NEMS Forecast Evaluation Methodology

This is a working document prepared as a job of work (DE-AP01-06EI38129.A000) on behalf of the Energy Information Administration (EIA) in order to solicit advice and comment on statistical matters from the American Statistical Association Committee on Energy Statistics. The topics presented here will be discussed at EIA's fall 2006, meeting with the Committee to be held October 5 and 6, 2006.

Summary

The purpose of this note is to initiate the consideration of a methodology for assessing the accuracy of National Energy Modeling System (NEMS) projections. NEMS is configured to project future energy product production and consumption in a fashion that accounts for the wide range of detailed circumstances that result in multi-market economic equilibria for energy products. In addition to market forces NEMS accounts for technological change and the impact of government actions and policies. The evaluation methodology advocated here calls for constructing statistical approximations of important energy market relationships implicit to NEMSS, e.g., crude oil supply. The approximations will be derived via regression analysis of the NEMS solutions prepared in support of the Annual Energy Outlook (AEO). The approximations are to be specified to account for important, explanatory relationships, e.g., the elasticity of crude oil supply to the price of oil. Based on this, “differences” between NEMS projections and the actual values of the variables projected can be partitioned among general uncertainty, “errors” in projecting explanatory variables, structural changes in market behavior, and transitory influences such as the weather. An illustration of the approach is provided for crude oil supply utilizing the versions of NEMS used in support of the 1998 – 2000 AEO’s.

September 2006

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Prologue. The purpose of the note below is to identify the goal of identifying differences between NEMS projections and actual data; and, given this, to partition the differences found among their major influences. The sense of the note is to identify what these influences might be and to identify a practical method for some of them for evaluating their relative roles in contributing to differences between NEMS projections and the eventual values of the variables projected. If the method outlined were implemented, there could be diagnostic value in assessing the variable/parameter sensitivities in a current version of NEMS compared to past versions. From a model management perspective, the sources of forecast differences might be used to support priorities for model component development. As it stands, since the analysis is not currently conducted, such potential benefits have not been demonstrated. As a result, as a resource allocation priority compared to other modeling issues, identifying and partitioning forecast differences in the manner proposed is problematical for the offices responsible for model maintenance and development.

An alternative perspective is that such an analysis is itself an information product that informs the community for whom the projections of energy production and consumption are prepared. In brief, that an assessment of forecast accuracy in the fashion proposed is an item of good professional practice. Accordingly, an analysis of forecast accuracy and the sources of differences between forecast and actual values might be prioritized apart from, rather than within, the process of resource allocation for model development and maintenance. While issues of method are important, perhaps the most important issue associated with this note is that of deciding if the analysis of forecast differences is a ***necessary*** activity in association with the production of the forecasts themselves.

Background. In principle, an evaluation of NEMS forecast accuracy that accounts for the various sources of differences between forecast and actual values can be readily accomplished. The form of the model, in brief, involves projecting a variety of important influences on energy markets, e.g., technology and the parameters of consumer behavior. Based on the projections of these "conditional variables" the model then determines the corresponding multi-energy-market equilibria and the associated projections of energy product prices and quantities. When a forecast period actually occurs, and the actual values of the conditional variables are known, the model can be re-run using the actual values for model assumptions and the resulting projections compared to the actual prices and quantities. The impact of individual conditional variables can be determined via differentially using the original projections and the actual values, *ceteris paribus*. Routines within the model might also be amended to account for changes in government policies, technologies, or consumer behavior. Extra-model influences such as weather could also be accounted for in the historical period, independent of NEMS. In general, the size of the model and need to maintain, and then run, non-current versions of the model over many years make this approach impracticable (at least so far for NEMS).

An alternative is to isolate the explanatory variables at issue for each model component to those that correspond to the basic economic forces associated with the energy markets represented by NEMS. Given this, the underlying interrelationships, e.g., price elasticities of supply and demand, can be determined for a current version of the model and then retained. In general, the method would be to selectively change important assumptions, *ceteris paribus*, and catalogue the corresponding sensitivities. Later, these sensitivities could be applied to actual data to determine the basis for forecast differences without having to archive and re-run the corresponding version of NEMS (This was done in Costello (2006) **Reduced Form Energy Model Elasticities from EIA's Regional Energy Model (RSTEM)** , released 5/9/2006 as a one time report, for price and weather effects) A differential accounting for the impact of differences in projected versus actual "conditional variables" could still be approximated from the sensitivities. As before, extra-model, transitory influences on the historical values could also be accounted for. The basis for the approach is to detect the important market sensitivities implicit to NEMS's representation of energy markets for each version of the model.

Proposed Method. There are basically two methods for extracting the underlying sensitivities implicit to NEMS. One, as already noted, is through comparative statics experiments with the model components themselves. The approach would be to solve the components, relative to a base or reference case, with each important assumption, e.g., the price of oil, changed, individually (with all other assumptions held constant), and compare results. The measure of sensitivity usually brought to comparative statics results is the elasticity (the ratio of the percentage change in the variable value solved for in the model , e.g., crude oil supply, to the percentage change in the assumption, e.g., the price of oil). Forecasts of future energy production and consumption could then be compared to the values of these variables that actually occur. Using the actual values of the conditional variables and the elasticities associated with the model version at issue, the differential impact of errors in projecting the conditional variables could be assessed. Although there have been individual studies of the sensitivities of certain NEMS components using this method, it is not generally used, e.g., in the recently released *Annual Energy Outlook Evaluation 2005,* DOE/EIA-0640(2006), July 2006, there is no breakout of forecasting error due to errors in projecting conditional variables, or any other specific source, although the sources of error in general are initially enumerated. Extracting the sensitivities using this method would be relatively expensive.

