Comparison of Jeffords-Lieberman and Smith-Voinovich-Brownback

I. INTRODUCTION

In May and June of this year, EPA received two separate congressional inquiries—one from Senators Jeffords and Lieberman and the other from Senators Smith, Voinovich, and Brownback—to analyze the economic and environmental impacts of potential policies to reduce sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury (Hg), and carbon dioxide (CO_2) emissions in the U.S. electricity sector. The requests differed in a variety of ways, including the policies to be analyzed, the stringency of emissions reductions, and the timing of meeting emissions goals.

Given the differences in the nature of the two requests, EPA employed those analytical tools that were most appropriate to answer the Senators' questions. There is no one unique or comprehensive tool that can answer the variety of questions posed by the two requests.

This paper will discuss both the common and diverse elements of the two requests and clarify how those questions are best assessed with the analytical tools available to EPA. In addition, the paper compares the EPA results with those reported by the Energy Information Administration (EIA).

II. COMPARISON OF THE REQUESTS

The EPA received two requests from the Senate to analyze the impacts of multi-emissions control policies in the U.S. electricity sector. Differences in results stem from two principal sources. First, the requests ask for analyses of different multi-emissions control options and reduction goals. The policies differ in the specific options to be analyzed, the stringency of emissions goals, and the timing of emissions reductions. Second, given the differences in the requests, EPA employed different modeling tools. These tools, if applied to the same scenarios, would probably yield similar, but not identical, results.

A. Summary of Scenarios

Jeffords-Lieberman Request

On May 17, 2001, Senators Jeffords and Lieberman asked the EPA to undertake an economic assessment of one multi-emissions reduction scenario using four different sets of technology assumptions. The emissions of SO_2, NO_x, Hg, and CO_2 from the U.S. electric power sector would be capped by the year 2007 at the following levels:

- NO_x emissions: 75 percent below 1997 levels;
- SO_2 emissions: 75 percent below full implementation of the Phase II requirements under Title IV;
- Hg emissions: 90 percent below 1999 levels; and
- CO_2 emissions: at 1990 levels.

The Senators also asked that EPA analyze the impact of four technology policy scenarios that attempt to spur energy savings and emissions reductions. These include the potential contributions of demand-side efficiency, natural gas-fired co-generation, and renewable energy sources.

Two of the technology scenarios requested by the Senators are characterized in the Energy Information Administration's *Annual Energy Outlook 2001* and two are described in *Scenarios for a Clean Energy Future,* a project of the inter-laboratory working group. The four scenarios are:

- AEO 2001 supply- and demand-side standard technology assumptions
- AEO 2001 supply- and demand-side advanced technology assumptions
- Scenarios for a Clean Energy Future moderate supply- and demand-side technology assumptions
- Scenarios for a Clean Energy Future advanced supply- and demand-side technology assumptions

Smith-Voinovich-Brownback Request

On June 8, 2001, Senators Smith, Voinovich, and Brownback, requested analysis of potential multi-emissions control strategies in the U.S. electricity sector. The Senators requested that EPA conduct two related analyses. The first focused on the cost of reducing emissions of SO_2, NO_x, and Hg within the electricity sector, under three scenarios of varying stringency. The second analysis examined the additional costs of offsetting U.S. electricity sector CO_2 emissions growth above 2008 levels. The CO_2 emissions offset program allows for reductions of any greenhouse gas from any source, anywhere in the world.

Specifically, the Senators requested that EPA analyze the impact of capping SO_2, NO_x, and Hg at three different levels:

- Scenario 1: NO_x emission at 75% below 1997 levels, SO_2 emissions 75% below full implementation of Title IV of the Clean Air Act, and mercury emissions at 75% below 1999 levels.
- Scenario 2: NO_x emission at 65% below 1997 levels, SO_2 emissions 65% below full implementation of Title IV of the Clean Air Act, and mercury emissions at 65% below 1999 levels.
- Scenario 3: NO_x emission at 50% below 1997 levels, SO_2 emissions 50% below full implementation of Title IV of the Clean Air Act, and mercury emissions at 50% below 1999 levels.
- The Senators also asked that EPA analyze the above scenarios while requiring that electricity sector CO_2 emissions above 2008 levels be offset by GHG reductions or sinks, available both domestically and internationally.

