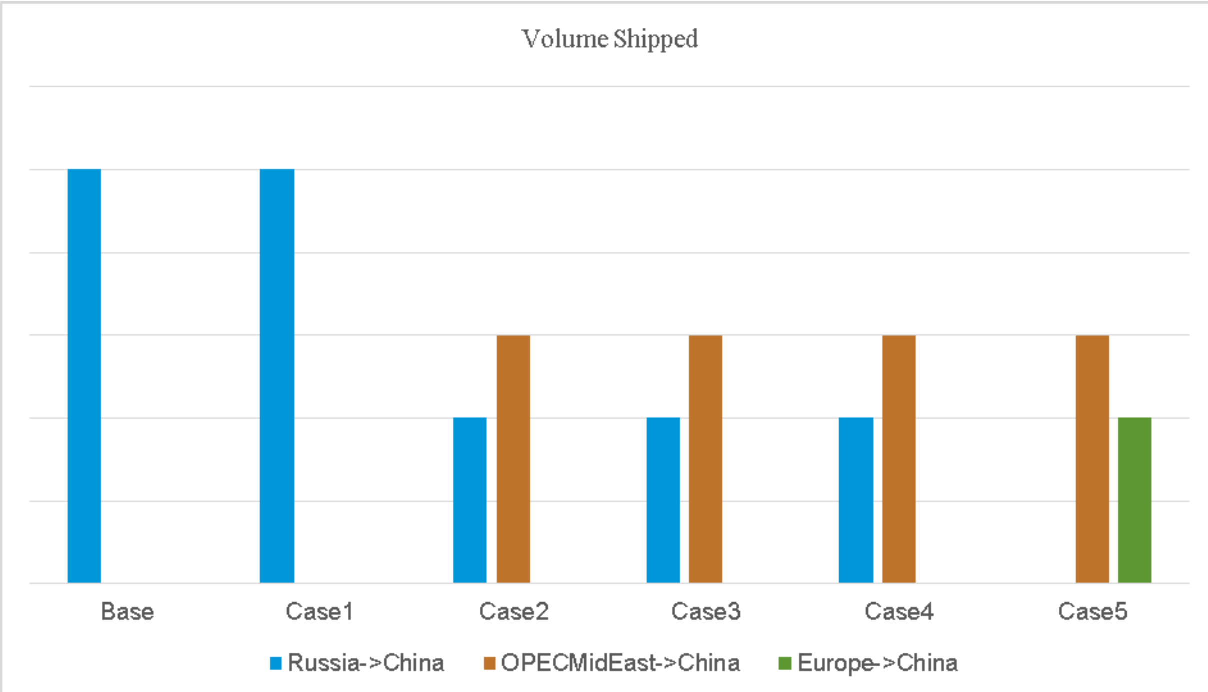
The logistics model solves a transhipment network problem, determining the optimal way to direct supplies of various commodities between a set of regions (nodes in the network) on transportation-mode specific routes (arcs on the network) to meet demand. The regions are denoted by type: upstream, conversion, or demand. Logistical assets included in the model are transportation modes (ships and pipelines) and nodal infrastructure (natural gas liquefaction and regasification facilities). Assets are designated by the commodity type (e.g., crude oil, natural gas, petroleum products, and LPG) that they carry or process (ships are further categorized by capacity size).

For each logistics model asset, the following data are either collected or estimated: capital costs, annual operations and maintenance costs (including fuel use), capacities, and associated factors (e.g., lengths and risk factors). For an arc, lengths (miles of pipelines or voyage days) are used to calculate operations and maintenance cost. For instance, voyage days are determined by the speed of the ship and the distance the ship travels between regions. This distance can be approximated by using a representative port for each region and solving Dijkstra's shortest path algorithm for the shortest distance between ports.

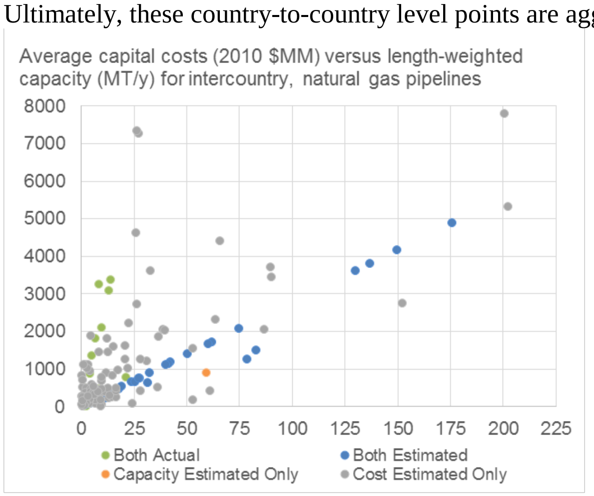
Missing costs or capacities from available data sets are estimated using the capacity-weighted averages for other assets of the same type that exist in the same start and end region type, carrying the same commodity. If values are still missing, averages are determined only using the start region type and the commodity type, or in some cases, only the commodity type. If the data set for a logistic asset is inadequate to determine a reasonable average, a proxy of the same asset type is used. This proxy is determined by the context of the data it is approximating. For instance, U.S. pipeline operations and maintenance cost data is averaged per commodity carried and scaled to the international level using gross domestic product per capita as the index

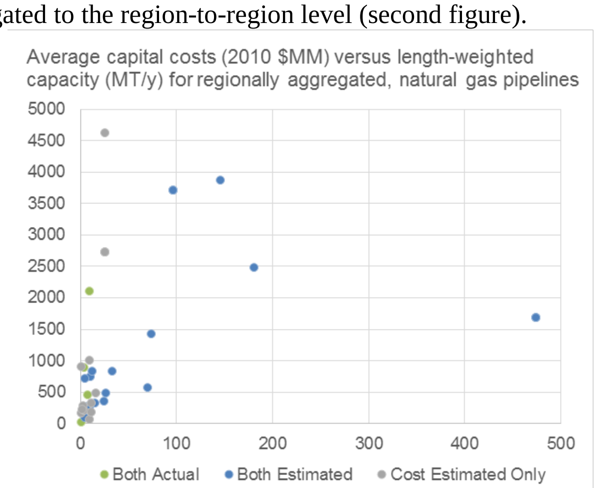
Section 3: Results and Conclusions

We present model capabilities in a scenario analysis context. In the reference case of EIA's IEO2017, China's pipeline and LNG imports of natural gas, as well as the share imported from Russia are projected to increase. The figure below demonstrates a prototype scenario analysis example where the results are illustrative of some of the dynamics that the new model exhibits as transportation costs from Russia to China increase. In this example, five scenarios are considered where transportation costs from Russia to China are increased by a factor of 50% each time. The figure below shows the imports from Russia decreasing and the slack being picked up by a lower cost supplier (OPEC Middle East) as the cost crosses the first threshold. When the cost crosses the second threshold, imports from Russia cease entirely and are replaced with imports from Europe since OPEC Middle East cannot satisfy the entire Chinese demand.



We also present preliminary logistics model input data for a topology of 67 regions and 12 commodities. An example of a data set requiring estimation for missing values is provided below in the first figure. It shows the average capital costs in millions of 2010 dollars versus the capacity, weighted by miles of pipeline, in millions of metric tons per year, for natural gas pipelines, aggregated by the start and end countries and type (upstream, conversion, or demand). The different data series show whether the costs or capacities are estimated or actual values. Ultimately, these country-to-country level points are aggregated to the region-to-region level (second figure).





Source: U.S. Energy Information Administration and IHS Market EDIN database