ERRORS AND OMISSIONS

IN THE

EASTERN WIND INTEGRATION TRANSMISSION STUDY ("EWITS")

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Abstract

The development of significant quantities of wind power capacity and other sources of renewable power as alternatives to conventional fossil-fired generation cannot be accomplished without significant expansions of the transmission system to accommodate these renewable resources. The cost of the transmission expansion is sizeable and who pays for the transmission expansion remains an open question. For extra high voltage ("EHV") transmission lines and expansion projects driven by environmentally focused public policy, such as state renewable portfolio standards, much of the debate centers on the benefits and costs of transmission-enhanced integration of such renewables. Studies of the benefits and costs of renewable resource integration and transmission expansion are key elements in shaping the policy debate and thinking about how the costs should be allocated among participants in the electric industry. Therefore, policy and decision makers must be able to trust that such studies are reliable, even as it is well understood that predictions about the costs and benefits of long-lived investments depend on numerous assumptions about future events about which there is great uncertainty.

This paper reports on investigations into the veracity and reliability of the Eastern Wind Integration and Transmission Study ("EWITS").[1] The EWITS is one of the largest regional wind integration studies to date. It was initiated in 2008 to examine the operational impact of up to 30% energy penetration of wind on the power system in the Eastern Interconnection of the United States. This study was set up to answer questions that utilities, regional transmission operators, planning organizations, and policy makers had about wind energy and transmission development in the east.[2]

While the EWITS is a more comprehensive analysis than its predecessors, this investigation of its assumptions and methodology warrants a conclusion that its economic findings are unreliable due to material errors and omissions, which are identified and discussed in this critique. After reviewing a draft of this critique, EnerNex, the lead contractor on the EWITS, issued a revised EWITS report. While this revision is welcomed, it remedied only one of the errors identified in this critique and this was insufficient to change the foregoing conclusion.

The initial objective of the review of the EWITS was to merely understand the study. However, the review turned into a detailed investigation once it became apparent that certain results in the EWITS Executive Summary were materially wrong. This investigation included a dialogue (primarily by e-mail) with National Renewable Energy Laboratory ("NREL") staff, which

[1] National Renewable Energy Laboratory, *Eastern Wind Integration and Transmission Study*, prepared by EnerNex Corporation, *Revised February 2011*, which was downloaded from: http://www.nrel.gov/wind/systemsintegration/pdfs/2010/ewits_final_report.pdf.

[2] A companion study for the Western Interconnect has also been prepared.

commissioned the EWITS, and the staff of EnerNex. This dialogue also lends support to the conclusion that material errors and omissions were made in the EWITS that render the conclusions it reaches unreliable.

Why release a critique at this time? *First*, as the timeline in Appendix A indicates, answers to questions posed about the EWITS were slow in coming. *Second*, the EWITS report is still being relied on to advocate policy choices.[3] The study's influence was expected to wane once critics reported its flaws, but few have spoken up. *Third*, the initial EWITS report was issued more than a year ago and an internet search surfaced no critical review of its economic analysis.

This investigation focused solely on the validity of the economic modeling and the economic assumptions used for the EWITS. No attempt was made to assess the validity of the wind generator performance or cost estimates used in the EWITS. However, the problems this investigation found would advise caution when drawing conclusions on the basis of any results presented in the EWITS about the value of wind integration accommodated by significant high-voltage transmission expansion.

1. Introduction[4]

Once it became obvious that certain results in the EWITS report were inconsistent with certain assumptions made, a dialogue was initiated with the NREL staff. This dialogue consisted of e-mails and telephone discussions that began on February 2nd, 2010 (less than two weeks after the release of the EWITS report). During a phone conversation on March 2nd, 2010, NREL staff answered, or agreed to obtain answers to, twelve questions (some questions had multiple parts) about the EWITS report. Answers to these questions were slow in coming (see Appendix A). For example, the Reference Case generation expansion plan was requested on March 2nd, 2010, and it was not provided until August 19th, 2010. The production tax credit assumptions, which were requested in a February 2nd, 2010 e-mail, were provided by EnerNex in an e-mail received on February 13th, 2011.

During this dialogue it was discovered that relevant information was omitted from the EWITS final report and this critique provides this information.

[3] For example, see http://www.narucmeetings.org/Presentations/milligan-naruc-oct07-2010.pdf, http://www.grist.org/article/2010-11-11-how-the-wall-street-journal-twisted-the-facts-on-transmission, http://files.eesi.org/wires_nopr_comments_092910.pdf and http://www.energyfuturecoalition.org/files/webfmuploads/Transmission%20Cost%20Allocation%20Letter%20FINAL%2003-25-10.pdf.

[4] Unless otherwise noted, page number references are to the EWITS Final Report - Revised February 2011. Any abbreviations that are not defined herein have the definition used in the EWITS report.

More than a year passed before EnerNex provided an e-mail admitting that Figure 3 in the EWITS Executive Summary (p. 30), which presents the annualized costs of each scenario considered, was materially wrong. The error caused the costs for the Reference Case to be overstated by approximately $13 billion per year (i.e., 10%). Thus, Figure 3 conveyed the impression that the annual costs for the wind integration scenarios were more comparable to the Reference Case annual cost than was justified.

This critique is organized in the remainder of this report under the following section headings:

- 2: Point Estimates Made the EWITS Economic Results Instantly Obsolete
- 3: Material Costs Were Excluded from the EWITS Grid Overlay Cost Estimates
- 4: The EWITS Fixed Charge Rates Could not be Verified
- 5: The Corrections to EWITS Figure 3
- 6: Recommended Actions
- 7: Summary
- 8: Purpose of this Document
- 9: Other Information

Appendix A provides a timeline of significant dates that pertain to this critique. The most significant communication was provided on February 13th, 2011 by EnerNex in response to a preliminary draft of this critique. EnerNex's response is appreciated since it conceded the Figure 3 error, it acknowledged that the annual cost estimates in EWITS were not "high-confidence" estimates and it expressed a "… hope that none of the cost figures cited in Figure 3 are used by themselves to justify any position". The EnerNex response also argued -- to no avail -- that the issues this critique characterizes as "errors" or "omissions", except for Figure 3, were really "A difference of opinion …" or "A misinterpretation of the study objectives and focus".

