APPENDIX U. INTERPOLATION OF UTILITY AND ENVIRONMENTAL RESULTS FROM NEMS-BT OUTPUT

TABLES

FIGURES

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The effects of proposed furnace and boiler energy-efficiency standards on the electricity and natural gas industries were analyzed using a variant of U.S. DOE/EIA's National Energy Modeling System (NEMS) called NEMS-BT, together with some exogenous calculations[a]. Because the relative size of the energy savings being implemented in NEMS-BT is too small to be seen in the context of the whole electricity and natural gas utility sector, NEMS-BT is not used directly. Rather, exploratory runs are conducted to estimate marginal effects, which are then used to calculate the small effects due to each proposed trial standard level.

To run a simulation in NEMS-BT, the Residential Demand Module space heating load is reduced annually according to the energy savings estimated by the National Energy Savings model (see Chapter 13) for each trial standard level. These energy savings increase over time and are distinguished by fuel type (electricity, natural gas, LPG, and oil).

The magnitude of the energy decrement that would be required for NEMS-BT to produce stable results safely out of the range of numerical noise is greater than even the most stringent standard under consideration. Therefore, it has been necessary, in both the utility analysis and environmental assessment, to estimate results in the range of the standard levels effects using interpolation. Interpolated values are derived from a series of higher decrement simulations based on the standard levels. The actual annual savings attributed to each standard level are compared between standard levels, and those with similar energy savings patterns over time are grouped together. One set of simulations is run for each of the savings groups. The standard levels for the residential furnace and boilers analysis were modeled as one grouping:

Standard Level 4: used to model Standard Levels 1, A, 2, B, and 5.

To preserve the pattern of energy savings over time for a trial standard level, savings in each year were multiplied by the same factor. This factor varies between standards because the magnitude of the savings changes. An appropriate set of multipliers was chosen to augment the savings to a magnitude that produces credible results. Using professional judgement, sets of three multipliers were selected for each of the trial standard levels as shown in Table U.1.

Table U.1 Set of Multipliers for Trial Standard Level 4

Trial Standard Level 4	3, 4, 5

[a] For more information on NEMS, please refer to the U.S. Department of Energy, Energy Information Administration documentation. A useful summary is *National Energy Modeling System: An Overview 2003.* DOE/EIA-0581(2003), March 2003. DOE/EIA approves use of the name NEMS to describe only an official version of the model without any modification to code or data. Because our analysis entails some minor code modifications and the model is run under policy scenarios that are variations on DOE/EIA assumptions, the name NEMS-BT refers to the model as used here (BT is DOE's Building Technologies office, under whose aegis this work has been performed).

The output for electricity generation and capacity by fuel type for each of the iterations (e.g., 3, 4, and 5 times the standard level) was then regressed, with the y-intercept forced through the origin, and the actual standard level forecast is interpolated along this regression line. The linear regression is forced through the origin because a zero change must be the case with no standard in place and because the target points of interpolation are close to the origin (i.e., at low energy decrements).

Figure U.1 shows an example of the interpolation approach for a proposed trial standard level X1. The magnitude of the energy savings multiplier is plotted on the x-axis against the reduction in coal installed generating capacity for each reported year, as shown by the various plotted lines. In general, results for the various NEMS-BT runs are reasonably stable and linear, with the noisy behavior appearing below the first multiplier of the trial standard level savings decrement.

The Department used the estimated reduction in total fuel generation at each trial standard level as determined by interpolation to determine emissions savings. Wherever possible, the environmental assessment analysis used marginal emissions rates over average emissions rates. However, as will be discussed further in this appendix, difficulties arose with using marginal rates in all circumstances and alternative methods needed to be used. Marginal emissions rates incorporate both effects of the standards—the emissions saved by the reduction in total generation and the slight change in the emissions characteristics of the whole power sector that result from the slight change in dispatch and capacity expansion plan. The net effect on the entire system is very small and, typically, the overall effect on emissions can be fully attributed to the decremental generation. The annual marginal emissions rates at the trial standard level was extrapolated from these rates (at multipliers of the trial standard level savings) by taking a simple average.

