EMF 20 Study Design:
Natural Gas, Fuel Diversity and North American Energy Markets

Hillard G. Huntington

EMF WP 20.1

November 2002

Energy Modeling Forum
448 Terman Center
Stanford University
Stanford, CA 94305-4026

EMF 20 Study Design
November 1, 2002

Scenarios

These specifications try to standardize assumptions for the EMF 20 scenarios. Modelers should use their judgement and should not override major features of their model in following these specifications. It is more important to be consistent with the major "story" behind each scenario.

1. Reference Case using EIA AEO2002 **Low Oil Price** Case fuel prices and economic growth for any *exogenous* trends in your model.

   World oil price (2000$/barrel): declines to $17.41 by 2005 and remains at $17.64 through 2020.
   Gross domestic product (% per year): 3.0% through the year 2020.
   Electricity demand (% per year): 1.8% through the year 2020.

   We have chosen the EIA low oil price ($18 per barrel in 2000$ by 2020) rather than the EIA reference case price ($25) from the *2002 Annual Energy Outlook.* There are several reasons that make this path more desirable for the EMF 20 cases.

   a. Most EMF 20 scenarios place upward pressure on natural gas prices. These scenarios are more believable if we begin at relatively low oil and gas prices.
   b. Except for shocks and recent events (including the Iraqi war premium scare), oil prices have generally been in the $15-$20 per barrel range on an annual basis since 1985.
   c. Although there is substantial uncertainty, higher long-term prices would require increased physical scarcity. The evidence for these conditions is mixed at the moment.

   Modelers are invited to offer an additional scenario that uses the AEO reference rather than low price path. Please submit those results as an additional spreadsheet in the enclosed EMFOutput.xls file.

2. Low Gas Supply Case where lower-48 and traditional (e.g., non-frontier) Canadian dry gas production is gradually reduced over time.

   Please reduce the supply curve (the quantity at each price) for these sources by 17 percent from the reference level by 2020. This reduction appears consistent with the EIA low E&P technology case, which decreased the rate of productivity improvements by 25% for these concepts:
   - finding rates
   - success rate improvements
   - drilling, equipment and operating costs

The recommended reduction is compared with two estimates of the reductions in production (with an adjustment for price changes) in EIA's low oil & gas E&P technology case:

	2010	2015	2020
Recommended Reduction	**-7%**	**-12%**	**-17%**
Adjusted Production (elasticity=0.4)	-7.17%	-10.61%	-16.73%
Adjusted Production (elasticity, low growth)	-6.29%	-13.44%	-17.27%

Of the two estimates below the recommended reduction, the top one assumes a price elasticity of domestic supply equal to 0.4 in all years. The bottom one assumes a price elasticity inferred from comparing the low and reference economic growth cases used by EIA.

The low technology assumptions will reduce the Canadian conventional supply **curve** but will leave unchanged the Canadian frontier supply **curve**. Canadian import levels can respond to any changes in gas price. Mexican, Alaskan and LNG supply **levels** should be assumed fixed for policy reasons at the EMF reference levels.

For this and all alternative scenarios, allow other energy prices to change if they are endogenous. Keep other prices constant if they are exogenous.

3. Lower Supply plus Higher Gas Demand Case

Previous case **plus** higher gas demand due to more economic growth relative to the EMF reference case. The higher demand conditions were chosen to reflect the EIA's high economic growth case, in which real GDP grows by 3.4% rather than by 3.0% per annum between now and the year 2020.

There is no additional adjustment for increased electrification because that assumption would complicate the desire to run reasonably standardized assumptions through all models. Total electricity demand grows by 2.1% rather than 1.8% in the EIA high growth case.

Modelers who can directly implement a higher economic growth should raise the growth in real GDP from 3.0% to 3.4% per annum between now and the year 2020.

Modelers who need exogenous expansion rates in natural gas demand should expand their total natural gas demands above their reference levels by 6.3% in year 2010, 7.1% in the year 2015, and 8.0% in the year 2020. Other years should

be expanded accordingly. These expansions rates are representative of the EIA's high growth case, after one makes an adjustment for the higher gas prices in that case. Details are shown in the appendix table.

4. Lower Supply, Higher Gas Demand plus Expanded Frontier Gas (plus LNG) Case

   Previous case plus additional frontier gas + LNG projects.

   Shift the supply curves for Canadian frontier, Mexican exports and LNG projects by these absolute volumes (fixed quantity at each price) above your reference levels. Modelers can substitute North Slope Alaskan gas for some of the LNG increments depending upon relative costs in the model.

   Modelers who need exogenous reference and high frontier estimates can choose assumptions based upon the Reference and High Frontier values shown below the recommended expansion estimates.