Appendix B lists other errors that are considered immaterial to the EWITS results *based on what is known at this time*.

Appendix C details the corrections needed to make the annualized capital costs in Figure 3 (p. 30) in the EWITS Executive Summary consistent with the assumptions presented in the EWITS report.

2. Point Estimates Made the EWITS Economic Results Instantly Obsolete

Study findings generally become obsolete after a few years because of changed conditions; however, because the EWITS used (regional) point estimates of natural gas prices, the EWITS results were obsolete the day the final report was published.

The EWITS natural gas price assumptions range from $8.01/MBtu for the SPP region (approximately $8.7/MBtu in 2010$) to $9.21/MBtu for New England (approximately $9.9/MBtu in 2010$) (EWITS Table 3-6, p. 94). The EWITS assumed that between 2008 and 2024, natural gas prices would rise at an annual rate of just under four percent (actual annual rates reported in Table 3-6 varied regionally).

Since the natural gas price bubble burst in the second half of 2008 natural gas prices have averaged about half what was assumed in the EWITS.

With only obsolete natural gas prices, nearly every result with a dollar sign in front of it should be viewed skeptically and there is nothing in the report that might inform the reader how the EWITS results would change under a more realistic post-bubble natural gas price forecast.

To be clear, the inability to make an accurate point forecast of natural gas prices is not the primary concern. The error was the decision to release the report without first updating the natural gas price assumptions and examining the results under those assumptions. The EWITS study team was fully aware of the centrality of natural gas prices to the EWIT's results as the final report clearly states:

> "The price signal is quite sensitive to the price of natural gas. … At the US$2009 price of natural gas in the $3–$4/MBtu range, the energy market prices are already level and the difference in energy price across the Eastern Interconnection is reduced. Less transmission can be justified at lower gas prices that reduce the differential pricing across the Eastern Interconnection". (EWITS, p. 212)

With this explicit recognition of the importance of natural gas prices to the study results and the impact of prices in that $3 to $4/MBtu range, it is surprising that sensitivities based on natural gas prices in that range were not conducted prior to releasing the study in January 2010.

Even with natural gas prices predicated on a bubble, the benefit-to-cost ratios for the grid overlays proposed in the EWITS report are not compelling. According to the EWITS Table 4-6 (p. 115), the four grid overlays for wind Scenarios 1 through 4 had benefit-to-cost ratios of 1.22, 1.09, 0.75 and 0.79. Thus, two of the four proposed grid overlays examined are estimated to

cost more than they are worth and, as the quotation above from the EWITS report confirms, post-bubble natural gas prices would further reduce the value of the benefits. Updating the natural gas price assumptions alone may be sufficient to cause all grid overlay benefit-to-cost ratios to fall well below 1.0.

Of course, the EWITS did include some sensitivity analyses (e.g., a $100/metric ton CO2 sensitivity) but these sensitivities examined the potential *upside* of increased reliance on remote wind. The EWITS report leaves the reader in the dark about the potential *downside* of investing hundreds of billions of dollars in remote wind and expansion of the transmission grid to accommodate it (e.g., the EWITS has no low natural gas price sensitivity, no low load growth sensitivity -- such as would happen if load efficiency was improved -- and new nuclear is never allowed to compete with remote wind, etc.).

It is troubling that a number of other studies (e.g., the Joint Coordinated System Plan or "JCSP", which is described as the "starting point" for EWITS in EnerNex's February 13th, 2011 response to a draft of this critique) advising major grid upgrades to deliver remote wind, which were created as gas prices were spiking, have never been updated with more realistic forecasts of post-bubble natural gas prices. If policy makers only have access to studies that are obsolete (see footnote 3), the risk that bad public policy decisions would be made seems quite significant.

EnerNex's response to a draft of this critique reported that the EWITS Technical Review Committee ("TRC") was responsible for the decision to bring the natural gas price assumptions forward from the JCSP Study[5] and the decision to forgo a sensitivity analysis on natural gas prices. EnerNex also asserted that the natural gas price assumptions are not errors or omissions but differences of opinion.

While it is doubtful that any knowledgeable and objective expert would defend the natural gas price point forecasts upon which EWITS is based, the crux of this criticism of the EWITS is the decision to omit any natural gas price sensitivity analysis from the EWITS.

3. Material Costs Were Excluded from the EWITS Grid Overlay Cost Estimates

The EWITS wind scenario grid overlay benefit-to-cost ratios are overestimated because material costs were omitted from the grid overlay capital costs estimates in the EWITS. To provide a more realistic picture of the economics for the wind scenario grid overlays, we estimated major

[5] Since the natural gas price assumptions shown in EWITS Table 3-6 (p. 94) and JCSP Table 5-20 (JCSP Report - Vol. 1, p. 44) differ, particularly for New England, EnerNex was asked to re-confirm its belief that the JCSP natural gas price assumptions were used for the EWITS; however, EnerNex did not respond to this request.

categories of missing costs and translated their effect on the grid overlay benefit-to-cost ratios, as shown below.

Without foreclosing the possibility of other categories of missing costs, the following three cost categories were definitely omitted from the EWITS grid overlay cost estimates:

I. Excluded Sub-220 kV Facility Upgrade Costs

EnerNex's February 13th, 2011 response to a draft of this critique states, "While PROMOD[6] does not limit the contingencies or number of monitored lines, substantial augmentation of what had been used for the JCSP study was not within the scope of the project". This important revelation meant that certain findings and conclusions from the JCSP Study were applicable to the EWITS as well.

