Supply and Demand Assumptions Behind EIA's Alternative Oil Price Paths

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Analysts often use long-term energy system models to quantify the broader impacts of persistent changes to oil supply or demand. Oil prices are important determinants in these models, and their price paths are typically given as exogenous inputs. This can lead to inconsistencies between the often implicit assumptions used to generate exogenous oil price paths and the assumptions built into a model designed to use these prices, which could result in misleading model results.

Oil prices are exogenous in long-term energy models for a number of reasons. National or regional energy models lack the geographic scope to determine oil prices, since oil is a globally-traded commodity. Global models often lack sufficient representation of either oil producers or oil consumers to determine market-clearing prices. Generating a long-term oil price projection can be problematic, so modelers often rely on an external source for this information.

Short-term models typically forecast oil prices using various time series regression techniques, yet they are seldom used as inputs to long-term models. Ideally, the results from short-term and long-term models should align with each other, since they attempt to describe the same market; but, differences in structure, assumptions, and determinants of oil prices between short-term and long-term models can yield diverging views of oil markets in the medium term. For instance, while long-term energy models typically assume that oil supply and demand will remain at equilibrium over time, short-term models don't always require production and consumption to be equal since period-to-period stock changes are assumed to balance the market.

Some models use oil price projections published by the U.S. Energy Information Administration (EIA) in its Annual Energy Outlook (AEO), including prices from the Reference, High Oil Price, and Low Oil Price cases. AEO results are determined by the National Energy Modeling System (NEMS), which is a modular, partial-equilibrium model of the U.S. energy system that projects the U.S. energy system in annual increments through the year 2050. As with any national model, NEMS relies on an initial, exogenous oil price path, called the World Oil Price (WOP). The WOP is a time series of annual average prices, each meant to represent the market clearing price of a hypothetical global crude oil commodity (i.e., Brent), extending from the last year for which historical prices are available to the end of the projection period. NEMS includes a mechanism to adjust the prices of crude oils of different qualities (e.g., light, sweet crude) due to changes in U.S. production over time. Thus, the prices ultimately published in the AEO Reference, High Oil Price, and Low Oil Price cases can differ from their respective input WOP prices.

Three WOP paths are constructed for each AEO: reference (WOP-R), high oil price (WOP-H), and low oil price (WOP-L). All three price paths incorporate historical annual average Brent spot prices. In the forward projection period, they represent the oil prices one might expect under a given scenario. Importantly, because NEMS models the reaction of the U.S. energy system to changes in the global oil price, all three WOP paths themselves are constructed assuming no change to U.S. supply or demand. Therefore, any differences among the three WOP price paths must be due to changes in supply and/or demand outside the U.S. The reference oil price path, WOP-R, uses a forecast of the Brent crude price taken from EIA's Short-Term Energy Outlook (STEO) monthly forecast, converted from nominal to real dollars and annualized, for the first two years of its long-term projection. Thereafter, a simplified standalone global partial equilibrium model is used to guide the evolution of the price path over time, with changes to supply and demand by region and over time informed by historical trends and analyst judgment. The WOP-R represents the prices EIA analysts would expect under the global conditions represented by the AEO Reference case, which include evolutionary technological change and current laws and policies. Since it is extremely unlikely that no new policies will be enacted that affect the price oil before 2050, this WOP-R path is both extremely unlikely and, moreover, potentially biased after the first two years. For example, additional policy actions outside the U.S. that reduced the global demand for oil would, presumably, lower the future price of oil below the WOP-R. For investment and planning purposes, rational oil market participants would likely anticipate such policy actions to the extent of their ability to do so; accordingly, their forecasts may be systematically different from WOP-R.

The high and low oil price paths (WOP-H and WOP-L) are meant to represent relatively extreme,

but non-specific conditions outside the U.S. that cause global oil prices to increase or decrease with respect to WOP-R. Operationally, the High Oil Price and Low Oil Price cases of the AEO are sensitivity cases; conceptually, WOP-H and WOP-L represent a series of regional and global events, both shocks and deviations from long-term trends, whose combined effect changes both non-U.S. oil supply and non-U.S. oil demand. It is necessary to assume near-term shocks in order to move the prices away from the STEO forecast in the first two years; however, global oil markets tend to absorb shocks relatively quickly, and one would expect the prices to revert back to the WOP-R over time. So, in addition to near-term shocks, WOP-H and WOP-L also assume systematic deviations from the long-term non-U.S. supply and demand trends to keep the WOP-H price high and the WOP-L price low.

In the WOP-H case, non-U.S. oil supply is assumed to decrease and non-U.S. demand increase; in the WOP-L case, the opposite is assumed. These are not price-mediated changes to production and consumption, but rather structural changes to the market. For instance, in the WOP-L case, the changes could correspond to additional policy actions and/or consumer choices that combine to keep demand low, additional undiscovered resources and technology advances that enable even lower-cost production of crude oil, global geopolitical conditions that favor oil production and trade, etc. The changes assumed for supply and demand push prices in the same direction (lower in WOP-L, higher in WOP-H), but they push equilibrium quantities in opposite directions. For both alternate oil price cases, it is assumed that the quantity changes induced by the changes to supply and demand roughly offset each other at the global level, keeping global production and consumption levels similar to the levels in the Reference case.

The three oil price paths are used as inputs to NEMS to understand the reaction of the U.S. energy system to different oil prices. As some of the modules within NEMS use perfect foresight, these prices can be interpreted as the market's expected value of average annual oil prices over time. One implication of this is that even the supply and demand shocks assumed in order to generate the WOP-H and WOP-L price paths are anticipated by the market. On top of these expected annual values, NEMS assumes that markets also anticipate price volatility in line with historical price volatility.

While the AEO High Oil Price and Low Oil Price cases are constructed as internally-consistent global scenarios, interpreting the scenarios can be difficult. Technically, the High Oil Price case models a future in which severe supply and demand changes outside the U.S. are anticipated by the market, but none of these changes affect the U.S. supply of or demand for oil at all. U.S. production and consumption are only affected by the different global oil prices. That scenario, though possible, would be extraordinary. The AEO Low Oil Price case is designed to be similarly extreme. Thus, although constructed around internally-consistent global scenarios, the AEO oil price cases are primarily interpreted as sensitivity cases.

The prices published in the AEO are sometimes used by other energy modelers as inputs to their models. Like any other exogenous inputs, such as population or economic growth, the assumptions behind these oil prices should be harmonized with the assumptions of the model scenario in which they are used. For example, in any global normative scenario, changes outside the U.S. could be needed that may reduce global demand for oil below the levels assumed in the construction of WOP-R. Decreased global demand should have an impact on oil prices. It may therefore be inconsistent to assume the same oil prices published in the AEO Reference case (close to WOP-R) in a global normative scenario.

EIA is continually working to improve its modeling capability. While the oil prices published in the AEO are determined largely outside the NEMS model, EIA is currently developing a new global hydrocarbon (oil and gas) supply model (called GHySMo) to be used for its International Energy Outlook. This new model will include the ability to adjust supply assumptions at a very granular level and explore the implications of these changes on global and regional prices. This capability should enable EIA and non-EIA modelers to ensure that oil prices remain consistent with a wide variety of global energy scenarios.