The method proposed here as an alternative is to estimate the market sensitivities implicit to NEMS based upon the solutions prepared each year for the AEO. Among other ways, NEMS solutions are saved in a binary format and can be processed by the PC-based graphic interface *Graf2000.* Solution data have been saved in this format starting with those prepared for the 1998 AEO. This utility includes a regression component that enables regression analysis to be conducted using resident data; and, a data extraction routine that enables any collection of solution series to be extracted and input to other statistical procedures. Initially, the proposed method entails no additional resource requirements in terms of running NEMS or archiving versions of NEMS for use at a future time.[1] Instead, the solution sets for the AEO versions of NEMS can be pooled for the projections to be evaluated at a future time.

The basic approach is to specify the underlying energy market supply and demand relationships in terms of their important, explanatory variables; and, given this, to estimate the relationships based upon NEMS solution data. The results of the estimates provide a description of the NEMS model version in terms of how energy markets are represented. The actual specifications utilized would be guided by the expertise of the EIA staff responsible for developing and maintaining individual model components. Since the solution sets can be readily archived, the actual regression analyses need not be conducted until the time that a model version is to be evaluated, although the outcomes of the regressions can have immediate diagnostic use in NEMS development.[2] A demonstration of the general success of representing NEMS components via regression analysis is given in: Buck and Lady, "Approximation of Large, Computer-Based Economic Models," presented at annual meetings of International Atlantic Economic Association on October 9, 2005 in New York City, New York. A copy of the paper can be downloaded from the link: http://optima-com.com/buck_lady/AES_Paper.htm

It is proposed to configure the means of performing the regression analyses in a fashion that can be routinely conducted and maintained by EIA staff. The goal of the statistical analyses is to enable the errors in EIA forecasts to be explicitly decomposed with respect to the following influences:

Transitory Influences, e.g., weather, strikes, accidents, embargoes not accounted for in the projections.

Institutional Influences, e.g., changes in laws and regulations and changes in data series definitions compared to model assumptions.

Structural Influences, e.g., changes in resource availability or energy use technology compared to model assumptions.*

Errors in Projecting Conditional Variables, e.g., differences in the eventual values of activity drivers and other exogenous factors such as GDP and population.*

Errors in Behavioral Parameters, e.g., changes in consumer price sensitivities compared to those assumed by the forecasting methodology.*

Uncertainty, e.g., the residual error of the projection method.

The methodology for partitioning forecast differences among (such as) the influences outlined above is as follows for the items indicated by “*”, given the availability of actual data for previously forecast values.

The equations derived to represent the important relationships of supply and demand are re-run using the actual values for the explanatory variables. The actual values are substituted for the values used (or solved for) in the original projections, one explanatory variable at a time. This enables the identification of the influence of each explanatory variable separately. The equation is then re-run with all explanatory variables assigned their actual values. For this case, the residual error is due to general forecasting "uncertainty" or other, structural changes. Structural change is the issue of whether or not the values of the coefficients in the forecasting equation have changed for the forecast period compared to the model version to which the equation had been "fit." The equation is re-estimated and the results compared to the outcome of the estimation used to approximate the characteristics of the model. One method to assess if there were significant "differences" between the original, and revised, estimate is the Chow test (Chow, Gregory, "Tests of Equality Between Sets of Coefficients in Two Linear Regressions," *Econometrica*, 28, (July 1960), pp. 591-605.). Additional methods may be proposed by the ASA committee as the project is ongoing. Events influencing the actual data not accounted for by the forecasting equation will be identified and evaluated by EIA staff as appropriate, e.g., weather effects for consumption variables can be determined independent of the regressions which are based on the NEMS assumption of “normal” weather..

Example for crude oil supply. An illustration of the above procedure is provided here for projections of crude oil (and lease condensate) supply. The market supply of crude oil is dependent upon the size of the developed resource base and the economics of oil extraction. Over time there are the additional considerations of the pace of resource development and discovery. Although (such as) projections of oil reserves and reserve additions are projected by NEMS, acquiring and processing these data was beyond the scope of preparing this initial proposal. Accordingly, for illustrative purposes, a simple specification of oil supply was brought to the NEMS solution data. For this, the explanatory variables were the world oil price (WOP) and crude oil production lagged one year. This “lagged endogenous variable” is a surrogate for such as projections of economic reserves. **Accordingly, the example is intended to**

crude oil supply.