Figure U.2 shows an example of the extrapolation for NO_x emissions rates for trial standard level X1. In this case, marginal rates for NO_x emissions are shown for each year. As is evident in the figure, more stable results are produced at higher levels of demand decrement. At lower decrement levels (i.e., both on the left-hand side of the figure and in years with small standards impacts), the emissions rate is quite variable. The dashed lines show the earlier years of the imposed standard—those in which the decrements to demand are smallest. The constant emissions rates at higher decrement levels are therefore assumed to hold in the range of small decrements commensurate with the various standard levels, and the implied marginal emissions rates are used to estimate emissions reductions.

Wherever possible, the Department calculated annual marginal emissions rates for each of the simulations in each standard level, based on the actual output from NEMS-BT. Unfortunately, the marginal rate often proved unstable with this high-natural-gas-saving standard, therefore requiring an alternative approach to estimating the CO_2 and NO_x emissions savings. Because of the significant natural gas savings associated with the proposed furnace/boiler energy efficiency standards, the marginal emissions rates were largely unstable compared with proposed energy efficiency standards dominated by electricity savings. The

instability was due to the increased natural gas generation in the power sector as a result of significant natural gas reductions in the residential sector that make power sector natural gas use more economically attractive. To rectify this problem, the Department estimated marginal CO_2 emissions rates by fuel type (coal, natural gas, and petroleum) rather than collectively as thermal generation to accommodate the opposing trends of each fuel. This was possible because NEMS-BT tracks CO_2 well and in more detail than NO_x. Thus, the Department estimated CO_2 emissions reductions using marginal emissions rates calculated separately by changes in coal, natural gas, and petroleum and then summed to estimate the overall impact from each trial standard level. For NO_x, however, emissions tracking is more rudimentary so the Department assumed average emissions rates for this pollutant because marginal rates were too unstable. Total emissions savings in each year are the product of the annual marginal/average emissions rate and the reduction in generation (by fuel or collectively) for that year (as calculated by the interpolation method described above).