	2000	2005	2010	2015	2020	2000-2020
Expansion (Tcf)						
Net Imports	0.00	0.60	1.61	2.88	4.00	
Canada	0.00	0.44	0.49	0.53	0.55	
Mexico	0.00	0.00	0.45	0.97	1.38	
Liquefied Natural Gas*	0.00	0.16	0.67	1.37	2.07	
Alaska (southern)	0.00	0.00	0.00	0.00	0.00	
Reference						
Net Imports	3.52	4.50	4.89	5.26	5.51	2.26%
Canada	3.46	4.08	4.51	4.90	5.06	1.93%
Mexico	-0.09	-0.22	-0.45	-0.47	-0.38	7.23%
Liquefied Natural Gas	0.16	0.64	0.83	0.83	0.83	8.60%
Alaska (southern)	0.43	0.50	0.53	0.57	0.60	1.73%
High Frontier						
Net Imports	3.52	5.11	6.50	8.13	9.51	5.09%
Canada	3.46	4.53	5.00	5.43	5.61	2.45%
Mexico	-0.09	-0.22	0.00	0.50	1.00	
Liquefied Natural Gas	0.16	0.80	1.50	2.20	2.90	15.64%
Alaska (southern)	0.43	0.50	0.53	0.57	0.60	1.73%

* Alaskan North Slope gas can be substituted for LNG if competitive in this case.

5. Lower Supply, Higher Gas Demand plus Advanced Renewable Technology Case

   The June meeting discussed the role of advanced renewable technologies.

   We would introduce the EIA technology assumptions for a high renewables case into the Low Supply/High Demand Case. These assumptions include a combination of lower capital and operating costs and expanded capacity factors. You can review these assumptions by visiting: http://www.eia.doe.gov/oiaf/aeo/assumption/renewable.html

Output Variables

Modelers are asked to report those output variables listed in the sheet EMFOutput.xls. Please report one scenario in a separate worksheet of this file.

Values for the year 2000, as reported by the *Annual Energy Outlook 2002,* are shown in these worksheets. These values are to help modelers to report the appropriate concept in the right units. They may differ from values that are reported in other more recent sources such as the *Natural Gas Annual* or *Annual Energy Review.* Please overwrite these values if you think that you have more recent data.

If you project another variable that resembles but differs from the requested data, please report it at the bottom of the sheet after all of the requested series. An example might be citygate prices rather than utility prices. Please provide a short description and units.

Please send the completed data set to Hill Huntington at hillh@stanford.edu by January 15, 2003. This deadline should help us detect any consistency problems between model outputs. Please let me know if you cannot meet that deadline so that we can decide whether we can include your results in our comparison charts for the meeting.

Requested Output Variables

Region	Variable		
United States	Real Gross Domestic Product	2000$ Billion	
United States	World Oil Price	2000$/Barrel	2
United States	Natural Gas Wellhead Price	2000$/Mcf	
United States	Coal Minemouth Price	2000$/Ton	1
United States	Average Electricity Price	2000Cents/kWh	
United States	Distillate Price for Central Generators	2000$/MMBtu	
United States	Residual Price for Central Generators	2000$/MMBtu	
United States	Natural Gas Price for Central Generators	2000$/MMBtu	
United States	Coal Price for Central Generators	2000$/MMBtu	
United States	Natural Gas Consumption by Central Generators	Quadrillion BTUs	
United States	Coal Consumption by Central Generators	Quadrillion BTUs	1
United States	Nuclear Power	Quadrillion BTUs	
United States	Renewable Consumption by Central Generators	Quadrillion BTUs	
United States	Total Fuel Consumption (including net imports) by Central Generators	Quadrillion BTUs	3
United States	Total Distillate Consumption	Quadrillion BTUs	
United States	Total Residual Consumption	Quadrillion BTUs	
United States	Total Natural Gas Consumption	Quadrillion BTUs	2
United States	Total Coal Consumption	Quadrillion BTUs	2
United States	Total Steam Coal Consumption	Quadrillion BTUs	2
United States	Total Renewable Consumption	Quadrillion BTUs	
United States	Total Energy Consumption	Quadrillion BTUs	9
United States	Total Delivered Electricity	Quadrillion BTUs	1
United States	Hydroelectric Consumption for Electricity	Quadrillion BTUs	
United States	Geothermal Consumption for Electricity	Quadrillion BTUs	
United States	Municipal Waste Consumption for Electricity	Quadrillion BTUs	
United States	Biomass Consumption for Electricity	Quadrillion BTUs	
United States	Solar Thermal Consumption for Electricity	Quadrillion BTUs	
United States	Solar Photovoltaic Consumption for Electricity	Quadrillion BTUs	
United States	Wind Consumption for Electricity	Quadrillion BTUs	
United States	Residential Gas Consumption	Tcf	
United States	Commerical Gas Consumption	Tcf	
United States	Industrial Gas Consumption	Tcf	
United States	Electricity Gas Consumption	Tcf	
United States	Total Gas Consumption (see Row 86)	Tcf	2
United States	Residential Gas Price	2000$/Mcf	
United States	Commercial Gas Price	2000$/Mcf	
United States	Industrial Gas Price	2000$/Mcf	
United States	Electricity Gas Price	2000$/Mcf	
United States	Average Delivered Gas Price	2000$/Mcf	
United States	Total Dry Gas Production	Tcf	1
United States	Onshore Gas Production	Tcf	1
Northeast	Onshore Gas Production	Tcf	
Gulf Coast	Onshore Gas Production	Tcf	
Midcontinent	Onshore Gas Production	Tcf	
Southwest	Onshore Gas Production	Tcf	
Rocky Mountain	Onshore Gas Production	Tcf	
West Coast	Onshore Gas Production	Tcf	
United States	Offshore Gas Production	Tcf	
United States	Alaska Gas Production	Tcf	
United States	Canadian Gas Imports	Tcf	
United States	Mexican Gas Imports	Tcf	-
United States	Liquefied Natural Gas Imports	Tcf	