On page 106 of the JCSP Study – Volume I[7] it is stated that "All the low voltage (below 220 kV) constraints were eliminated from the event file" [8] of PROMOD ***and*** the "estimated cost to fix all low voltage constraints was assumed as 25% of the total overlay cost".[9]

It was inconsistent for the EWITS to discard the JCSP Study's 25% cost adder after adopting the JCSP Study's simplifying assumption (i.e., ignore all sub-220 kV transmission facility overloads) on which this adder was predicated. While the adequacy of the JCSP Study's 25% adder may be argued, the use of such an adder for the EWITS would have resulted in far more realistic cost estimates.

II. Excluded Costs for Certain Facilities Operated at Voltages Over 220 kV

The JCSP study team performed an analysis of the JCSP results and according to Table 4 on page 12 of Volume II of the JCSP Report[10], the configuration of PROMOD used in the JCSP resulted in overloads on hundreds of transmission facilities operated at 220+ kV.

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[6] A description of the PROMOD IV® ("PROMOD") computer software used for the EWITS may be found on pages 87-90 of the EWITS report. (This footnote was added here for clarity -- it does not appear in the original.)

[7] http://sppoasis.spp.org/documents/swpp/transmission/JCSP_Report_Volume_1.pdf.

[8] The transmission constraints that PROMOD enforces are specified in a so-called "Event File". If a PROMOD user removes a constraint from the Event File, then PROMOD is free to dispatch the generation fleet such that the associated transmission facilities overload. (PROMOD users routinely remove immaterial transmission constraints since doing so will reduce the amount of time required to complete a PROMOD study.)

[9] Recognizing that the removal of material constraints from the PROMOD Event File would result in generator dispatch patterns that overload many sub-220 kV transmission facilities, the JCSP study team proposed that 25% be added to the JCSP cost estimates to provide funds to remedy these overloads.

[10] http://sppoasis.spp.org/documents/swpp/transmission/JCSP_Report_Volume_2.pdf

Some 500 kV and 765 kV facilities were even allowed to overload in the JCSP study. Since the JCSP only reported the number of overloaded facilities assuming low wind energy conditions (i.e., weekday afternoon conditions in May, June, July and August), it is suspected that significantly more overloads would be observed under high wind energy conditions. Notwithstanding these findings, the EWITS adopted the JCSP Study's PROMOD configuration.[11] Thus, it is expected that a more thorough examination of the EWITS transmission plans would likewise reveal hundreds of overloaded 220+ kV transmission facilities.

Furthermore, the JCSP investigators realized that their PROMOD configuration was deficient and provided a roadmap so that others could avoid their mistakes and also understand and appreciate the limitations of the study. The JCSP Report - Volume 2, p. 12 states, "The conclusion drawn from this exercise is that PAT[12] can be a (sic) used to evaluate and refine the contingency sets that are included in the PROMOD models used to develop the economic overlays in order to ensure that new, potential reliability issues are taken into account". Unfortunately, these JCSP findings and conclusions were disregarded and these flaws were carried forward into the EWITS.

III. Excluded Costs Needed to Maintain Voltage and Grid Stability

The decision to forgo detailed voltage and stability studies in a study like the EWITS was reasonable; however, it was an error to add nothing to the EWITS cost estimates to account for investments needed to resolve such problems, which are inevitable when relying on remote generators. This biased the EWITS results in favor of remote wind generation.

To illustrate the impact of accounting for these three categories of costs that have been overlooked in the EWITS, the JCSP 25% adder is used to estimate the cost of remedying overloads on sub-220 kV transmission facilities. The JCSP offered no estimate of the capital expenditures needed to resolve the overloads on 220+ kV facilities, so it is assumed that an additional 25% would be needed to address those problems. Based on reports out of Texas[13] (not available to the EWITS Study Team prior to the completion of the EWITS study), addressing

[11] This is not a criticism of PROMOD. The PROMOD user (i.e., the EWITS study team in this case) has complete freedom to specify which transmission constraints, if any, must be satisfied in a PROMOD study.

[12] "PAT" is the acronym for the PROMOD Analysis Tool, which is an easy to use adjunct to PROMOD. (This footnote was added here for clarity -- it does not appear in the original.)

[13] A discussion of the voltage and stability of the Texas Competitive Renewable Energy Zone ("CREZ") can be found in the following document: http://www.ercot.com/content/news/presentations/2011/CREZ%20Reactive%20Power%20Compensation%20Study.pdf.

the voltage and stability issues will be assumed to add another 10%. Table 1 illustrates the effect of adding these excluded costs on the benefit-to-cost ratios reported in the EWITS.

Once these excluded costs are added, none of the EWITS grid overlays would have benefits that exceeded their costs. In fact, this would still be true if the missing costs are only half of the amounts in Table 1. Also, Table 1 has no correction to the benefit-to-cost ratios to account for lower post-bubble natural gas prices, which would further reduce the benefit-to-cost ratios by reducing the benefits.

TABLE 1
An Illustration of the Effect of Excluded Costs on the Economic Viability of the EWITS Grid Overlays
(All dollar amounts are in billions of 2009$)

EWITS Scenario	Benefit-to-Cost Ratios (EWITS Table 4-6)	Grid Overlay Cost (EWITS Table 4)	Adders for Excluded Costs			Total Cost with Additions to Provide for Excluded Cost	Benefit-to-Cost Ratios with Additions to Provide for Excluded Costs
			Sub-220 kV	220+ kV	Voltage and Stability		
1	1.22	$93.2	$23.3	$23.3	$9.3	$149.1	0.76
2	1.09	$79.9	$20.0	$20.0	$8.0	$127.8	0.68
3	0.75	$64.9	$16.2	$16.2	$6.5	$103.8	0.47
4	0.79	$92.6	$23.2	$23.2	$9.3	$148.2	0.49

EnerNex's February 13th, 2011 response to a draft of this critique stated: "The benefit/cost ratios were not intended as a metric for project viability, but rather as a way to numerically compare the four scenarios studied". Notwithstanding this intention, no better metric is known for evaluating the viability of grid upgrades that are not essential to grid reliability (i.e., the grid overlays proposed for EWITS Scenarios 1 through 4). The benefit-to-cost ratio threshold proposed by FERC in its Notice of Proposed Rulemaking ("NOPR") on transmission planning and cost allocation was 1.25[14] and the Midwest ISO, which was a subcontractor for the EWITS, applies a benefit-to-cost threshold of between 1.2 and 3.0 for economic projects to qualify for regional cost allocation, with the threshold value increasing with the in-service date.[15]

[14] Federal Energy Regulatory Commission, *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, Docket No. RM10-23-000, June 17, 2010 http://www.ferc.gov/whats-new/comm-meet/2010/061710/E-9.pdf, p. 92.