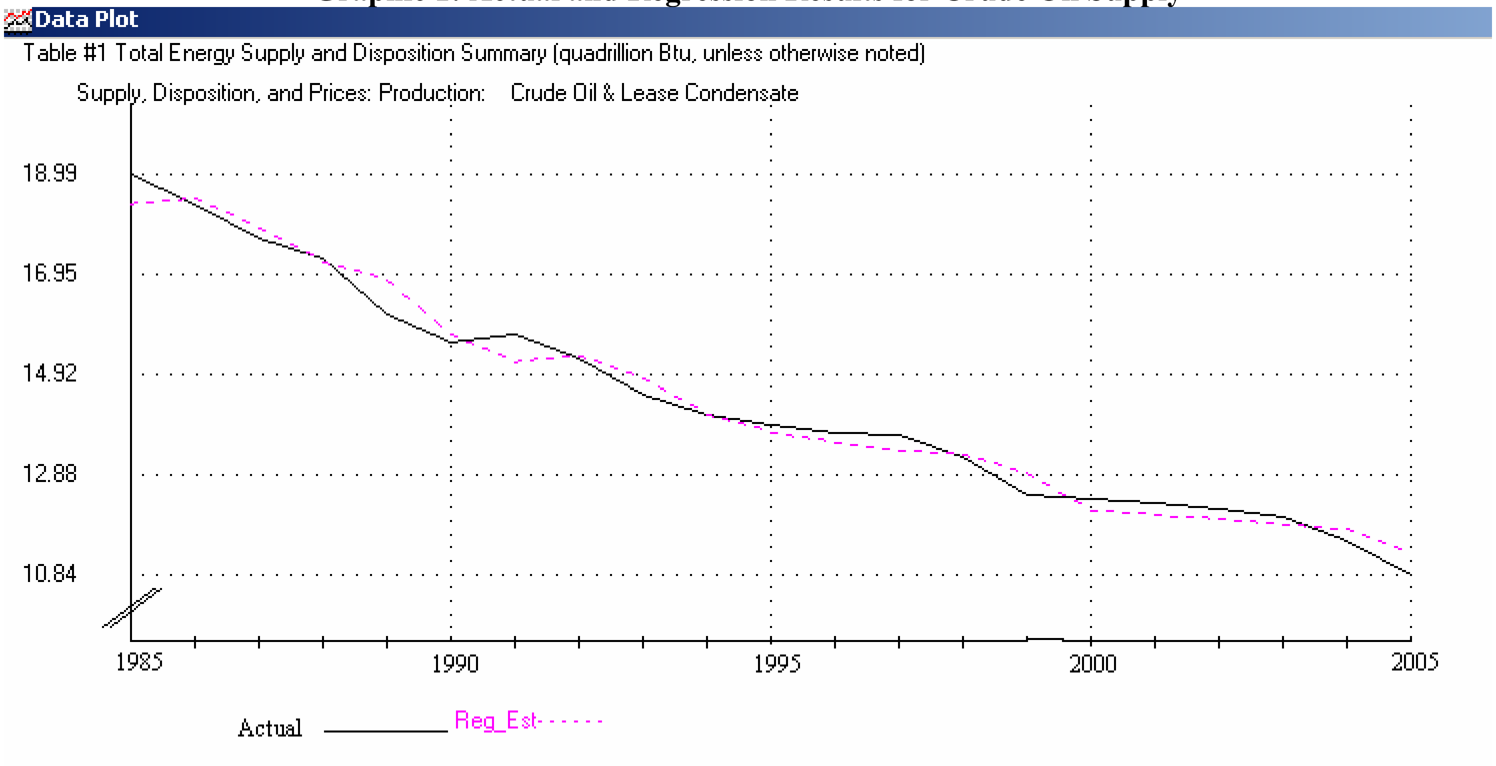
The most recent year for historical data is 2005. For this illustration, NEMS projections of crude oil production for this year were compared to actual data for the 1998-2000 versions of NEMS.[3]

The regression specification to be applied to NEMS solution data to represent the implicit crude oil market supply relationship is given by:

$$Q_t = a + bWOP_t + cQ_{t-1}, \quad (1)$$

where Q_t = crude oil production in year t and WOP_t = the world oil price in year t. As noted, the lagged endogenous variable is intended to represent the underlying trends in oil reserves; and also, the associated inter-temporal impact of changes in the WOP. For purposes of comparison, this specification was used to estimate the crude oil supply function using actual data from 1984 – 2005. A plot of the results is given below in Graphic 1. Detailed regression results are given in Appendix A.

Graphic 1: Actual and Regression Results for Crude Oil Supply



As summarized in the tables below, the fit of the supply function to the data was quite good (the average, absolute percent error was 1.81%); however, the statistical significance of the price elasticity was low.

Equation (1) was fit to the solution data for the five principal scenarios for each of the 1998-2000 AEO. The lagged endogenous variable was always significant and played by far the dominant role in the accuracy of the projection. The price effect, while small, was significant for two of the three versions of NEMS considered.

For the three versions of NEMS, the crude oil production projection for 2005 was high for all of them, ranging from 13.68% high in 1998 to 4.7% high in 2000. The equation was re-run for each NEMS version using actual data for both the WOP (adjusted to the monetary units of each NEMSS version) and lagged production, and then with actual data with each individually, using the NEMS projection of the other variable. The "back cast" using actual data for both explanatory variables was more accurate in for two of the three NEMS versions. Inspection revealed that the NEMS WOP projection was significantly low for all three versions of NEMS. Accordingly, use of the actual WOP with the oil supply equation made the resulting projection less inaccurate, i.e., even higher. Alternatively, simply using the correct value for lagged quantity led to a mush more accurate projection for two of the three versions of NEMS with little difference for the third.

Not accounted for by the analysis is the inter-temporal impact of the WOP on oil resource development. The historical time series of the WOP for the two decades before 2005 shows a flat, and significantly lower profile than the price in 2005, as given below.

