Summary of Liquid Fuels Market Module Workshop

Background

The Energy Information Administration (EIA) embarked on an effort to review and potentially replace the Petroleum Market Module (PMM) of the National Energy Modeling System (NEMS) in late Fall of 2008. The process began with a solicitation from current NEMS customers and stakeholders on what issues and questions the new Liquid Fuels Market Module (LFMM), a potential replacement for the PMM and its satellite submodels,[1] should be able to address well. The issues and questions were aggregated slightly into a more manageable size and then prioritized by both the stakeholders and EIA. A brief discussion of the LFMM requirements and their prioritizations are provided in EIA's white paper *Needs Assessment and Model Development Process: the Liquid Fuel Market Module (LFMM) for the National Energy Modeling System* (May 10, 2009), and a summary of the LFMM project and scope was presented to the American Statistical Association Committee on Energy Statistics in the Spring of 2009 from which further advice was received and incorporated.

A technical LFMM Workshop was held on September 30, 2009. (Attached are a copy of the workshop agenda and the invited list of participants.) Four experts[2] were contracted to write short white papers and make presentations that summarized their views on the technical issues raised in the LFMM requirements and prioritizations paper. This document summarizes the major points of the discussion and the extent to which there appeared to be consensus or major disagreements. EIA and the discussants found that the discussions were useful even though there was not complete agreement on many issues.

Caveat: Some of the recommendations, if undertaken, imply commitments to implicitly do other modeling or programming which may not be obvious to the reader and which can have significant resource and labor implications for EIA. The recommendations will be evaluated based on the benefits provided versus the costs required to implement the recommendations and maintain the system. For example, the development and maintenance of two refinery models, e.g., one detailed international and one U.S. model, may translate into high development and maintenance costs; the resource costs will have some impact on the choices made for the LFMM design.

Summary of the Workshop Discussion

The LFMM workshop was hosted at EIA and raised a number of important issues that must be considered in formulating the new LFMM within the NEMS system. The major discussion issues are summarized below based on the highlights of the authors' presentations and the following discussions. Many of these issues remain unresolved and open to further debate/discussion.

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[1] The submodules of PMM include cellulosic ethanol, biomass-to-liquids, pyrolysis oils and other synthetic liquids from coal and natural gas.

[2] The authors were, in alphabetical order, Vince DiVita of (Jacobs Consultancy), Terrence Higgins of Hart (HART), Dave Hirshfeld (MathPro, Inc.), and Professor Fred Murphy of (Temple University). Another expert, Larry Bredeson of Shell, offered to make a presentation at the workshop but would not submit a white paper.

1. *General Modeling Approach*

There was general consensus that a linear programming (LP) approach is the best overall modeling choice for the new LFMM.[3] However, a number of concerns were raised with respect to using an LP framework for the LFMM:

a) Complex LP models run the dual risk of over-constraining for the sake of appearance and over-optimizing. For example, like the current PMM or any other model, arbitrary constraints can be inserted to control model behavior to force a visually acceptable result.
b) There was broad consensus among workshop participants that the current PMM LP model was overly complicated due to the inclusion of too many intermediate streams.
c) There is a serious danger of large LPs becoming non-transparent, even when using matrix generation languages like GAMS or MPL.
d) At least one author expressed concern about using an LP to determine product prices and suggested using exogenously determined prices. Refinery margins would then be obtained from the difference between these prices and the marginal crude oil price used by the LP. This approach would not be acceptable for use in NEMS because virtually all primary and delivered fuel prices, with the exception of crude oil, are endogenously determined as part of the derived competitive energy market equilibrium. An exogenous assumption of the liquid product prices in NEMS or a simple relationship between crude oil prices and product prices would nullify the equilibrium aspect of NEMS solutions, including inter-fuel competition within the energy market.

Also debated regarding the scope of the base LP model was what parameters/inputs should be built directly into the LP framework or determined exogenously. The discussion points included:

a) refinery fuel efficiency forecasts
b) international fuel prices and supplies, computed perhaps in an offline international refinery model
c) alternative fuels modules providing supplies and prices
d) projections of refinery retirement and expansions
e) retail product prices and refinery margins

In addition, workshop participants agreed that the LP framework must be flexible enough to deal effectively with the following new policy issues:

a) renewable fuels mandates and incentives
b) bunker fuel regulations, e.g., MARPOL
c) carbon policies, e.g., cap-and-trade, low carbon fuels standards, etc.

[3] Larry Bredeson argued that his spreadsheet-based case study approach is less complicated and easier to work with than an LP, but the consensus was that his approach would require users to have too high a level of refinery experience to be practical for EIA and most other users. Furthermore, it was not clear how one would address the myriad of policies issues that the LFMM should address within a spreadsheet approach, particularly without having the expertise to adjust the model in a systematic and consistent fashion.

Finally, the concept of an LP toolkit was widely supported. That is, a single underlying data base and modeling structure that allows different levels of detail for different analysis applications would be worth developing. A simpler base representation for the LP model would be used within NEMS while a more detailed representation or representations would be used to experiment offline in order to determine operating modes for the LP.