Table 1 summarizes the two Senate requests.

Table 1. Comparison of Senate Requests

Requirement	Jeffords-Lieberman	Smith-Voinovich-Brownback
SO_2 reduction target(s):	75% below full implementation of Title IV of the CAA	75%, 65%, and 50% below full implementation of Title IV of the CAA
NO_x reduction target(s):	75% below 1997 levels	75%, 65%, and 50% below 1997 levels.
Hg reduction target(s):	90% below 1999 levels	75%, 65%, and 50% below 1999 levels.
CO_2 reduction target:	Reduce to 1990 levels	Offset increases above 2008 levels, as estimated by EIA
CO_2 offset sources:	US electricity sector only	Any GHG or sequestration, anywhere in the world
Compliance period:	Start date 2002; full compliance by 2007	Start date 2002; first half of required reductions by 2007; full compliance by 2012
Allows banking emissions credits in earlier years?	Yes, beginning in 2002	Yes, beginning in 2002
Baseline:	EIA's Annual Energy Outlook 2001	EIA's Annual Energy Outlook 2001
Technology:	AEO 2001 standard, AEO 2001 advanced, SCEF moderate, SCEF advanced technology scenarios	Employs technology assumptions endogenous to the analytical models

B. Differences in Results Due to Differences in Scenarios Requested

While the two requests were similar in that they sought analysis of multi-pollutant strategies for the U.S. electricity sector, differences in the requests led to significantly different results.

1) Stringency of "3-Pollutant" Emissions Reductions

The SO_2, NO_x, and Hg ("3-pollutant") emissions reduction requirements in the Jeffords-Lieberman request are greater and sooner than those in the Smith-Voinovich-Brownback request. (See Section II.A and Table 1.) Consequently, economic impacts such as allowance prices and fuel market impacts are likely to be more significant for the Jeffords-Lieberman request.

2) Assumptions about the Availability of Technology and Its Rate of Deployment

The Jeffords-Lieberman request focused on how advanced technology assumptions on both the demand and supply sides of the electricity market would influence the effectiveness and costs of domestic multi-emissions policies. These exogenous policy variables represent greater technology penetration and, therefore, generally lower the economic impacts of meeting emissions reduction requirements. The Smith request did not request that EPA examine advanced technologies and their impacts.

3) Treatment of CO_2

The Jeffords-Lieberman request seeks to analyze reductions of the "3-pollutants" in conjunction with mandatory CO_2 reductions to 1990 levels in the electricity sector. This is relevant in that the concomitant reduction of CO_2 within the electricity sector will pose an interaction effect, thereby influencing the cost of 3-P mitigation policies. The Smith-Voinovich-Brownback request analyzes CO_2 mitigation policy as a linked, but separate, control strategy. Specifically, it creates an offset policy, seeking to offset growth in CO_2 emissions beyond 2008 levels with reductions or sequestration anywhere in the worldwide economy. Allowing such market flexibility significantly reduces overall CO_2 mitigation costs.

4) Stringency of CO_2 Requirement

The two CO_2 policies also vary significantly in their stringency. The Jeffords-Lieberman requirement to reduce CO_2 emissions to 1990 levels represents a reduction of approximately 183 million metric tons carbon equivalent (MMTCE) by 2007 and 263 MMTCE by 2015. The Smith-Voinovich-Brownback requirement to offset CO_2 emissions beyond 2008 levels requires no more than 75 MMTCE by 2020. The considerably larger reduction of CO_2 under the Jeffords-Lieberman request, with no ability to offset, has significant impacts not only on the economy but also on the actions necessary to address the other three pollutants.

III. COMPARISON OF ANALYTICAL TOOLS

Given the different scenarios and policy options that EPA was requested to examine, different analytical modeling tools were employed. For example, some scenarios called for an assessment of the impacts of policy options only on the U.S. electricity sector. Other scenarios requested that the economy-wide impacts of multi-emissions control strategies be examined. If an economy-wide assessment were requested, EPA deployed an economy-wide modeling framework that captured the interaction between the multi-emissions control program and the whole U.S. economy.