Year	Nominal WOP	$2004 WOP
1984	28.54	46.02
1985	26.67	41.73
1986	16.16	24.74
1987	17.65	26.31
1988	14.08	20.29
1989	17.68	24.55
1990	21.13	28.25
1991	18.02	23.28
1992	17.75	22.41
1993	15.72	19.4
1994	15.18	18.35
1995	16.78	19.87
1996	20.31	23.61
1997	18.11	20.71
1998	11.84	13.39
1999	17.23	19.21
2000	27.53	30.04
2001	21.82	23.25
2002	23.91	25.04
2003	27.69	28.42
2004	36.07	36.07
2005	49.34	48.00

How this price profile is accounted for in the NEMS crude oil supply projection methodology might be accounted for more explicitly in a more detailed regression specification that was used here. Finally, hurricane Katrina resulted in a supply disruption sufficient to account for some the NEMS projection differences. A recent analysis concluded that the oil supply disruption due to Katrina was .647 quads, or 5.9% of measured total production.[4]

In summary, the source of NEMS projection differences for crude oil supply is not significantly in the immediate-run impact of oil prices, although, compared to the regression results using actual data, the WOP-effect on oil supply is generally larger and more significant. The explicit accounting for projections of reserves would provide a more satisfactory partition of the basis for projection differences from actual data. Significantly, when the effect of Katrina is accounted for, actual production (10.84+.647=11.487) falls within the NEMS high and low oil supply cases for each versions of NEMS. For each version of NEMS the residual "uncertainty" not accounted for by the influences measure is small. The results of the regression analyses are provided below in Tables 1-4. Next, notes defining the basis for the table entries and elaborations of some of the points above are provided. Finally, in an Appendix, the results of the regression analyses are provided for the historical data and for the 1998-2000 versions of NEMS.

Table 1: Domestic Crude Oil/Lease Condensate Production in 2005 (Quads)[5]

AEO Year	1998	1999	2000	History
Actual	10.84	10.84	10.84	10.84
NEMS High Case	13.31	12.83	11.71	
NEMS Base Case (%Δ)	12.32 (13.68)	12.31 (13.56)	11.35 (4.7)	n/a
NEMS Low Case	10.88	11.54	10.58	
NEMS Sim (%Δ)	12.33 (13.75)	12.32 (13.67)	11.43 (5.44)	11.26 (3.9)
R^2	.981	.998	.991	.981
Average Absolute % SIm Difference	.162	.163	.366	1.81
Backcast Actual All (%Δ)	11.50 (6.17)	11.40 (5.12)	12.07 (11.36)	n/a
Backcast Actual WOP only (%Δ)	12.46 (14.95)	12.34 (13.87)	12.06 (11.23)	n/a
Backcast Actual Lag only (%Δ)	11.38 (4.97)	11.37 (4.92)	11.44 (5.57)	n/a

Table 2: World Oil Price (WOP) in 2005 ($/Barrel)[5]

AEO Year	1998	1999	2000	History
$Units	$1996	$1997	$1998	$2004
Actual	41.40	41.98	42.45	48.01
NEMS (%Δ)	20.19 (-51.1)	19.24 (-54.15)	20.49 (-51.73)	n/a
NEMS Sim Elasticity (t-statistic)	.011 (2.24)	.002 (.54)	.054 (5.78)	.004 (.221)
Long Run Elasticity	n/a	n/a	.527	.136

Table 3: Domestic Crude Oil/Lease Condensate Production in 2004 (Quads)

AEO Year	1998	1999	2000	History
Actual	11.503	11.503	11.503	11.503
NEMS (%Δ)	12.44 (8.18)	12.42 (7.94)	11.49 (-.14)	n/a
NEMS Sim Elasticity (t-statistic)	1.02 (115)	1.05 (128)	.898 (31.2)	.996 (30.3)

Table 4: Sources of NEMS Base Case Projection Differences

AEO Year	1998	1999	2000
Total % Difference	+13.68	+13.56	+4.7
% Due to Price Projection	-1.2	-.20	-5.79
% Due to Lag Projection	+8.78	+8.75	-1.4
% Due to Weather	+5.9	+5.9	+5.9
% Residual	+.20	-.89	-3.41

Notes

1. A fair number of NEMS scenarios are run in support of each AEO, e.g., around forty were run for the AEO2006, in order to reveal important sensitivities and uncertainties. As the use of regression analysis of solution data is developed for the purposes proposed here, some number of additional runs might be formulated to facilitate the isolation of important influences for the ultimate evaluation of NEMS projections.

2. Large changes in year to year implicit sensitivities could detect anomalies in model development.

3. NEMS solutions for "early" years depend all, or in part, upon projections utilizing EIA's short term forecasting system. Accordingly, for the illustration here, NEMS projections are assessed only when more than five years out. Since the NEMS solutions for an AEO are finalized in the fall of the year prior to publication, this makes the solutions for the 2000 AEO the most recent for assessment. Solution data of the sort proposed for processing are only available starting for the solutions prepared in support of the 1998 AEO.

4. In a January 5, 2006 press release the Department of the Interior's Minerals Management Service reported that 111,633,122 barrels of oil production had been shut in due to Katrina for the period 8/26/05-1/5/06. At 5.8 million Btu's per barrel this amounts to .647 quads. The press release is available at: http://www.mms.gov/ooc/press/2006/press0105.htm.

5. “NEMS Sim” refers to the projections provided by the regression equation. For this and the tables below: Actual crude oil production was from the AER 2005, Table 1.2 as posted on the EIA website on 7/27/06; the value for the actual WOP used was that quoted in the August 2006 MER for 2005 as “Landed Cost of Imported Oil;” the price index used to adjust monetary units to those used in each of the nine versions of NEMS was the “GDP Chain-Type Price Index,” as taken from Table B-3 (Appendix B) of the 2006 Economic Report of the President. The percentage base for all differences is the actual value of the variable. The elasticities are evaluated at the means of the variables used for the forecasts, e.g., the WOP elasticity is equal to b(WOP/Q) where “b” is the estimated regression coefficient and {WOP,Q} are the means of the variables. The “long run” elasticity accounts for the impact of a change in the WOP being transmitted to future years via the lagged endogenous variable. The effect is convergent for $0 < c < 1$, and multiplies the short run elasticity by $(1/(1-c))$. In the table, “n/a” identifies cases for $c > 1$ or $b < 0$. All of the regressions using NEMS solution data were run for data pooled from all five principal scenarios prepared for the AEO using the projected values for the years 2005-2020 inclusive. The high and low oil production cases are, respectively, from the high and low world oil price scenarios.