[15] See http://www.ferc.gov/eventcalendar/Files/20080212162855-ER06-18-009.pdf, pages 2-3.

The EnerNex response to a draft of this critique pointed out that some regional upgrade costs were included for two regions but not for the other five regions. In view of this response, EnerNex was asked to provide the dollar amounts of such regional upgrade costs so that they could be evaluated. Since there was no response to this request, these amounts were estimated using the EWITS fixed charge rate for transmission of 15% (Table 8-1, p. 209) and the annual Transmission Costs (see Table C-1 in Appendix C of this critique) and these appeared to be trivial in relation to the expected magnitude of the costs that were excluded.

The EWITS report fails to adequately warn the reader regarding the materiality of these excluded costs. Although there are caveats in the EWITS report stating that some costs have not been accounted for, only one admits that these "… could be substantial …" (p. 114).[16] The EWITS report goes so far as to suggest that further refinement "… could reduce the estimated costs of the overlay …" (p. 58), which is untenable given all the costs that were excluded from the EWITS cost estimates. Furthermore, the EWITS report would not lead those unfamiliar with PROMOD to understand that the study team configured PROMOD to disregard the cost of overloads on most transmission facilities.

For EWITS, the PROMOD Analysis Tool should have been used to either enhance PROMOD's Event File (so that remote generator output would be curtailed to prevent transmission facility overloads) or to identify the overload facilities (so that a better estimate of the cost of upgrading these facilities could be provided).

4. The EWITS Fixed Charge Rates Could not be Verified

The EWITS used a 15% fixed charge rate assumption (Table 8-1, p. 209) for transmission investment. A significantly higher value (19.1%)[17] is apparently in use in a portion of the Eastern Interconnect footprint analyzed in the EWITS. The JCSP, which EnerNex described as the "starting point" for the EWITS, presents results for a range of transmission fixed charge rates starting from a *minimum* of 15% going up to 25%.[18] Annual costs are proportional to the fixed charge rate so less transmission investment will be cost-justified if the actual fixed costs exceed the 15% rate assumed in the EWITS (e.g., assuming a 19% fixed charge rate with all other factors the same, all the EWITS grid overlay benefit-to-cost ratios would fall below 1.0).

Furthermore, fixed charge rates increase as book life decreases (all other factors being the same) and the fixed charge rates in Table 8-1 (p. 209) contradict this pattern (generator book

[16] A caveat that is similar to the one found on p. 114 appears on p. 38 but without the observation that the excluded costs "could be substantial".

[17] See slide 16 at http://www.pjm.com/~/media/committees-groups/committees/teac/20100414/20100414-2010-market-efficiency-input-assumptions.ashx.

[18] See JCSP Report Volume 1, Figure 5-42, Table 5-44 and Table 5-47.

lives are found in EWITS Table 3-8, p. 97 -- the transmission book life assumption was requested but never disclosed).

EnerNex's February 13th, 2011 response to a draft of this critique reports that the production tax credit was assumed to be zero for the EWITS fixed charge rates and that the fixed charge rate assumptions were "… discussed with the TRC …". Otherwise, the fixed charge rate starting assumptions (e.g., interest rate, rate of return on equity, debt equity ratios and tax rate assumptions) and their source were never disclosed. Without the starting assumptions it is impossible for anyone (including the EWITS study team) to independently verify the appropriateness of the EWITS fixed charge rate assumptions. For example, it cannot be determined if different debt-to-equity ratios were assumed for the different types of new generators.

The fixed charge rate starting assumptions should have been published in the EWITS report. The EWITS study team should have obtained the fixed charge rate starting assumptions and evaluated the reasonableness of these assumptions. Then, the study team should have independently derived fixed charge rates based on those starting assumptions.

As an example, the federal production tax credit ("PTC") applied to wind development has expired and been reinstated by Congress on a number of occasions. The PTC should have been considered through a sensitivity analysis that would demonstrate its effect on the EWITS results as well as on federal tax receipts.

5. The Corrections to EWITS Figure 3

It was obvious that the New Generation Capital Costs in Figure 3 of the EWITS Executive Summary (p. 30) in the January 2010 release of the EWITS report were not consistent with the assumptions published in EWITS Table 8-1 (p. 209).