Analytical Tools for Jeffords-Lieberman: AMIGA model

The Jeffords-Lieberman request principally focuses upon how varying technology assumptions on both the demand and supply sides of the electricity market would influence the effectiveness and costs of one domestic multi-emissions policy scenario. However, the request also asks what the economy-wide implications of a multi-emissions control program in the U.S. electricity sector would be.

To best assess this question, EPA employed the All Modular Industry Growth Assessment (AMIGA) model. AMIGA is a general equilibrium modeling system for the U.S. economy, with a detailed representation of the U.S. electricity sector. The AMIGA model encompasses SO_2, NO_x, Hg, and CO_2 emissions, while explicitly incorporating end-use detail of energy technology into the modeling framework. In addition, AMIGA includes the Argonne Unit Planning and Compliance model, which captures a variety of technology characteristics within the electricity sector.

Because the Jeffords-Lieberman request was limited to domestic measures focused on the relationship between technology assumptions and program effectiveness, and because it focused upon the impacts on both the U.S. electricity sector and the U.S. economy, AMIGA was deemed by EPA to be an appropriate tool with which to conduct the analysis.

Analytical Tools for Smith-Voinovich-Brownback: IPM®, SGM, off-line economic tools

The Smith-Voinovich-Brownback request necessitated the coupling of several different economic tools: the Integrated Planning Model (IPM®) for "3-pollutant" analysis in the electricity sector, the Second Generation Model (SGM) for analysis of CO_2 policy, agricultural and forestry models to assess the availability of CO_2 offsets, and non-CO_2 GHG abatement curves.

Whereas AMIGA is a general equilibrium model of the whole U.S. economy, IPM® is a detail-rich bottom-up dynamic linear programming model of the electric power sector. The level of detail and bottom-up structure of IPM® makes it particularly well suited for performing detailed and realistic evaluations of the control, fuel choice, electric dispatch, construction and retirement, and financial (e.g., allowance usage and banking) decisions that will be made from the national to the plant level in response to legislative proposals like those in the Smith-Voinovich-Brownback request. These capabilities allow IPM® to capture, to the extent possible, the perspective of utility managers, regulatory personnel, and the public in reviewing important investment options for the electricity sector. Decisions are made based on minimizing the net present value of capital and operating costs over the full planning horizon.

Due to these capabilities, IPM® has been used extensively both for public and private sector evaluations of policies affecting the electric power sector. While these capabilities made IPM® well suited for the Smith-Voinovich-Brownback request, the extent and level of detail of the model's technology assumptions made it less adaptable to analyzing the four technology variations in the Jeffords-Lieberman request within the time frame required by the request.

Smith-Brownback-Voinovich requested that EPA examine a CO_2 offset program that encompasses all greenhouse gas emissions and sequestration opportunities anywhere in the world. Given the nature of this request, analytical tools are required that can examine greenhouse gas abatement opportunities both in the U.S. and internationally.

To address these questions, this analysis incorporates the results of the Second Generation Model (SGM), forestry and agricultural models such as the Forestry and Agriculture Optimization Model (FASOM) and analyses of non-CO_2 GHG emissions and abatement opportunities. These tools evaluate GHG abatement opportunities in various sectors both domestically and internationally. SGM is a computable general equilibrium model of the world that can be used to estimate the domestic and international economic impacts of policies designed to reduce GHG emissions.

The Non-CO_2 and agricultural sinks models used in the Smith-Voinovich-Brownback analysis are necessary to estimate the GHG offsets scenario. Unlike the broader CGE models, these models typically use bottom-up engineering marginal abatement curves for alternative mitigation technologies. They are detail-rich and international in scope. The models used for U.S. forestry and agricultural sinks are dynamic, in that they account for production, consumption, and international trade for a wide range of agricultural products.

IV. COMPARISON OF EIA ANALYSIS TO SMITH-VOINOVICH-BROWNBACK AND JEFFORDS-LIEBERMAN

The Smith-Voinovich-Brownback and Jeffords-Lieberman analyses conducted by EPA also differ from the multi-emissions analyses performed by the Energy Information Administration (EIA) of the Department of Energy. The two sets of analyses—EPA's and EIA's—yield generally similar results. Differences in EIA's findings and those of EPA can be attributed to the separate analytical tools and methodologies used by each organization. While a side-by-side comparison of EPA's and EIA's findings is difficult for these reasons, EPA has provided two tables below comparing EPA's and EIA's findings for the Smith-Voinovich-Brownback (Table 1) and Jeffords-Lieberman (Table 2) requests.