Appendix Crude Oil Supply Regression Results

History

Endogenous Variable:
Table #1 Total Energy Supply and Disposition Summary (quadrillion Btu, unless otherwise noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate

Exogenous Variables:
1) Table #1 Total Energy Supply and Disposition Summary (quadrillion Btu, unless otherwise noted)
Supply, Disposition, and Prices: Prices (2004 dollars per unit): World Oil Price ($ per bbl) 10/

2) Lagged Table #1 Total Energy Supply and Disposition Summary (quadrillion Btu, unless otherwise noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate

Exogenous Variable	Mean	Coefficient	Elasticity	t-statistic
Variable# 1	25.56688	.002101	.003739	.221085
Variable# 2	14.74595	.970695	.996464	30.2608
Constant		-.00292		

Endogenous	Mean	SER	R-sq	LR-Multiplier
Variable	14.36462	.341296	.980845	34.12386964681

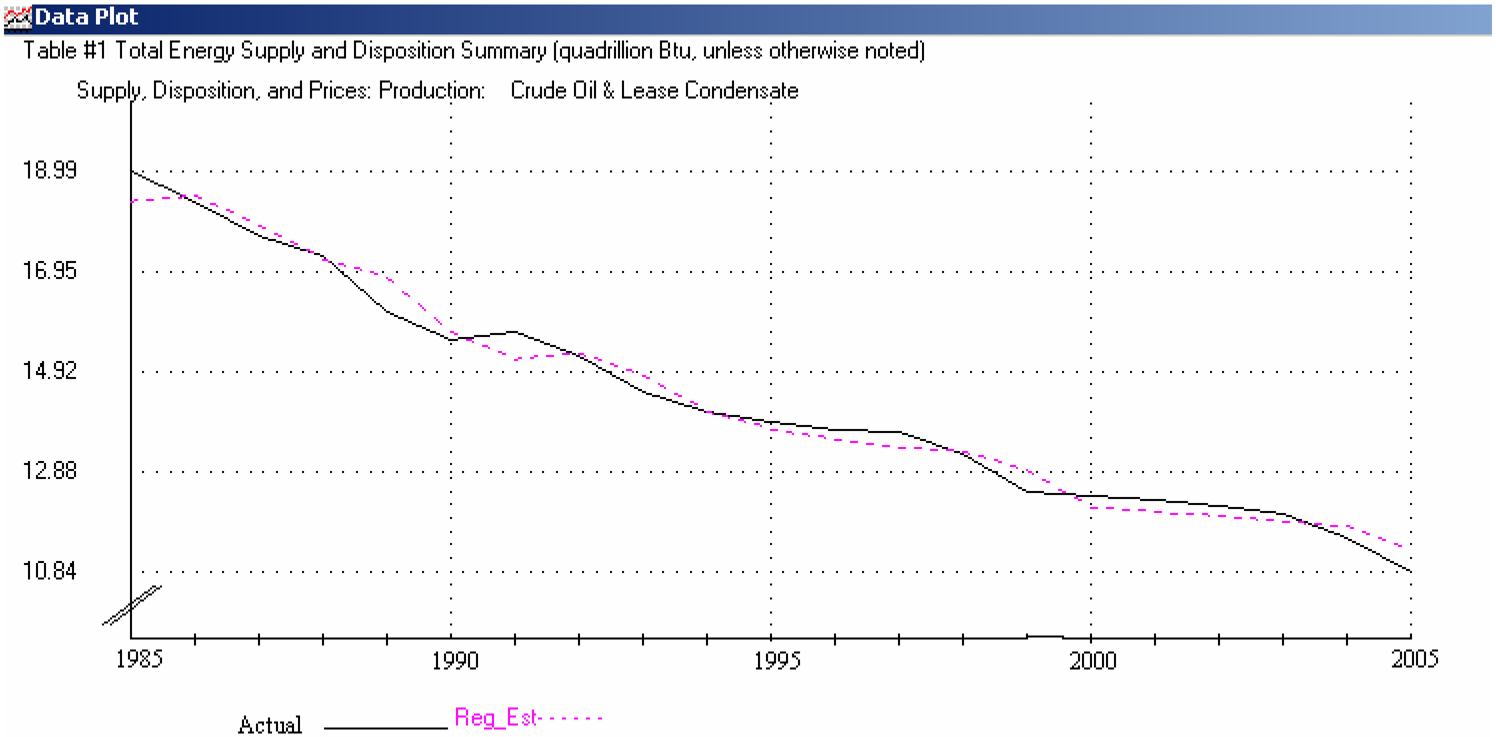
Data pooled for the years 1985 to 2005 for Historical Data

Table #1 Total Energy Supply and Disposition Summary (quadrillion Btu, unless otherwise noted)

Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate

Year	Actual	Estimated	%abs((Est-Act)/Act)
1985	18.992	18.38042	3.22
1986	18.376	18.4845	0.59
1987	17.675	17.88984	1.215
1988	17.279	17.19674	0.476
1989	16.117	16.8213	4.37
1990	15.571	15.70112	0.836
1991	15.701	15.16068	3.441
1992	15.223	15.28505	0.408
1993	14.494	14.81474	2.213
1994	14.103	14.10488	0.013
1995	13.887	13.72855	1.141
1996	13.723	13.52672	1.43
1997	13.658	13.36143	2.171
1998	13.235	13.28296	0.362
1999	12.451	12.88458	3.482
2000	12.358	12.14631	1.713
2001	12.282	12.04177	1.956
2002	12.163	11.97176	1.572
2003	12.026	11.86335	1.353
2004	11.503	11.74644	2.116
2005	10.84	11.26384	3.91

Average Absolute Percent Error = 1.808953


Data Plot
Table #1 Total Energy Supply and Disposition Summary (quadrillion Btu, unless otherwise noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate
18.99
16.95
14.92
12.88
10.84
1985
1990
1995
2000
2005
Actual
Reg_Est

AEO 1998 Simulation Results

Endogenous Variable:
Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.