2. *Refinery Designs*

For the proponents of the LP approach, there were three basic proposals for the refinery design:

a) Some argued that a single aggregate refinery per region with a simplified process slate would be appropriate for forecasting applications because such a model would be easier to maintain and sufficient for forecasting applications (Murphy, Hirshfeld). Others disagreed and argued that at least two refinery types were needed to deal effectively with light/heavy crude differentials.
b) Others proposed that if a single, relatively simple, refinery model per region is used, more detailed refinery models for special studies and specific analyses, e.g., changing fuel specifications, should be developed and maintained. For example, EIA could keep more detailed models for "special studies" representing certain subsets of refineries, such as "all Petroleum Administration for Defense District (PADD) 3 refineries" and "a typical PADD 3 coking refinery." These more detailed models would be used to inform/calibrate the forecasting model and would operate off of the same core data sets (DiVita and Hirshfeld).
c) A third proposal suggested that refinery capacity in a given region should be separated into a composite "base level" group which processes the majority "average" crude input to a region and a "marginal level" which processes the marginal crude. The marginal production operations would be the only ones that may add capacity and also determine the marginal costs for finished products (Higgins).

For general forecasting for the *Annual Energy Outlook*, the broader question is whether or not the precision gained from having more than one refinery per region (or multiple refinery models, one for NEMS and a detailed one for special studies) is worth the effort and the additional maintenance and resources required. Those who argued against one aggregate refinery in each region claimed that at least two refinery types were needed to deal effectively with light/heavy crude differentials.

3. *Modeling Platform*

Possible new modeling platforms mentioned at the workshop were GAMS and MPL because they would make the new model more transparent, easier to maintain, and generally more user-friendly. As noted earlier, a standalone but detailed refinery system could be used for detailed analysis and provide the key parameters and model structure for the more aggregate regional NEMS refinery. Used in this fashion, the connection to more detailed data and analysis could be maintained while allowing better consistency with the simpler LP module integrated into NEMS.

4. *Domestic Regional Issues*

The currently used PADD-level representation was in general considered adequate to represent the U.S. refining industry, with some modifications. However, three alternative variations of the 5 PADD regions were suggested to improve the quality of the projections:

a) California should be its own region, due to its special fuel specifications and progressive environmental regulatory policies.
b) Divide PADD2 into PADD2 North and PADD2 South given Oklahoma's peculiar position as a PADD2 State located close to the Gulf region and the use of West Texas Intermediate crude oil as a benchmark price for light crude oil.
c) Divide PADD3 into three sub-PADDs, perhaps distinguished by crude import types or differences in the processing technologies available in each sub-region.

Any sub-PADD breakouts should be considered carefully because an increase in the number of regions could substantially add modeling complexity and run time. The trade-offs between an increase in the number of regions versus an increase in the number of refineries was not discussed.

5. *International Connection*

There was broad consensus that global petroleum markets are key drivers of refinery margins and product prices and consequently that the LFMM should incorporate a reasonably accurate depiction of at least the relevant international market flows. For example, most participants agreed with the need for a separate European Union (EU) model due to their growing diesel demand and excess motor gasoline production. (Fred Murphy and others suggested that international refinery operations should be modeled in the LP in some level of detail to be determined through experimentation, although he recommends that international refinery capacity expansion be done offline or econometrically. He also suggested that the international model may only need to be run once per model year). However, there was broad consensus that the regionality of the international part should be kept as a small as possible while maintaining accuracy/plausibility of inputs to the domestic market:

a) A break-out of the non-U.S. world into the EU for product imports, Canada/Mexico for crude imports and product exports, and the rest of world for crude imports.
b) Integration of at least some subset of the international markets specifically addressing the "short-haul" versus "long-haul" trading partners.[4]

There was some consensus that while a complex and detailed model of world petroleum prices/supplies might be warranted, it should be kept separate from the base U.S. refinery model. Perhaps an offline international model could provide supply/price data to be used in the LFMM or could be systematically parameterized to develop a reduced form of the larger model. There was also a suggestion to let the international inputs iterate with the LFMM in a limited way.

[4] Short-haul trading would encompass areas like the Bahamas, Puerto Rico, Virgin Islands, and possibly some of the Canadian provinces. Long-haul trading was primarily focused on Europe but could also address other areas, particularly when looking out beyond 2030

6. *Alternative Fuels*

A few participants and one author (Hirshfeld)[5] argued that it is not productive to spend time on detailed models of fuels emanating from commercially unproven technologies. The suggestion was to exogenously develop alternative fuel supplies and prices as placeholders to fulfill, in particular, the renewable fuel standard (RFS) constraints that exist today. It was pointed out in the discussion that despite the speculative nature of this kind of forecasting, government funding, support, and policies for some alternative fuels warrants some detailed technology modeling although no one suggested that the technological modeling should be at the detailed level of refinery processes.