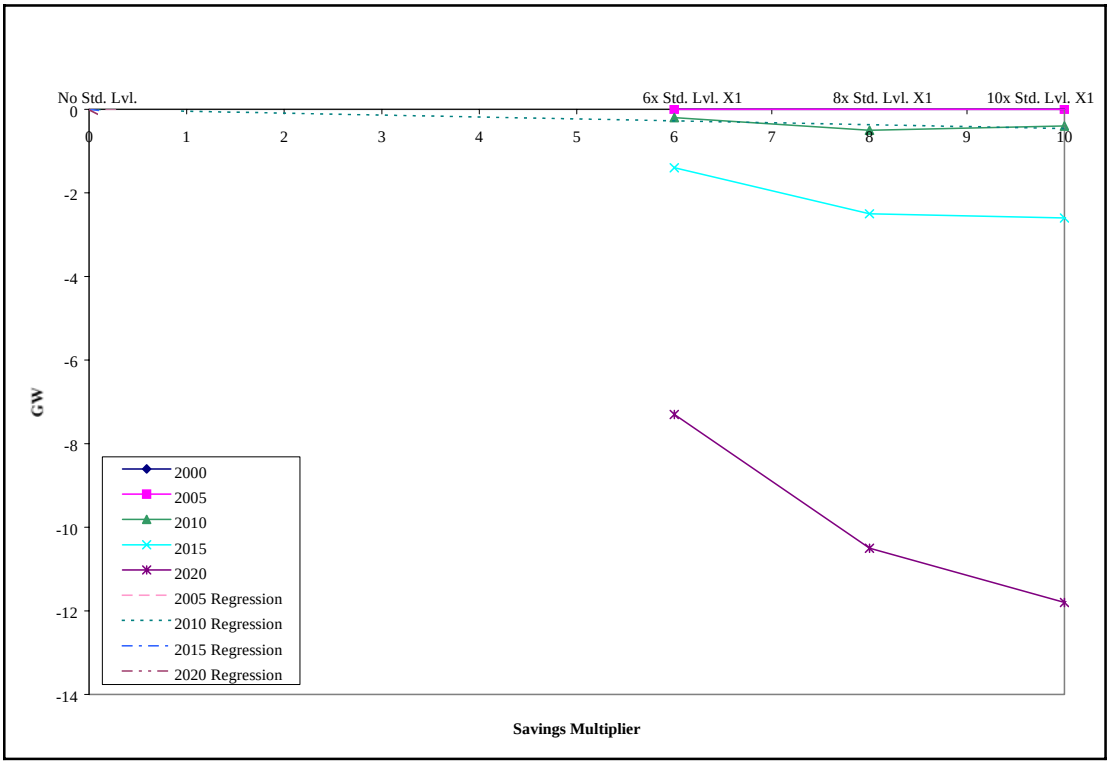

Figure U.1 An Example of Interpolation of a Trial Standard Level: Difference in Coal Capacity

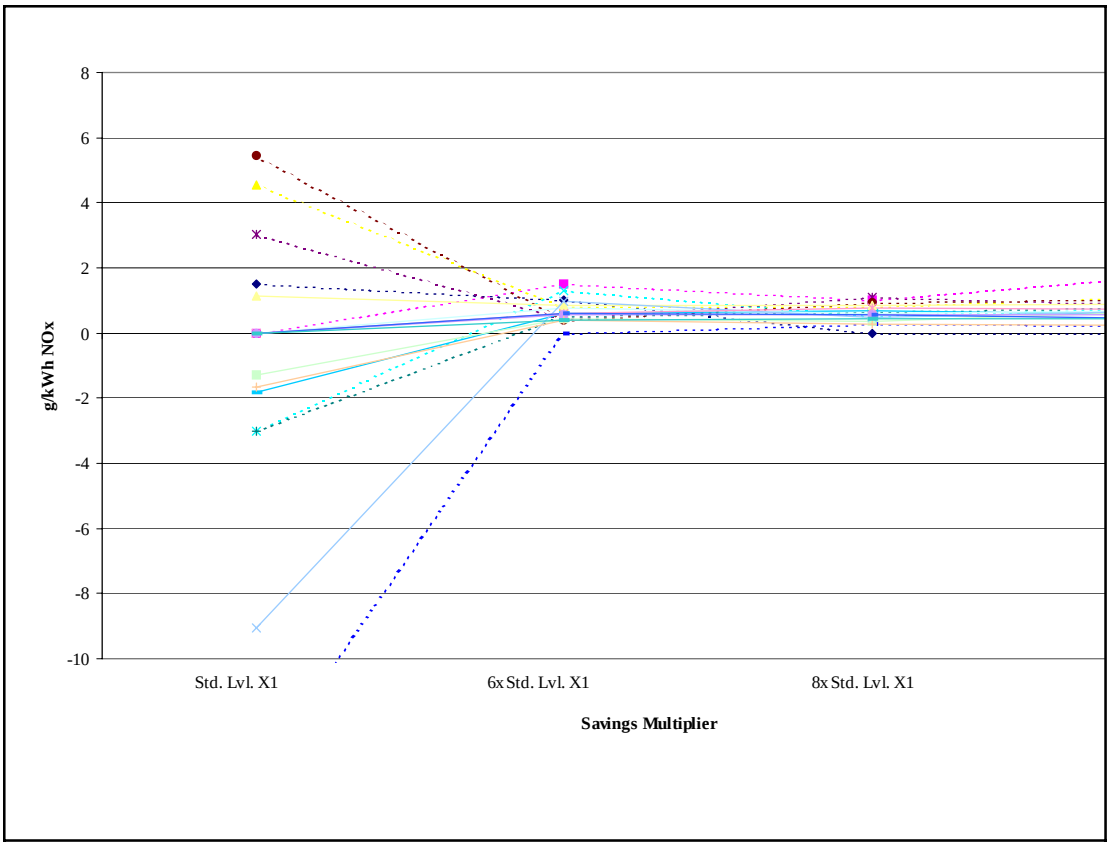

Figure U.2 Example of Trial Standard Level: X1 Marginal NOx Emissions