Exogenous Variables:
1) Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Prices (1996 dollars per unit): World Oil Price ($ per bbl) ...

2) Lagged Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.

Exogenous Variable	Mean	Coefficient	Elasticity	t-statistic
Variable# 1	21.09386	.006141	.011359	2.2424
Variable# 2	11.52222	1.012341	1.022852	115.76361
Constant		-.390142		

Endogenous	Mean	SER	R-sq	LR-Multiplier
Variable	11.40381	.055787	.998362	-81.03071063933

Data pooled for the years 2005 to 2020 for the solutions given below:

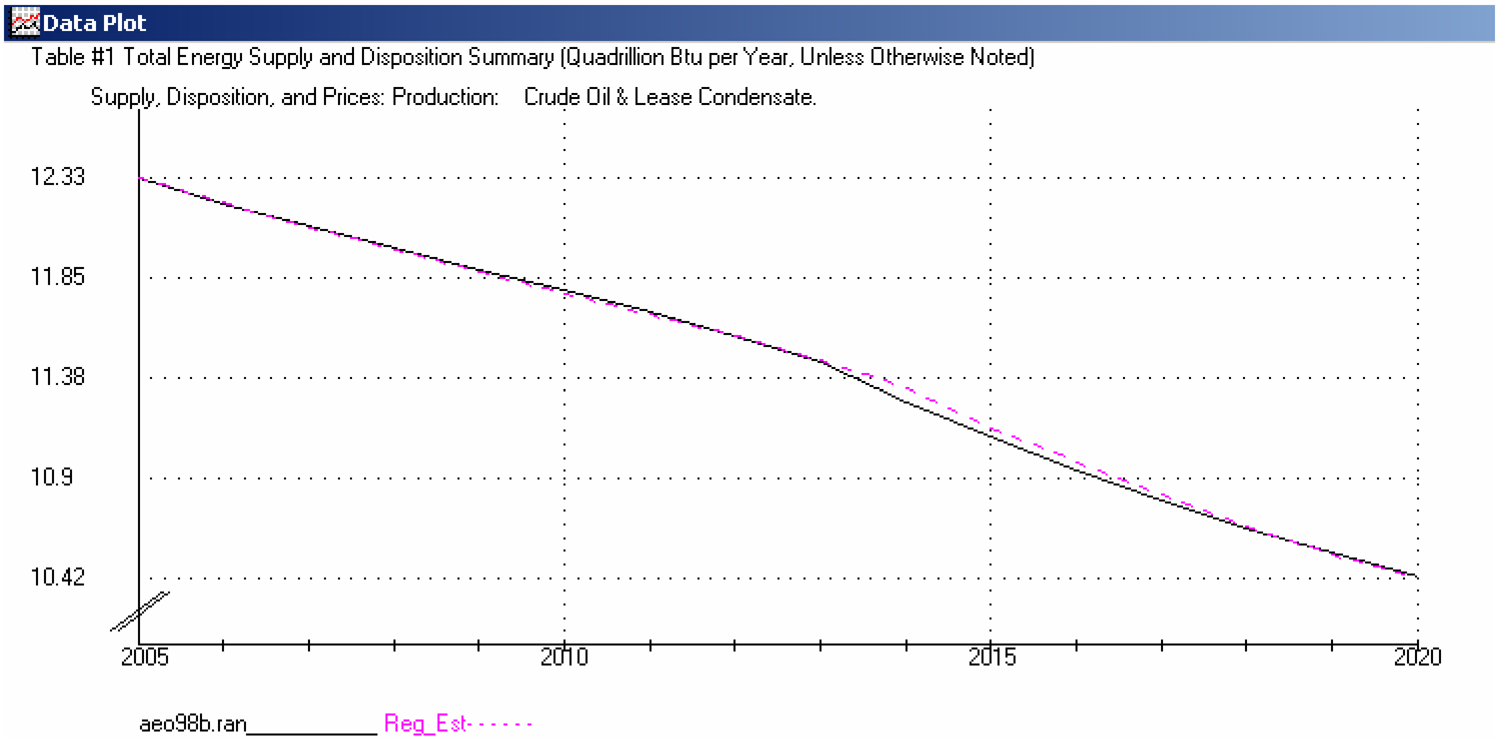
aeo98b.ran	hmac98.ran	lmac98.ran	hwop98.ran	lwop98.ran

Estimation Results for aeo98b.ran

Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.

Year	Actual	Estimated	%(Est-Act)/Act
2005	12.32254	12.33081	0.067
2006	12.20534	12.20866	0.027
2007	12.10194	12.09089	0.091
2008	11.99377	11.98713	0.055
2009	11.89241	11.87854	0.117
2010	11.78969	11.77682	0.109
2011	11.69125	11.67369	0.15
2012	11.57265	11.57496	0.02
2013	11.44692	11.45567	0.076
2014	11.25463	11.32913	0.662
2015	11.09442	11.13527	0.368
2016	10.9388	10.97394	0.321
2017	10.78883	10.81739	0.265
2018	10.65493	10.6666	0.109
2019	10.54534	10.53207	0.126
2020	10.42591	10.4224	0.034

Average Absolute Percent Error = .1623125


Data Plot
Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.
12.33
11.85
11.38
10.9
10.42
2005
2010
2015
2020
aeo98b.ran
Reg_Est

AEO 1999 Simulation Results

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2) Lagged Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.