New England	Total Gas Consumption	Tcf	
Middle Atlantic	Total Gas Consumption	Tcf	
East North Central	Total Gas Consumption	Tcf	
West North Central	Total Gas Consumption	Tcf	
South Atlantic	Total Gas Consumption	Tcf	
East South Central	Total Gas Consumption	Tcf	
West South Central	Total Gas Consumption	Tcf	
Mountain	Total Gas Consumption	Tcf	
Pacific	Total Gas Consumption	Tcf	
United States	Total Gas Consumption	Tcf	2
New England	Utility Gas Consumption	Tcf	
Middle Atlantic	Utility Gas Consumption	Tcf	
East North Central	Utility Gas Consumption	Tcf	
West North Central	Utility Gas Consumption	Tcf	
South Atlantic	Utility Gas Consumption	Tcf	
East South Central	Utility Gas Consumption	Tcf	
West South Central	Utility Gas Consumption	Tcf	
Mountain	Utility Gas Consumption	Tcf	
Pacific	Utility Gas Consumption	Tcf	
United States	Utility Gas Consumption	Tcf	
New England	Utility Gas Price	2000$/Mcf	
Middle Atlantic	Utility Gas Price	2000$/Mcf	
East North Central	Utility Gas Price	2000$/Mcf	
West North Central	Utility Gas Price	2000$/Mcf	
South Atlantic	Utility Gas Price	2000$/Mcf	
East South Central	Utility Gas Price	2000$/Mcf	
West South Central	Utility Gas Price	2000$/Mcf	
Mountain	Utility Gas Price	2000$/Mcf	
Pacific	Utility Gas Price	2000$/Mcf	
United States	Utility Gas Price	2000$/Mcf	

Total includes transportation, pipeline fuel and lease and plant fuel in addition to the sectors reported above.

Appendix: Background Table for the High Demand Assumptions

	2000	2010	2015	2020
High GDP				
Electricity Demand	3426.1	4284.0	4734.9	5173.1
Total Gas Demand	22.8	29.1	32.6	35.0
Electricity Gas Demand	4.2	7.4	9.5	10.4
Wellhead Gas Price	3.60	3.31	3.36	3.65
Reference				
Electricity Demand	3426.1	4169.9	4555.7	4916.1
Total Gas Demand	22.8	28.1	31.3	33.8
Electricity Gas Demand	4.2	6.9	8.9	10.3
Wellhead Gas Price	3.60	2.85	3.07	3.26
% Price change: reference versus high-growth	0.00%	-14.92%	-8.93%	-11.35%
Inferred demand elasticity, E&P technology cases		-0.174	-0.318	-0.369
% Demand change, if prices held constant	0.00%	2.59%	2.84%	4.19%
Gas demand level with constant prices	22.8	29.9	33.6	36.5
Demand shift: High demand w constant prices	0.0	1.8	2.2	2.7
% Shift from Reference	**0.0%**	**6.31%**	**7.10%**	**8.00%**
Shift in High Case w Price Change	0.0%	3.59%	4.09%	3.57%
% Change in electricity demand	0.00%	2.70%	3.86%	5.09%
% Change in electricity's gas demand	0.17%	7.97%	6.49%	0.63%