There was some consensus that the alternative fuels should be segregated as much as possible from the main LP/refinery model. The inherent risk with the segregation approach is that the economic decision-making may not be entirely consistent with the rest of the market economics and may distort the duals or prices that are provided by the LP solution. What the interface between these two segregated groups of models should was unresolved.

7. *Capacity Expansion and Model Foresight*

There were several different approaches offered for making refining capacity expansion decisions.

a) The need for the latest software interface platforms and database structure was raised by at least two authors in the interest of providing the LFMM with both flexibility and transparency. One approach advocated was to use an econometric estimation method to add capacity. However, the question was raised as to how EIA could econometrically model future legislative requirements in the LFMM if the econometric equations are based on historical data series since presumably there would not be historical precedent for the estimation in most cases.
b) Another suggested that capacity expansion should be included in the LP, but that a myopic approach would be preferable (Higgins). Similarly, this raised questions on how to deal with the step-wise nature of future known legislative requirements, such as a RFS, and the resulting jagged pattern of capacity builds that would likely result when building myopically. This argued for at least some forward-looking capacity expansion algorithm.
c) The third area focused on the issue of rationalizing capacity, i.e., retirements. Given the current state of the industry, the issue of transitioning to a lower capacity level, due to retirements and shutdowns, needs to be addressed based on economics and product demand constraints. That is, refinery capacity “rationalization” needs to be explored further under conditions, for example, that the product slates for both the United States and Europe are shifting to higher percentages of diesel over gasoline.

Again, this area seemed less conclusive and needs more thought given the variety of environmental and economic policies likely to be analyzed using the new LFMM.

[5]Notably David Hirshfeld was the only author to seriously address the issue of alternative fuels in his presentation or his white paper.

8. *Other Issues*

a) The need for the latest software interface platforms and database structure was raised by at least two authors in the interest of providing the LFMM with both flexibility and transparency.
b) The topic of seasonal issues was raised, such as summer and winter gasoline pricing, and how to incorporate those into the LFMM.
c) There was significant presentation time devoted to the need for model calibration and backcasting, although no conclusion was reached in the follow-up discussion on this issue.
d) Model design and development should take into account the analyst's time/effort to set up the model for runs and to decode results.
e) The issue of computational time was raised in the context of the possibility of running the LFMM once per model year instead of iterating with other NEMS modules. This raised questions from the audience as to how the competition for feedstocks, such as biomass, could be modeled without iterating with the Electricity Market Module or how the choice of fuels in flex-fuel vehicles could be made without iterating with the Transportation Demand Module. This issue could become moot if the simpler LP runs faster, i.e., if the cycle time burden is actually reduced.

APPENDIX A

LFMM WORKSHOP AGENDA

Liquid Fuels Market Module Technical Workshop
September 30, 2009

Location: **U. S. Department of Energy**
Energy Information Administration
1000 Independence Avenue, S.W.
Room 2E-069/081

9:00 AM -- 9:30 AM Introductions and Welcome

Dr. Richard Newell – Administrator
Welcome and Context

Andy S. Kydes – Senior Technical Advisor/OIAF
Administrative Matters

9:30 AM -- 10:00 AM
Larry Bredeson, Shell Oil Company
Discussion

10:00 AM -- 11:00 AM
Terrence Higgins, Hart Downstream Energy Services
Discussion

11:00 AM -- 12:00 Noon
Professor Frederic Murphy, Temple University
Discussion

12:00 noon -- 1:30 PM
Lunch

1:30 PM -- 2:30 PM
David Hirshfeld, MathPro Inc
Discussion

2:30 PM -- 3:30 PM
Vincent DiVita, Jacobs Consultancy
Discussion

3:30 PM -- 4:30 PM
Wrap-Up and Open Discussion

APPENDIX B -- Invitees of the Workshop

<u>DOE Invitees</u>

Bruce Bawks, EIA
William Brown, EIA
Michael Cole, EIA
John Conti, EIA
Adrian Geagla, EIA
Rodney Geisbrecht, NETL
Peter Gross, EIA
Howard Gruenspecht, EIA
Paul Holtberg, EIA
John Holte, EIA
Susan Holte, EIA
Alexander King, EIA
Richard Newell, EIA
Michael Schaal, EIA
Joanne Shore, EIA
Mac Statton, EIA
Glen Sweetnam, EIA
Phillip Tseng, EIA
Thomas White, Office of Policy, DOE

<u>External Experts</u>

Larry D. Bredeson, Shell Oil Company
Gary Brush, EIA Consultant
Vincent DiVita, Jacobs Consultancy
Tim Fitzgibbon, McKinsey and Company
Less Goudarzi, OnLocation
Terrence Higgins, Hart Downstream Energy Services
Dave Hirshfeld, MathPro
Niko Kydes, OnLocation
Alfred L. Luaces, Purvin & Gertz, Inc.
John Marano, Consultant
Elizabeth May, SAIC
Hitesh Mohan, INTEK Inc.
Frederic Murphy, Temple University
Sandy Sanders, OnLocation
Elisabeth Varhopoulou, ExxonMobil
Kevin Waguespack, Baker & O'Brien.
Art Weis, American Petroleum Institute