

**APPENDIX 13A. NEMS-BT EXTENSION MODELING BEYOND 2025**

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## APPENDIX 13A. NEMS-BT EXTENSION MODELING BEYOND 2025

### 13A.1 INTRODUCTION

To analyze the effects of proposed distribution transformer energy-efficiency standard levels on the electric utility industry, DOE used the U.S. DOE/Energy Information Administration (EIA)'s National Energy Modeling System (NEMS). DOE/EIA uses NEMS to produce a baseline energy forecast for the U.S. through 2025, the *Annual Energy Outlook 2005 (AEO2005)*. The Department used a variant known as NEMS-BT to provide key inputs to the analysis. The current forecast horizon of NEMS-BT is 2025; however, some aspects of the distribution transformer energy-efficiency standard rulemaking analysis extend beyond this date to the last year of improved efficiency equipment shipments, 2038.

Past utility analyses and environmental assessments have relied on replicating 2025 results to the end of the forecast. However, more recent energy-efficiency standards tend to have more distant onset years, making NEMS-BT inadequate for capturing the entire life cycle of appliances subject to proposed standards. For example, the first year of proposed distribution transformer savings is 2010, only 15 years before the NEMS-BT horizon. A three- to five-year lead time for power plant construction further reduces noticeable impacts. Although replicating the 2025 results has served as a simple and reasonable approach in the past, it seems increasingly inadequate for recent rulemakings.

To address this concern, the Department has developed a limited-form adjunct version of the NEMS model capable of modeling to 2050. The NEMS-BT2 2050 extension model, based on the *AEO2004*<sup>1</sup> version of NEMS-BT, was developed by OnLocation, Inc., under a subcontract to the Department. Because extensive code and input file changes were required to allow NEMS-BT2 to run to 2050, it has been impossible to date to extend the *AEO2005*<sup>2</sup> version of NEMS-BT. Therefore, the Department uses the *AEO2005* version to conduct the analysis through 2025 and the *AEO2004* NEMS-BT2 2050 extension version for the 2026–2038 period. Also, some assumptions and adjustments were required to ease the transition from year 2025 to 2026, compensating for the inherent differences between these two versions.

The NEMS2-BT extension model to 2050 does not run all modules. Table 13A.1.1 summarizes the active and inactive modules. Because the NEMS-BT2 2050 extension model was developed for the primary purpose of modeling energy-efficiency standards, the residential and commercial demand modules as well as the electricity module are needed. The renewables module is closely tied to the electricity module, and so is active for that reason, while the coal module is active because it was extended in a previous project. Many of the other modules are much less relevant to the distribution transformer analysis and were, therefore, not extended.

To extend NEMS-BT2 to 2050 required four types of modifications:

- resizing of the huge data array that holds all the annualized variables,

- extension of the exogenous inputs,
- extension of the endogenous variables, and
- changes to the algorithms in the source code.

Because not all modules run, many endogenous variables were modified and turned into fixed variables. For example, commercial floorspace growth and retirements are usually calculated in NEMS-BT’s macro module. When this module is turned off in a forecast to 2025, NEMS-BT uses a previous forecast of commercial floorspace through 2025, creating a new forecast to 2050. However, since there is no previous forecast to 2050 from which to borrow, fixed inputs from 2026 to 2050 are created by calculating the average growth from 2000 to 2025 by building type by region, and making a simple extrapolation. Similar simple extrapolations have been made for numerous variables, especially for macroeconomic quantities.

Establishing deviations from EIA’s 20-year-ahead estimates and creating a 45-year-ahead estimate would be difficult, so most of the inputs that describe values that cannot be assumed to grow—for example, the cost and technology characteristics for distributed generation—are extended by flat-lining the 2025 values through 2050. The code changes, while tedious, are straight-forward compared to establishing input and endogenous variable changes.