Table 1. Comparison of the EIA and EPA Analyses of the Smith/Voinovich/Brownback Request

	EIA 2010	EIA 2020	EPA 2012	EPA 2020
Total Program Costs[1] (billions):				
50%:	3.1	4.8	2.7	3.12
75%:	7.2	12.3	5.03	6.88
Allowance Prices:				
SO_2 ($/ton):				
50%:	$210	$719	$722	$1,008
75%:	$295	$1,737	$904	$1,263
NO_x ($/ton):				
50%:	$1,208	$1,108	$340	$475
75%:	$2,072	$2,825	$830	$1,145
Hg ($/lb):				
50%:	$14,452	$21,119	$4,018	$5,610
75%:	$31,923	$85,225	$6,614	$9,234
Emissions:				
SO_2 (million tons):				
50%:	6.90	4.47	6.57	5.20
75%:	5.51	2.24	4.85	3.68
NO_x (million tons):				
50%:	3.36	3.17	3.59	3.68
75%:	2.34	1.64	2.82	2.39
Hg (tons):				
50%:	25.8	21.5	29.7	28.1
75%:	17.2	10.8	22.6	17.6

[1] EIA also provides resource costs that do not include financing and profits typically associated with new investments. For this case, EIA's estimated average annual increase in resource costs equal $1.4 billion and $4.4 billion for the 50% and 75% reduction cases, respectively.

Table 1. Comparison of the EIA and EPA Analyses of the Smith/Voinovich/Brownback Request (cont.)

	EIA		EPA	
	2010	2020	2012	2020
Power Plant Generation (billions of kWh):				
Coal:				
50%:	2213	2270	2113	2145
75%:	2115	2121	2030	2080
Natural Gas:				
50%:	1161	1868	1132	1534
75%:	1243	2160	1215	1597
Total Coal Production[2] (million short tons):				
50%:	1088	1142	1009	1022
75%:	1038	1070	965	985
Regional Coal Production[3] (million short tons):				
Appalachia:				
50%	427	398	345	358
75%	422	371	336	361
West:				
50%	625	726	468	464
75%	597	686	429	427
Interior:				
50%	186	160	n/a	n/a
75%	169	152	n/a	n/a

[2] Includes coal produced for electric generators only.

[3] EIA's estimates reflect **total** regional coal production while EPA's values reflect total consumption of coal that was produced in each region. EPA's and EIA's values also may vary due to differences in the states included in each region. Because these numbers reflect **total** production, they will sum to a greater value than the numbers for electric generators only.

Table 1. Comparison of the EIA and EPA Analyses of the Smith/Voinovich/Brownback Request (cont.)

	EIA		EPA	
	2010	2020	2012	2020
Midwest:				
50%	n/a	n/a	141	146
75%	n/a	n/a	148	149
Central & West Gulf:				
50%	n/a	n/a	55	54
75%	n/a	n/a	52	49
Significant Differences Between EIA and Smith/Voinovich/Brownback CO_2 Offsets Analyses:				
GHG emissions and offsets analyzed:	CO_2 energy sector emissions and offsets only		CO_2, CH_4, N_2O, High GWP emissions, along with terrestrial sequestration	
Modeling tools used:	SGM		SGM, IPM, FASOM, ASMGHG, COMAP, non-CO_2 industry models	
Assumption of other countries' implementation of Kyoto:	Assumes Kyoto Implementation		One scenario assumes Kyoto implementation, one does not	
Cases for offsets program effectiveness:	Assumes ideal program (100%)		Case I: ideal (100%); Case II: weak economic signal (50%/25%); Case III: anyway tons (120%)	
Offsets Required in 2020 (Scenario 2):	Domestic: 75 MMTCE; Other countries: ~ 300 MMTCE		Domestic: 58-75 MMTCE; Other countries: 273 MMTCE	

Table 2. Comparison of the EIA and EPA Analyses of the Jeffords/Lieberman Request