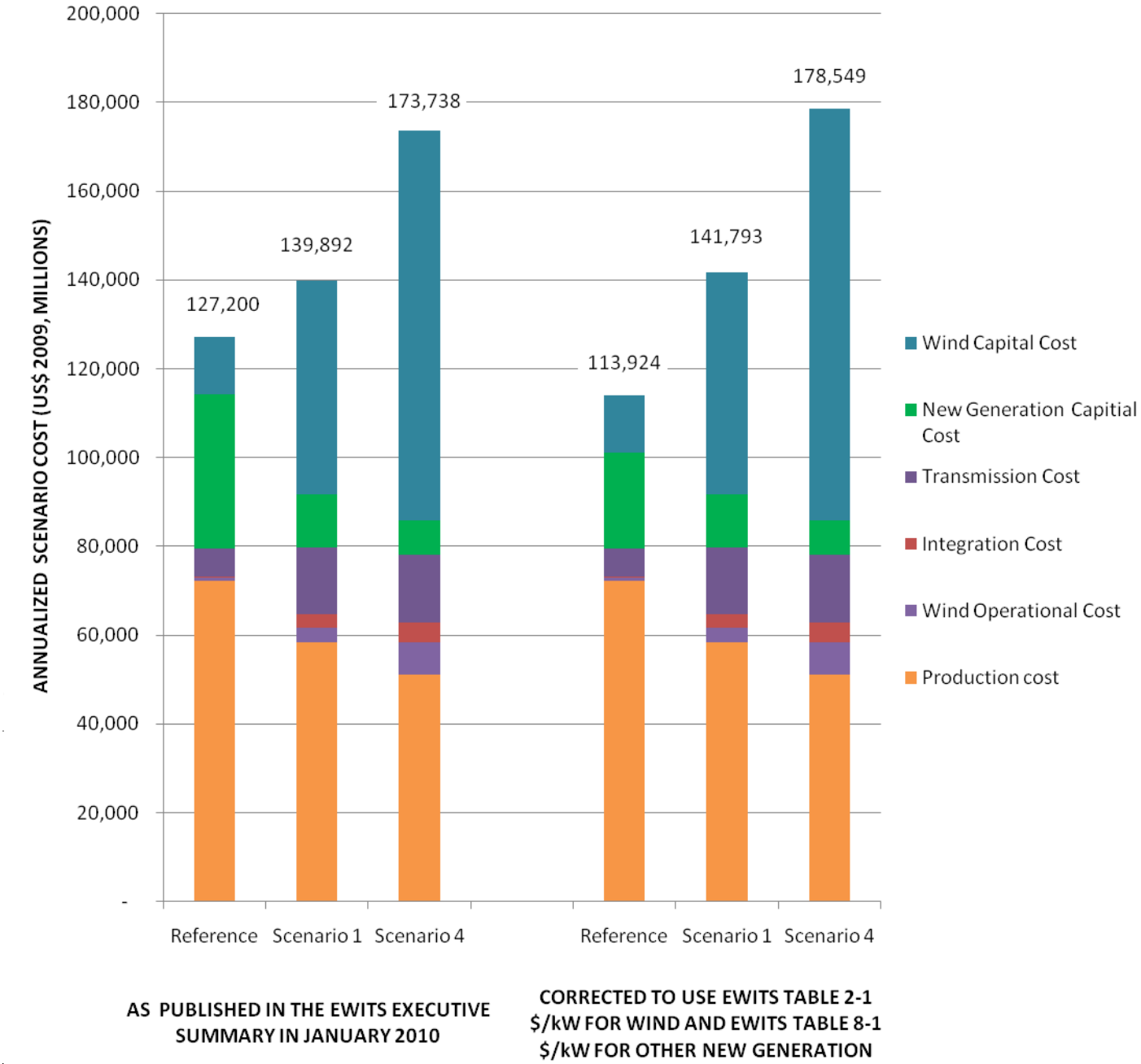
The Figure 3 error was noted and reported to NREL more than a year before it was acknowledged in EnerNex's February 13th, 2011 response to a draft of this critique. Thanks are extended to the staff of EnerNex for revising the EWITS report to include a corrected Figure 3 and arranging to have the revised report posted in February 2011.[19] Also, the Wind Capital Costs presented in the EWITS Figure 3 were found to be inconsistent with the $/kW values published in EWITS Table 2-1 (p. 67).[20]

[19] The link to the EWITS Report found at http://www.nrel.gov/wind/systemsintegration/ewits.html is still labeled January 2010 but the file that may be obtained using this link is internally captioned "Revised February 2011". The only revision appeared to be the correction of EWITS Figure 3.

[20] See Item ii in Appendix B for a discussion of the three contradictory $/kW construction prices for new wind generators reported in the EWITS report.

The following figure compares the EWITS Figure 3 annual costs for the Reference Case, wind Scenario 1 (the least costly 20% wind energy scenario studied for the EWITS) and wind Scenario 4 (the 30% wind energy scenario) AS PUBLISHED January 2010 to the correct values. Appendix C provides the detailed calculations that support the following figure.

The Effect of Correcting EWITS Figure 3



http://files.eesi.org/hoecker_042610.pdf (slide 13, page number 25).

- The *incorrect* January 2010 version of EWITS Figure 3 indicates that the annualized cost for the 20% wind Scenario 1 is approximately $13 billion per year more costly (i.e., approximately 10%) than the Reference Case. After the correction, the cost for wind Scenario 1 is shown to be approximately $28 billion per year more costly (i.e., approximately 24%) than the Reference Case. (Also, if the effects of post-bubble natural gas prices and the excluded grid overlay costs were included in these cost, this cost difference would be even greater.)

- Using the *incorrect* Figure 3 published January 2010 and the wind energies in EWITS Table 2-2 (p. 72)[22], the marginal cost burden for ratepayers for 20% wind (EWITS Scenario 1) is approximately $24 per MWh of additional wind energy.[23] Using the *corrected* Figure 3, this burden would be approximately $54 per MWh of additional wind energy.[24] Thus, the error is material and potentially misleads readers about the marginal cost of increased reliance on remote wind. The incremental cost of going from 20% wind (EWITS Scenario 1) to 30% wind (EWITS Scenario 4) is approximately $91 per MWh of additional wind energy using the incorrect Figure 3 and $99 per MWh using the corrected Figure 3. (These marginal costs would be greater still if the effects of post-bubble natural gas prices and the excluded grid overlay costs are included).

- The EWITS press release and various other policy advocacy documents assert that a key finding of the EWITS is that "Wind energy development is a highly cost-effective way to reduce carbon emissions"[25]; however, this finding never explicitly appears in the EWITS Report. To validate this finding the CO2 abatement costs for the EWITS were derived using the annual costs shown in Figure 3 and the CO2 abatements estimated from the EWITS results. Using the *incorrect* Figure 3 one would believe that the Scenario 1 CO2

[22] It was noted that the wind energy presented in Table 2-2 (EWITS p. 72) is generally greater than the wind energy shown in EWITS Figures 6-13, 6-14 and 6-15 (p. 171-172). It is assumed this difference is due to wind curtailment and transmission losses associated with remote wind. If the lower values were used, then the cost per MWh would be somewhat higher.

