EMF 31 Scenario Design (March 6, 2014)

Scenarios for US and Global Models

This preliminary study design describes the assumptions for scenarios in the first round of EMF 31. US and North American models are asked to simulate the first four cases. Global models are asked to simulate case #1 (Reference), case #2 (High US Resources), case #5 (High International Demand) and case #6 (Oil-Indexed Pricing). Modelers are welcome to simulate other cases at their discretion.

Generally, do not override model results for endogenous variables or where you have strong priors. We are testing the model how you use it. Please document any major changes from these assumptions if you decide to override these guidelines.

Case #1: EMF Reference or Baseline

The EMF 31 Reference or Baseline scenario is patterned after the new Annual Energy Outlook 2014 Early Release that is available from the US Energy Information Administration at http://www.eia.gov/oiaf/aeo/tablebrowser/.

Modelers should consider using the AEO 2014 projections for world oil prices, U.S. economic growth and population trends, and current regulatory policies in-place at this time. The one exception will be regulations covering the electric power sector where noted below.

The case should incorporate the following assumptions for the power sector:

1) Calibrate to AEO 2014 power plant costs and fuel supply curves if you do not use your own estimates. Power plant cost assumptions for AEO2014, which are very similar to those for AEO2013, can be accessed at http://www.eia.gov/forecasts/aeo/assumptions/pdf/table8_2_2014er.pdf.

2) Following the AEO reference case, include CAIR and MATS, but not the non-air new EPA regulations (coal combustion residues, CWA Section 316(b)). Models that represent the retrofit/retire decision at a fine level of detail are requested to report gigawatts (GW) of retirements for use by more aggregate models. (If you agree to report detailed retirements, please let us know in advance.)

3) Include the proposed New Source Performance Standards (NSPS) for CO2, which would have the effect of prohibiting new coal without CCS. These rules are not yet implemented.

In addition, global models should allow a steady decline in the share of natural gas sales under contracts that are indexed to oil prices in certain Asian economies. The Japanese delivered gas price is about $16 per mmbtu, or 87% of the Brent crude oil price ($107/B) in Btu terms. In the EMF reference case, modelers should steadily decrease the role played by oil indexation over time by either: (a) reducing the percentage of Japanese gas sales under oil-indexed pricing, or (b) reducing the gas price as a percent of the oil price under oil-indexed contracts. By 2025, please eliminate any oil-indexed contracts that maintain gas prices higher than market-determined prices. This assumption calls for gas-on-gas competition in all regions. If you are uncertain about the speed of this decline, please apply them uniformly each year. Please adjust other Asian contracts (Korea, India and China) and those for Russian exports relative to these assumptions for Japan. Modelers are free to use their discretion in making these assumptions, which are offered as guidelines.

Case #2: High Resources

The EMF 31 High Resources scenario is patterned after the deviation between the High Oil/Gas Resources and Reference cases in the previous Annual Energy Outlook 2013 released by the US Energy Information Administration, also available at http://www.eia.gov/oiaf/aeo/tablebrowser/. The top portion of Table 1 summarizes several key variables for this AEO case.

Please follow the assumptions for resources and well spacing in the AEO 2013 High Resource case if you represent shale supplies separately. Otherwise, reduce the inflation-adjusted (real) costs for each level of total gas production by the amount shown for Henry Hub prices in each year (i.e., shift the supply curve downward). Set % deviations in prices and production after 2040 equal to % deviations in 2040.

For global models, please keep international supply and demand conditions (price-quantity curves) outside the United States unchanged.

The AEO High Resource case represents a larger resource base and improved productivity and well-spacing in both U.S. domestic shale oil and natural gas production. For consistency with most EMF model results, however, we *recommend that you shift the natural gas supply curve alone*. If you decide to simulate this case as representing high shale supply conditions rather than for natural gas alone, you may consider as well these changes from the EMF reference or baseline case:

- Expand domestic crude oil production by the amount shown for each year.
- Reduce inflation-adjusted crude oil prices by the amount shown for Brent in each year unless your model determines world crude oil prices endogenously;