	EIA		EPA	
	2010	2015	2010	2015
Cost Measures:				
Change in GDP:				
Scenario A:	-.3%	-.01%	-.05%	-.01%
Scenario B:	-.2%	+.01%	-.01%	-.0002%
Scenario C:	-.2%	-.03%	+.05%	+.07%
Scenario D:	-.06%	+.04%	+.1%	+.1%
Change in Consumption:				
Scenario A:	n/a	n/a	-.3%	-.2%
Scenario B:	n/a	n/a	-.3%	-.2%
Scenario C:	n/a	n/a	-.2%	-.1%
Scenario D:	n/a	n/a	-.1%	-.05%
Allowance Prices:				
SO_2 ($/ton):				
Scenario A:	$46	$18	$210	$308
Scenario B:	$152	$253	$240	$353
Scenario C:	$316	$96	$274	$403
Scenario D:	$130	$284	$306	$449
NO_x ($/ton):				
Scenario A:	0	0	$1,233	$1,812
Scenario B:	0	0	$1,342	$1,972
Scenario C:	0	$449	$1,478	$2,172
Scenario D:	0	$511	$1,564	$2,299
Hg ($/lb):				
Scenario A:	$241,000	$203,000	$119,000	$175,000
Scenario B:	$255,000	$205,000	$127,000	$187,000
Scenario C:	$274,500	$242,500	$136,500	$200,500
Scenario D:	$240,500	$201,000	$147,000	$216,000
CO_2 ($/TCE)				
Scenario A:	$93	$111	$110	$138
Scenario B:	$69	$76	$94	$119
Scenario C:	$64	$78	$81	$102
Scenario D:	$54	$51	$68	$86

Table 2. Comparison of the EIA and EPA Analyses of the Jeffords/Lieberman Request (cont.)

				EIA
	2010	2015	2010	2015
Emissions:				
SO_2 (million tons):				
Scenario A:	2.99	2.64	4.04	2.07
Scenario B:	2.99	2.64	3.91	2.14
Scenario C:	2.99	2.64	3.93	2.17
Scenario D:	2.99	2.64	3.88	2.24
NO_x (million tons):				
Scenario A:	1.64	1.53	2.11	1.58
Scenario B:	1.76	1.68	2.09	2.14
Scenario C:	1.74	1.70	2.11	1.63
Scenario D:	1.78	1.71	2.11	1.62
Hg (tons):				
Scenario A:	4.30	4.30	14.43	9.34
Scenario B:	4.30	4.30	14.37	9.70
Scenario C:	4.30	4.30	14.56	10.01
Scenario D:	4.30	4.30	14.41	10.12
CO_2 (million metric tons):				
Scenario A:	475.8	476.1	499	518
Scenario B:	474.5	474.7	504	524
Scenario C:	474.2	474.2	512	535
Scenario D:	475.3	475.0	514	537
Power Plant Generation (billions of kWh):				
Coal:				
Scenario A:	1,276	1,146	1,467	1,406
Scenario B:	1,324	1,230	1,501	1,476
Scenario C:	1,357	1,307	1,559	1,558
Scenario D:	1,395	1,339	1,587	1,614
Gas and Oil:				
Scenario A:	1,406	1,771	1,095	1,429
Scenario B:	1,303	1,594	1,048	1,318
Scenario C:	1,149	1,281	964	1,182
Scenario D:	1,100	1,270	904	1,069

Table 2. Comparison of the EIA and EPA Analyses of the Jeffords/Lieberman Request (cont.)

	EIA		EPA	
	2010	2015	2010	2015
Total Coal Consumption (million short tons):				
Scenario A:	733	671	n/a	n/a
Scenario B:	751	706	n/a	n/a
Scenario C:	766	744	n/a	n/a
Scenario D:	785	751	n/a	n/a
Regional Coal Production (million short tons):				
Appalachia:				
Scenario A:	267	246	n/a	n/a
Scenario B:	270	247	n/a	n/a
Scenario C:	283	274	n/a	n/a
Scenario D:	279	272	n/a	n/a
West:				
Scenario A:	403	372	n/a	n/a
Scenario B:	412	395	n/a	n/a
Scenario C:	410	395	n/a	n/a
Scenario D:	437	411	n/a	n/a
Interior:				
Scenario A:	267	246	n/a	n/a
Scenario B:	270	247	n/a	n/a
Scenario C:	283	274	n/a	n/a
Scenario D:	279	272	n/a	n/a