[23] The incorrectly reported cost increase from the Reference Case to wind Scenario 1 of $12.692 billion (= $139.892 billion - $127.200 billion; see Appendix C, Table C-1, for the source of these values) divided by the wind energy increase of 520 TWh (744 TWh – 224 TWh) from Table 2-2 (EWITS, p. 72).

[24] The cost increase from the corrected Reference Case to the corrected wind Scenario 1 of $27.869 billion ($141.793 billion - $113.924 billion; see Appendix C for the calculation of these values) divided by the wind energy increase of 520 TWh (744 TWh – 224 TWh) from Table 2-2 (EWITS, p. 72).

[25] See for example http://www.nrel.gov/news/press/2010/801.html, http://97.74.195.121/newsroom/releases/01-20-10_AWEA_Welcomes_NREL_Wind_Integration_Report.html or http://www.energyfuturecoalition.org/files/webfmuploads/Transmission%20Cost%20Allocation%20Letter%20FINAL%2003-25-10.pdf.

abatement cost is approximately $31 per metric ton.[26] However, using the *corrected* Figure 3, the CO2 abatement rate based on the EWITS is approximately $68 per metric ton of CO2[27], which is not cost effective when compared to most other CO2 abatement strategies[28] and it is certainly not "highly cost effective" by any reasonable standard. Furthermore, the CO2 abatement rate to move from 20% wind (EWITS Scenario 1) to 30% wind (EWITS Scenario 4) is approximately $140 per metric ton of CO2.[29] Thus, the *incorrect* EWITS Figure 3 apparently led to the mistaken belief that a "key finding" of EWITS was that remote wind energy development is a highly cost-effective way to reduce carbon emissions.[30]

6. Recommended Actions

The following general policy recommendations should be considered when studies are publicly funded:

- Future studies should not rely on point estimates for assumptions that are central to a study's conclusions and known to have significant uncertainty.[31]
- Draft reports allow study deficiencies to be identified. Future studies should be managed to have a draft report completed with a contingency fund remaining (e.g., 15%

[26] The reported CO2 drop from the Reference Case to Scenario 1 was estimated to be approximately 410 million metric tons per year. This estimate was derived by taking the reported average change in coal, CC and CT output moving from the Reference Case to Scenario 1 (average change found in EWITS Figures 6-16, 6-17 and 6-18, EWITS Report, pages 172-3) times assumed CO2 emission rates of 0.9, 0.35 and 0.6 metric tons per MWh for coal, CC and CT, respectively. The cost change, according to the *uncorrected* Figure 3 is $12.692 billion ($139.892 billion – $127.200 billion; see Appendix C, Table C-1, for the source of these values), which, if divided by 410 million metric tons, equals $31 per metric ton of CO2 reduced.

[27] This $68/metric ton is the EWITS annual costs (corrected to use the data in EWITS Tables 2-1 and 8-1, as explained in Appendix C) for Scenario 1 ($141.793 billion) less the Reference Case annual cost ($113.924 billion) divided by 410 million metric tons CO2 as explained in the preceding footnote. (This rate will be higher still with post-bubble natural gas prices and if the excluded grid overlay costs are added.)

[28] http://www.mckinsey.com/clientservice/sustainability/pdf/US_ghg_final_report.pdf Exhibit B (page xiii) offers a comparison of the cost of various CO2 abatement strategies.

[29] This value is the EWITS annual cost (corrected to use the data in EWITS Tables 2-1 and 8-1, as explained in Appendix C) for Scenario 4 ($178.549 billion) less the Scenario 1 annual cost ($141.793 billion) divided by the reported CO2 abatement from Scenario 1 to Scenario 4 of approximately 260 million metric tons (estimated as explained in the preceding footnote 26).

[30] A justification for this "key finding" of EWITS, which did not depend on the information in Figure 3, was requested but nothing was provided.

[31] For example, rather than study hourly wind profiles for 2004, 2005 and 2006, two of these years could be analyzed freeing up some funding to investigate the sensitivity of the results to more important assumptions.

of the study budget). The contingency fund would be available to address the deficiencies identified by those reviewing the draft report. Ideally, draft reports would be posted for public comment and the comments addressed before the final report is published.

- If there are no funds to correct obsolete study assumptions, then the obsolete information should be omitted from study reports. For example, those EWITS conclusions that hinge on the obsolete natural gas price forecast could have been stripped out and an abbreviated EWITS report released. Otherwise, there should be a page one disclaimer warning readers that the study report is offered "AS IS" with the obsolete results clearly identified for the reader. Alternatively there can be a section headed, "limitations of the study" that provides an explanation of various assumptions made, data used and methodological shortcuts taken that limit the results for purposes of policy making.

With respect to the EWITS, the following remedial actions should be considered:

- The economic results for the EWITS Reference Case and at least one wind scenario should be recalculated using a contemporary natural gas price forecast. Since the EWITS computer models have already been constructed, doing this would probably cost only a few percent of what was spent on the EWITS.

- Adders, such as were used to create Table 1 of this critique, should be estimated and used to compensate for the costs that have been excluded from the EWITS grid overlay cost estimates.

- An effort should be made to ascertain the assumptions underlying the fixed charge rates used in the EWITS. If these can be determined, then these should be reported so the accuracy of the fixed charge rates can be verified.

It is believed that all these deficiencies could be remedied or mitigated without substantial additional expenditures.

The EnerNex February 13, 2011 response to a draft of this critique states that these recommendations are unlikely to be adopted for budgetary and other reasons.

7. Summary

A post-bubble natural gas price forecast is expected to materially change the costs reported in the EWITS. Unfortunately, there is nothing in the EWITS report to illustrate how the results change as natural gas prices change. Significant costs have been excluded from the EWITS grid overlay cost estimates and including reasonable estimates is expected to mean that all the

EWITS grid overlays will have costs in excess of benefits. The annual cost information presented in Figure 3 in the January 2010 edition of the EWITS Executive Summary was materially incorrect and any findings or conclusions based on these costs are suspect.