Exogenous Variable	Mean	Coefficient	Elasticity	t-statistic
Variable# 1	21.38648	.000966	.001807	.546316
Variable# 2	11.55995	1.038382	1.049795	127.881358
Constant		-.590025		

Endogenous	Mean	SER	R-sq	LR-Multiplier
Variable	11.43428	.049681	.997553	-26.05387942264

Data pooled for the years 2005 to 2020 for the solutions given below:

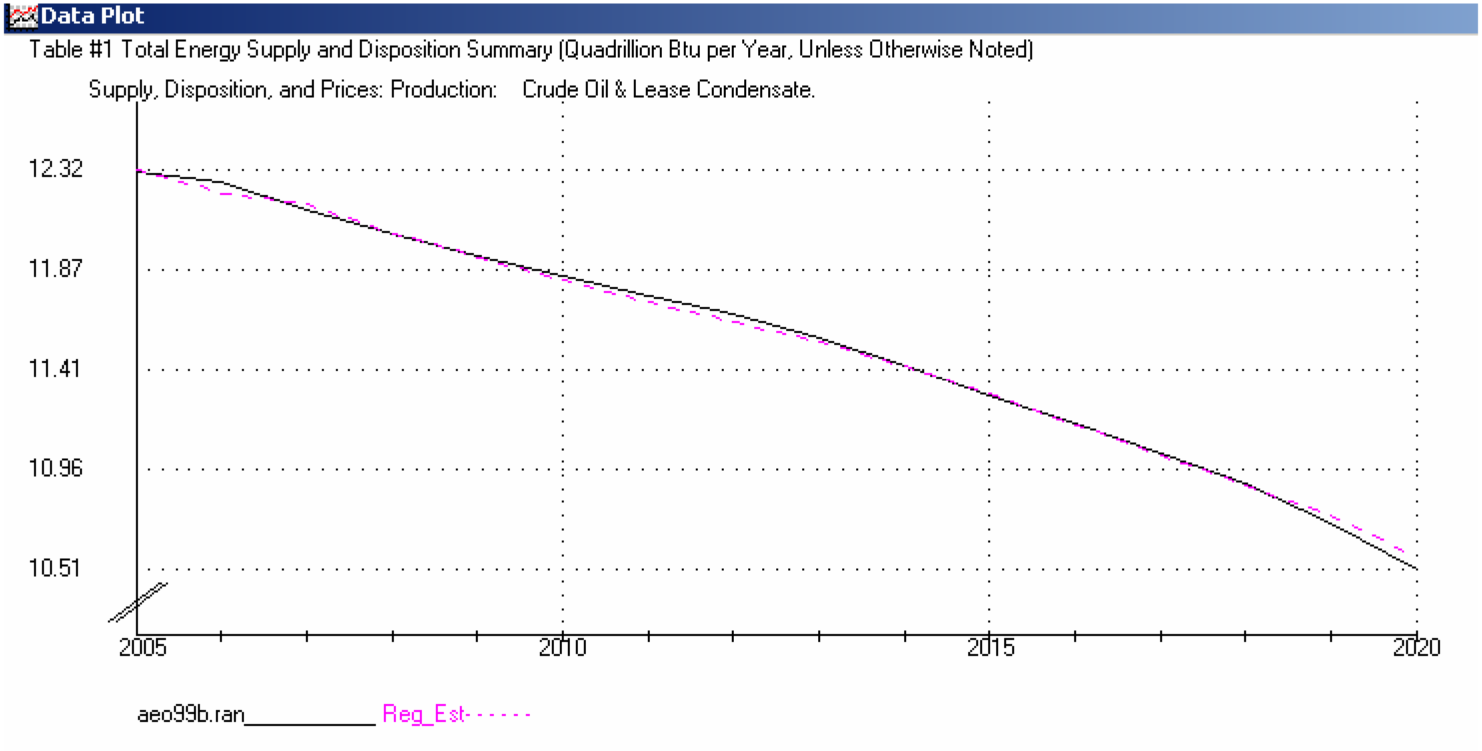
aeo99b.ran hmac99.ran lmac99.ran hwop99.ran lwop99.ran

Estimation Results for aeo99b.ran

Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.

Year	Actual	Estimated	%(Est-Act)/Act
2005	12.31041	12.32166	0.091
2006	12.25971	12.21235	0.386
2007	12.1361	12.16043	0.2
2008	12.02927	12.03221	0.024
2009	11.9313	11.9214	0.083
2010	11.83284	11.8198	0.11
2011	11.74482	11.71769	0.231
2012	11.6603	11.62642	0.291
2013	11.55284	11.53878	0.122
2014	11.43066	11.42729	0.03
2015	11.29543	11.30053	0.045
2016	11.1615	11.16023	0.011
2017	11.02854	11.02131	0.066
2018	10.89726	10.88341	0.127
2019	10.71355	10.74726	0.315
2020	10.50622	10.55669	0.48

Average Absolute Percent Error = .16325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12.32
11.87
11.41
10.96
10.51
2005
2010
2015
2020
aeo99b.ran
Reg_Est

AEO 2000 Simulation Results

Endogenous Variable:
Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.

Exogenous Variables:
1) Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Prices (1998 dollars per unit): World Oil Price ($ per bbl) ...