Table 1. % Deviation (Δ Logarithm) between 2013 AEO Resource and Reference Cases

High Oil/Gas Resources	2015	2020	2025	2030	2035	2040
Production (quadrillion Btu)						
Crude Oil and Lease Condensate	14.7%	25.6%	37.4%	45.2%	46.6%	50.7%
Dry Natural Gas	8.7%	15.1%	17.2%	21.4%	25.1%	30.4%
Prices (2011 dollars per unit)						
Brent Spot Price (dollars per barrel)	-4.0%	-7.1%	-9.7%	-10.8%	-11.4%	-12.2%
Natural Gas at Henry Hub (dollars per mmBtu)	-27.6%	-41.8%	-48.3%	-50.5%	-51.8%	-59.4%
Coal, Delivered (dollars per million Btu)	-2.6%	-4.1%	-5.2%	-6.0%	-6.6%	-6.8%
Low Oil/Gas Resources						
Production (quadrillion Btu)						
Crude Oil and Lease Condensate	-7.2%	-9.0%	-9.1%	-5.4%	-7.0%	-3.5%
Dry Natural Gas	-4.4%	-9.4%	-11.8%	-14.6%	-18.0%	-20.4%
Prices (2011 dollars per unit)						
Brent Spot Price (dollars per barrel)	1.7%	2.2%	2.2%	1.4%	1.8%	1.4%
Natural Gas at Henry Hub (dollars per mmBtu)	14.6%	26.2%	25.9%	26.7%	27.6%	28.0%

Coal, Delivered (dollars per million Btu)	1.9%	2.6%	2.2%	1.9%	1.8%	1.3%

Case #3: Restricted Access

The EMF 31 Restricted Access scenario will attempt to project conditions when federal, state and local governments restrict access to oil and natural gas shale formations. In the initial round of EMF 31, this case will be based upon the deviation between the Low Oil/Gas Resources and Reference cases in the previous Annual Energy Outlook 2013 released by the US Energy Information Administration, also available at http://www.eia.gov/oiaf/aeo/tablebrowser/. The bottom portion of Table 1 summarizes several key variables for this AEO case. Ultimately, we hope to develop improved estimates for these production impacts from other studies. Compliance costs may exceed social damages associated with environmental or social externalities; this case is not normative.

Increase the inflation-adjusted (real) costs for each level of total gas production by the amount shown for Henry Hub prices in each year (i.e., shift the supply curve upward). Set % deviations in prices after 2040 equal to % deviations in 2040.

For global models, keep international supply and demand conditions (price-quantity curves) outside the United States unchanged.

For consistency with most model results, we recommend that you shift the natural gas supply curve alone. If you decide to simulate this case as representing low shale supply conditions rather than for natural gas alone, you may consider as well these changes from the EMF reference or baseline case:

- Reduce domestic crude oil production by the amount shown for each year;
- Increase inflation-adjusted crude oil prices by the amount shown for Brent in each year unless your model determines world crude oil prices endogenously;

Case #4: Technology Performance Standard

The purpose of this case is to evaluate how changes in the regulation of the power sector's carbon dioxide emissions will impact natural gas markets. Modelers are requested to simulate a technology performance standard (TPS) for the electric power sector. The tradable emissions rate Performance Standard sets a fleet average CO2 emissions rate standard (tons/MWh) across all existing and new fossil generators and allows trading of credits to achieve the standard. A generator earns (owes) a credit on each MWh of generation for each ton/MWh that its emissions rate is below (above) the standard. A TPS was selected for this case because of its relevance to ongoing EPA deliberations on an upcoming performance standard for existing plants, and because it will highlight coal-gas tradeoffs under a power sector carbon policy.

The TPS can be thought in three equivalent ways:
- a credit trading system in which generators are allocated credits based on the standard emissions rate and must hold enough credits to cover their actual emissions rate;
- a cap-and-trade policy that allocates emissions allowances to all generators on the basis of current period electricity production;
- a simultaneous tax on CO2 emissions at the current credit trading price and subsidy based on the standard emissions rate.

Details of policy implementation are as follows:

- The policy covers all new and existing fossil fuel (carbon-emitting) powerplants beginning in the year 2015 but excludes renewable and nuclear plants.
- The emissions rate target would have to be met on average across all of these plants, not by each individual unit.
- The target CO-2 emissions rate for these plants should be set equal to 95 percent of the current average emissions rate for carbon-generating plants in that initial year (2015). Although modelers should use assumptions consistent with your framework, EPA eGRID2012 data covering 2009 suggests that this initial target in 2015 to be 1656 pounds per MWH (equal to 95% of 1743 lb/MWh).
- The target CO-2 emissions rate for these plants should decrease by 2% each year through 2050.
- No banking of credits for use in future periods is allowed by this policy.

Case #5: High International Demand

This case will expand international natural gas demand outside of the United States by the percentages shown in Table 2. In the first round, modelers can select how they want to distribute this global demand expansion by country or world region. Eventually, we hope to calibrate this demand expansion to a more realistic scenario. One example might include these developments:

- All nuclear plants in Japan and South Korea are displaced by combined-cycle natural gas plants.
- Half (or some %) of coal plants in China and India are displaced by combined-cycle natural gas plants.
- China and other Asian economies adopt more compressed natural gas vehicles than expected in the EMF reference or baseline case.