8. Purpose of this Document

This document provides the communities that are members of the Municipal Electric Authority of Georgia ("MEAG Power") the basis for MEAG Power's analysis and recommendation not to pursue an EHV grid overlay to bring energy from Midwest wind generators to Georgia as envisioned in the EWITS. Plant Scherer and Plant Wansley in Georgia, which are both co-owned by MEAG Power, were chosen as delivery points for the EWITS grid overlays. This choice was made by the EWITS study team and MEAG Power was not consulted regarding the cost or appropriateness of interconnecting an EHV grid overlay with its facilities in Georgia.

Also, this document provides MEAG Power's staff a technical basis for responding to a coalition of wind advocates and for-profit transmission companies that are using the EWITS (and the JCSP study) results to lobby Congress and federal regulators to impose a grid overlay surcharge that would apply to MEAG Power's communities. If this coalition's consumption-based surcharge is imposed, it will apply to MEAG Power's customers even though they will continue to receive their electricity supply from in-state generators. Using the cost estimates shown in Table 1 above (with the excluded costs added), MEAG Power's staff estimates such a surcharge would increase what MEAG Power's customers pay for their transmission service by 300% to 400% and the incidental benefits, if any, that MEAG Power's customers would receive from a grid overlay are expected to be trivial relative to such cost.

9. Other Information

Danny Dees, Manager of Transmission Policy for MEAG Power, is responsible for the content of this document. His contact information is as follows: ddees@meagpower.org

In the event any of the links in this document should become broken, the documents were downloaded and will be e-mailed upon request provided there are no copyright concerns.

MEAG Power is an instrumentality of the State of Georgia and the owner of 2,069 MW of generating capacity, approximately 1,320 miles of transmission lines and 200 substations, operated at various voltages up to 500 kV, and all located within the State of Georgia. MEAG Power's system peak load is approximately 2000 MW.

MEAG Power's emission rates per MWh are approximately 30% below the national average. Furthermore, MEAG Power's native load customers have committed to own 22.7% of two

additional nuclear units in Georgia (as well as fund the transmission capacity required to integrate this new capacity), which would further reduce MEAG Power's air emissions.

MEAG Power routinely opposes those seeking to impose resource planning and transmission planning preferences on its customers when MEAG Power's existing plans are more cost effective.

Appendix A – Timeline of Significant Dates

Time Period	Activity
1/20/2010	EWITS report published.
1/20/2010 through 2/1/2010	EWITS report analyzed.
2/2/2010	Twelve questions formulated and e-mailed to NREL.
3/2/2010	Twelve questions are discussed by phone. Questions 2, 3, 7, 8, 11 and 12 are answered during the phone call. Dees rephrased question 1. NREL staff offers to get answers to Questions 1 (rephrased), 4, 5, 9 and 10 and to confirm its answer to Question 6. Notes of this phone call were e-mailed to NREL on the evening of 3/2/2010.
4/30/2010	E-mail sent to NREL requesting answers to open questions.
5/27/2010	4/30/2010 e-mail from Dees acknowledged by NREL.
8/11/2010	E-mail sent to NREL seeking answers to open questions.
8/16/2010	NREL staff acknowledges 8/11/2010 e-mail.
8/19/2010	Phone conversation with NREL staff. NREL sends e-mail to EnerNex staff (with a copy to Dees) asking them to respond to questions 4 and 5. NREL sends e-mail to Midwest ISO (EWITS subcontractor) staff (with a copy to Dees) asking them to respond to questions 1 (rephrased), 9 and 10.
8/19/2010	NREL forwards answers provided by Midwest ISO to questions 1 (rephrased), 9 and 10.
10/7/2010	Following further analysis, a spreadsheet was sent to NREL showing that certain Figure 3 values were inconsistent with the assumptions in the EWITS report.
10/25/2010	After a number of failed attempts to reach NREL staff by phone, an e-mail was sent to NREL alleging EWITS Figure 3 is materially wrong.
10/28/2010	NREL e-mail states that an unpublished assumption was apparently used for Figure 3 and that Figure 3 is correct. Dees estimates the value of this unpublished assumption and replies to NREL seeking confirmation that this is the approximate value for the unpublished assumption.
12/14/2010	Based on the available information, a draft critique is e-mailed and NREL staff offers to have it reviewed.
2/13/2011	Dees receives an e-mail with an attached response to the draft critique authored by the EnerNex staff. This EnerNex response is dated 1/19/2011.
2/28/2011	Dees e-mails EnerNex asking questions and seeking clarifications regarding their 2/13/2011 response of the 12/14/2010 draft critique.
4/4/2011	The EnerNex staff never responded to the 2/28/2011 e-mail.

Appendix B - EWITS Errors That Appear To Be Immaterial

1. Some inconsistent captions in EWITS Figures 3 and 10 were explained. (The costs shown in Figure 10 and captioned "Production Costs" are the sum of the values also captioned "Production Cost" in Figure 3 PLUS the (Figure 3) "Integration Costs" PLUS the (Figure 3) "Wind Operational Cost".)

2. The EWITS Report claims to have used three contradictory capital cost assumptions for wind:

EWITS Source	Onshore Wind Capital Cost	Offshore Wind Capital Cost
Table 2-1, p. 67	$1,875/kW in **2009$**	$3,700/kW in **2009$**
Table 3-8, p. 97	$1,750/kW in 2008$	$2,440/kW in 2008$
Table 8-1, p. 209	$1,875/kW in 2008$	$3,700/kW in 2008$

   The NREL staff explained that the results in the EWITS Report were based on the EWITS Table 2-1 values and that the study was conducted in such a way that the other values did not affect the EWITS results.