2) Lagged Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.

Exogenous Variable	Mean	Coefficient	Elasticity	t-statistic
Variable# 1	21.09438	.028584	.054042	5.77773
Variable# 2	11.16395	.897522	.898054	31.192915
Constant		.53448		

Endogenous	Mean	SER	R-sq	LR-Multiplier
Variable	11.15733	.068051	.990887	9.758192002185

Data pooled for the years 2005 to 2020 for the solutions given below:

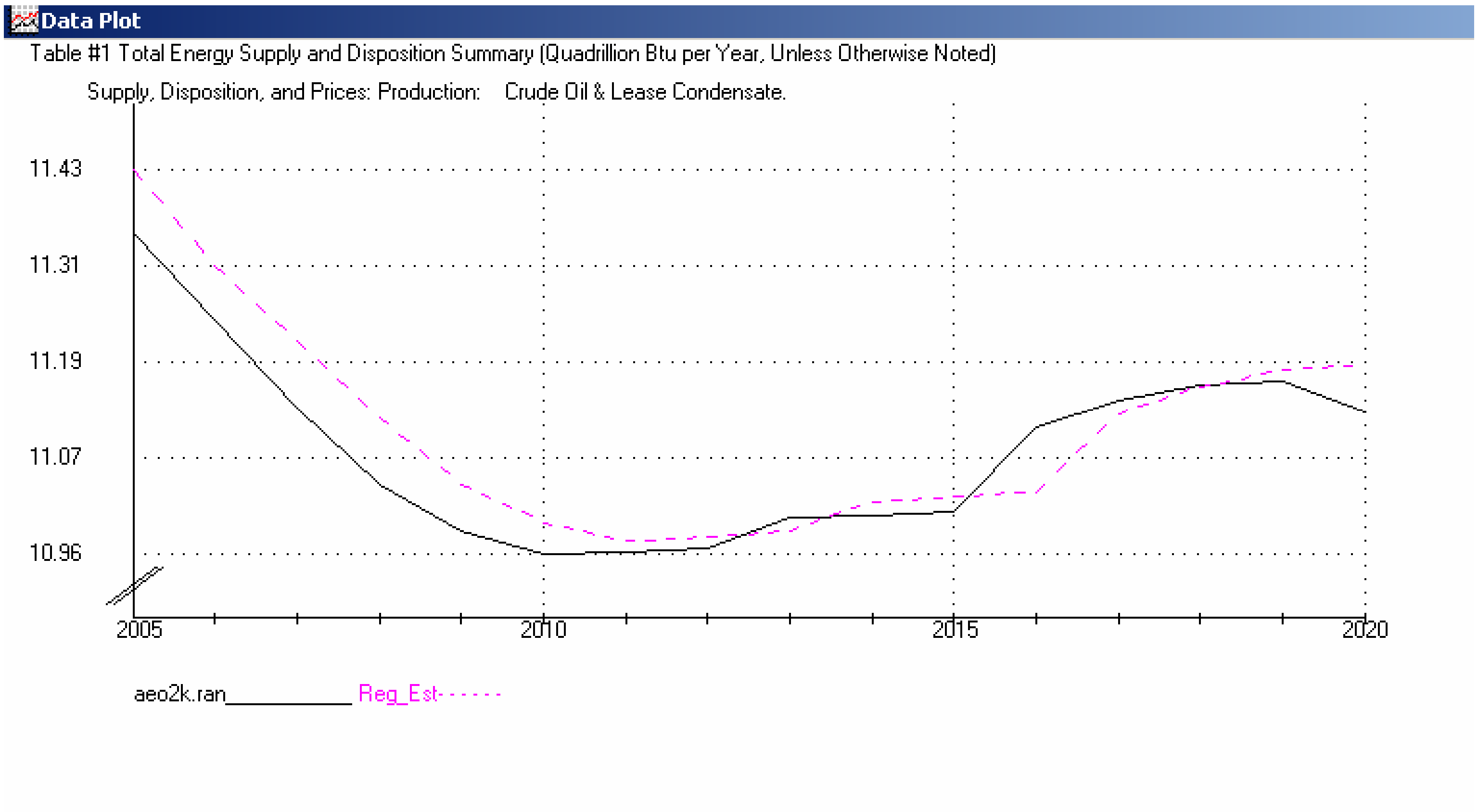
aeo2k.ran	hmac2k.ran	lmac2k.ran	hwop2k.ran	lwop2k.ran

Estimation Results for aeo2k.ran

Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.

Year	Actual	Estimated	%(Est-Act)/Act
2005	11.35001	11.42934	0.699
2006	11.24389	11.30978	0.586
2007	11.13607	11.21767	0.733
2008	11.04106	11.12372	0.749
2009	10.98465	11.04159	0.518
2010	10.95652	10.99378	0.34
2011	10.95853	10.97136	0.117
2012	10.96388	10.9763	0.113
2013	11.00002	10.98392	0.146
2014	11.00318	11.01949	0.148
2015	11.00747	11.02547	0.163
2016	11.11085	11.03214	0.708
2017	11.14443	11.12806	0.147
2018	11.16455	11.16102	0.032
2019	11.16817	11.18222	0.126
2020	11.12987	11.18829	0.525

Average Absolute Percent Error = .365625


Data Plot
Table #1 Total Energy Supply and Disposition Summary (Quadrillion Btu per Year, Unless Otherwise Noted)
Supply, Disposition, and Prices: Production: Crude Oil & Lease Condensate.
11.43
11.31
11.19
11.07
10.96
2005
2010
2015
2020
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