Table 2. % Deviation for High International Demand

	2015	2020	2025	2030	2035	2040
Demand Shock	2%	6%	8%	10%	12%	14%

Case #6: Oil-Indexed Pricing

This case evaluates the competitiveness of US natural gas exports when Japan and other relevant regions reduce their share of oil-indexed contracts less rapidly than in the reference case. Please reduce the contract decline process by a factor of two, such that all oil-indexed contracts are eliminated by 2035 rather than by 2025 in the reference case. Modelers are invited to submit other modeler choice scenarios applying different assumptions. Please document any key assumptions if you submit these additional alternative cases. All other assumptions should remain the same as in the reference case.

Measured Costs

Please indicate whether you can report the costs (benefits) of an alternative case (policy or supply conditions) relative to the reference case. Please describe how costs are computed and what they represent. For example, a model may estimate costs in one of several ways:

- the social welfare costs attributable to changes in consumer and producer surpluses;
- the loss in aggregate economic consumption of all goods and services;
- the additional costs associated with the power sector's generation costs;
- changes in gross domestic product; or
- an alternative metric that is not included in the above list.

Output Variables:

Modelers are requested to submit results by April 16 in order that EMF staff can review results for any inconsistencies prior to the May meeting. Please report results from each scenario covering the 2015-2050 period in a worksheet provided my EMF. Please report any variables that you can from the following list:

Sector	Variable	Units	Additional Notes	2012(EIA)
Consumption	Liquids	Quad BTU	See Table AEO, A2. Includes Liquefied Petroleum Gases and Other, E85,Motor Gasoline, Jet Fuel, Kerosene, Distillate Fuel Oil, Residual Fuel Oil, Petrochemical Feedstocks, and Other Petroleum.	35.87
Consumption	Natural Gas	Quad BTU	Includes Pipeline Fuel and Lease and Plant Fuel.	26.20
Consumption	Coal	Quad BTU		17.34
Consumption	Nuclear	Quad BTU		8.05
Consumption	Renewables	Quad BTU	Includes hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources.	6.65
Consumption	Total Primary	Quad BTU	Also includes Biofuels Heat and Coproducts, Renewable Energy, Liquid Hydrogen, Non-biogenic Municipal Waste, and Electricity Imports	95.02
Industrial	Liquids	Quad BTU	See Table AEO, A2. Includes Liquefied Petroleum Gases and Other, Motor Gasoline, Distillate Fuel Oil, Residual Fuel Oil, Petrochemical Feedstocks, and Other Petroleum.	8.06
Industrial	Natural Gas	Quad BTU	Excludes Pipeline Fuel and Lease and Plant Fuel.	7.29
Industrial	Coal	Quad BTU		1.48
Industrial	Renewables	Quad BTU		1.48
Industrial	Electricity	Quad BTU		3.35
Industrial	Total Delivered	Quad BTU		23.63
Electricity	Natural Gas	Quad BTU		9.46
Electricity	Coal	Quad BTU		15.82
Electricity	Nuclear	Quad BTU		8.05
Electricity	Renewables	Quad BTU		4.59
Electricity	Total	Quad BTU		38.53
Residential	Natural Gas	Tcf	Divide Quad BTU by 1.022	4.17
Commercial	Natural Gas	Tcf	Divide Quad BTU by 1.022	2.90
Industry	Natural Gas	Tcf	Divide Quad BTU by 1.022. Excludes Pipeline Fuel and Lease and Plant Fuel.	7.14
Electric	Natural Gas	Tcf	Divide Quad BTU by 1.022	9.25
Transportation	Natural Gas	Tcf	Divide Quad BTU by 1.022. Gas used in motor vehicles, trains, and ships.	0.04
Total Consumption	Natural Gas	Tcf	Divide Quad BTU by 1.022. Includes Pipeline Fuel and Lease and Plant Fuel.	25.64
Production	Natural Gas	Tcf	Marketed production (wet) minus extraction losses.	24.06
LNG Net Exports	Natural Gas	Tcf	Exports minus Imports	(0.15)
Mexico Net Exports	Natural Gas	Tcf	Exports minus Imports	0.62
Canada Net Exports	Natural Gas	Tcf	Exports minus Imports	-1.99
Total Net Exports	Natural Gas	Tcf	Exports minus Imports	-1.51
Price	Henry Hub	2012$/mmbtu	Excludes any carbon fees	2.75
Price	Brent Oil	2012$/barrel	Excludes any carbon fees	111.65
Price	Coal Minemouth	2012$/ton	Excludes any carbon fees	39.94
Price	Electricity	2012 cents/kwh	All sectors; excl. carbon fees	9.84
Economy	Real GDP	Billion 2005$		13593.20
Economy	Economic Cost	Billion 2005$	Costs w/r to Reference	0.00
Economy	Carbon Dioxide	Million Metric Tons	Total Energy-Related (all sectors)	5289.86
Electricty	Sulfur Dioxide E	Million Short Tons	Electricity only	3.34
Electricity	Nitrogen Oxide E	Million Short Tons	Electricity only	1.68