3. The EWITS Table 4 costs should be labeled 2009$, not 2024$.

4. NREL acknowledged that the values in EWITS Tables 3-1 and 3-3 were incorrectly captioned “SERC”. Essentially, what is captioned “SERC” is SERC minus TVA (with Kentucky utilities and AECI), Entergy, and minus those systems that belong to an ISO or RTO (Ameren in MISO and Dominion in PJM).

5. The Fixed O&M caption in EWITS Table 3-8 should be $/kW/YEAR rather than $/kW.

6. "18,00" in EWITS Table 3-4 should be "1800".

Appendix C – Calculations to Make EWITS Figure 3 Consistent with EWITS Tables 2-1 and 8-1

TABLE C-1
Data Table for Figure 3 AS PUBLISHED in the EWITS Report in January 2010 (Billions of $)[32]

	Production Cost	Wind Operational Cost	Integration Cost	Transmission Cost	New Generation Capital Cost	Wind Capital Cost	Total
Reference	72.207	0.779	0.189	6.387	34.744	12.894	127.200
Scenario 1	58.409	3.226	2.967	15.043	12.171	48.075	139.892
Scenario 2	57.827	3.793	2.728	13.043	12.171	52.612	142.173
Scenario 3	55.782	5.328	2.337	11.276	12.171	66.736	153.631
Scenario 4	51.057	7.407	4.269	15.249	7.882	87.874	173.738

TABLE C-2
Calculation of the Scenario 1 New Generation Capital Cost

Row		CC	Coal	CT	Total
A	MW Additions (EWITS Figure 4-1, p. 101)	3,600	32,400	54,000	
B	2008$/kW (EWITS Table 8-1, p. 209)	857	1833	597	
C	2009$/kW (1.03 x Row B)	882.7	1888.0	614.9	
D	New Generation Capital Cost (Row A x Row C) expressed in billions of $	3.178	61.171	33.205	
E	Fixed Charge Rate (EWITS Table 8-1)	0.1250	0.1250	0.1243	
F	Annual New Generation Capital Cost (billion $) (Row D x Row E)	0.397	7.646	4.127	**12.171**

The total on Row F of Table C-2 (bold) matches the Table C-1 New Generation Capital Cost as expected. Similar calculations for Scenarios 2, 3 and 4 also matched; however, the Reference Case New Generation Capital Cost did not match as Table C-3 shows.

[32] Data table downloaded from http://wind.nrel.gov/public/kodell/Figures/Graph_SourcedataLH.xls.

TABLE C-3
Calculation of Reference Case New Generation Capital Cost

Row		CC	COAL	CT	TOTAL
A	MW Additions (unpublished values provided in an 8/19/2010 e-mail by Midwest ISO staff)	6,000	75,600	40,800	
B	2008$/kW (EWITS Table 8-1, p. 209)	857	1833	597	
C	2009$/kW (1.03 x Row B)	882.7	1888.0	614.9	
D	New Generation Capital Cost (Row A x Row C) expressed in billions of $	5.296	142.732	25.088	
E	Fixed Charge Rate (EWITS Table 8-1)	0.1250	0.1250	0.1243	
F	Annual New Generation Capital Cost (billion $) (Row D x Row E)	0.662	17.842	3.118	**21.622**

For the Reference Case, the value published in January 2010 in the EWITS Figure 3 for the New Generation Capital Cost ($34.744 billion) is inconsistent with EWITS Table 8-1 by $13.122 (34.744 – 21.622) billion per year.

According to an August 19th, 2010 e-mail from the Midwest ISO staff, there was 57,000 MWs of new wind capacity in the Reference Case and using values from EWITS Table 2-1 (p. 67), the Wind Capital Cost is $12.740 billion (= 57,000 x 1875 x 0.1192), which is a reasonable match to the corresponding value in Table C-1 above (12.894).

Using the wind additions in EWITS Table 1 (p. 26) and the costs in EWITS Table 2-1 (p. 67), the Wind Capital Cost for Scenario 1 is $49.977 billion (2009$) (=223,609 MW x $1875/kW x 0.1192) versus the Figure 3 value of $48.075 billion (See Table C-1 above). It was discovered that by using the $/kW value in EWITS Table 3-8 (p. 97) the Wind Capital Cost value in Table C-1 could be matched (see item ii in Appendix B above for a discussion of the three contradictory wind capital cost assumptions in the EWITS).

Likewise, the expected Wind Capital Cost for Scenario 4 is $92.685 billion (= [{337,708 – 79,100} x 1875 + 79100 x 3700] x 0.1192) versus the EWITS Figure 3 value of $87.874 billion. The values calculated for Wind Capital Cost for Scenarios 2 and 3 were $54.1 billion and $65.4 billion, respectively, which also differ from the values in Table C-1. No explanation for these differences was obvious.

Finally, there are some immaterial differences between the wind additions shown in EWITS Figure 4-1 (p. 101) and the values in EWITS Table 1 (p. 26) but these do not explain the differences in the Wind Capital Costs.

Table C-4 summarizes the changes for three of the EWITS scenarios. Values shown in bold differ from what appears in the EWITS report.

TABLE C-4
Data Table if Figure 3 Was Based on the $/kW values in EWITS Tables 2-1 and 8-1 (Billion $)

	Production Cost	Wind Operational Cost	Integration Cost	Transmission Cost	New Generation Capital Cost	Wind Capital Cost	Total
Reference	72.207	0.779	0.189	6.387	**21.622**	12.**740**	**113.924**
Scenario 1 20% Wind	58.409	3.226	2.967	15.043	12.171	4**9.977**	**141.793**
Scenario 4 30% Wind	51.057	7.407	4.269	15.249	7.882	**92.685**	**178.549**

Except for the New Generation and Wind Capital Costs, the costs shown in Table C-4 are unadjusted from the January 2010 edition of the EWITS report in order to isolate the errors in Figure 3 that were due solely to inconsistencies between the uncorrected Figure 3 and the assumptions presented in the EWITS report (i.e., no attempt was made in Table C-4 to reflect the effect of lower post-bubble natural gas prices or to add the excluded transmission costs discussed in this critique).