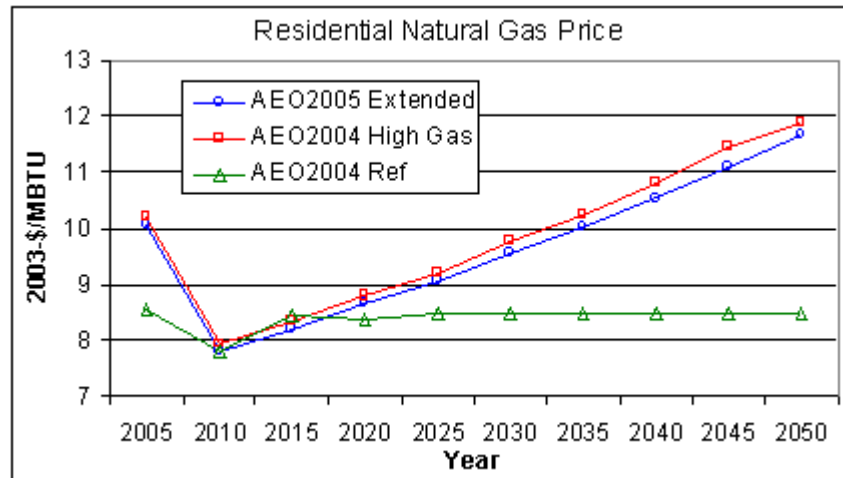
**Table 13A.1.1 Summary of Active and Inactive NEMS-BT2 Modules**

Residential Demand Module	ON
Commercial Demand Module	ON
Transportation Demand Module	OFF
Industrial Demand Module	OFF
Oil and Gas Supply Module	OFF
Natural Gas Transmission and Distribution Module	OFF
Coal Market Module	ON
Renewable Fuels Module	ON
Macroeconomic Activity Module	OFF
International Energy Module	OFF
Electricity Market Module	ON
Petroleum Market Module	OFF

The NEMS-BT2 2050 extension model is intended to project the NEMS-BT 2005 version results beyond 2025 as accurately as possible. This is accomplished by modifying the critical

residential delivered natural gas price. This gas price forecast is assumed in other parts of the distribution transformer rulemaking analysis to be the *AEO2005* with an extension beyond 2025, based on the growth rate from 2015 to 2025; so, for consistency, this same price trajectory is also assumed in the NEMS-BT2 2050 extension. *AEO2005* forecasted higher natural gas prices than *AEO2004*, so modifications were made to increase the natural gas prices in the 2004 NEMS-BT2 2050 extension model to match.

Figure 13A.1.1 shows the modified residential natural gas price with and without the *AEO2005* price increase. The *AEO2004* price (green triangle line) represents the lower gas prices in the 2004 NEMS-BT2 2050 extension model before the forced increase. The *AEO2005* (blue circle) line represents the 2005 NEMS-BT forecast extended to 2050, assuming the continued 2015–2025 growth rate mentioned above. The actual extension model price is shown as the red square line. This change is particularly important for the distribution transformer analysis because standards can influence the overall natural gas price, which can in turn have a significant effect on the generation fuel mix.



**Figure 13A.1.1 Modified Residential Delivered Natural Gas Price**

As previously mentioned, the Department applied some techniques to produce a smooth and believable transition from year 2025 to year 2026 results when using the 2005 version of NEMS-BT forecast to 2025, followed by results from the 2004 NEMS-BT2 2050 extension model. For example, the *AEO2005* model forecasts lower overall installed generating capacity yet higher electricity demand than the *AEO2004*. To address this discrepancy, DOE applied a simple adder to all years 2026–2050, that represents the 2025 difference between the two models. It applied this adder to all results in the utility analysis and environmental assessment.

Additionally, to be consistent with the *AEO2005* typical meteorological year (TMY) System Load Reference Case, all *AEO2004* 2050 extension runs substitute the NEMS system load shapes with the TMY system load shape.

The NEMS-BT2 2050 extension model is not modified to run the High and Low Economic Growth sensitivity cases, so DOE interpolated extensions to these cases from the Reference Case results. The Department ran the High and Low Economic Growth sensitivities for the 2005 NEMS Reference Case with TMY System Load runs for Trial Standard Levels 1 through 6, yielding results for the 2005 interpolated 2025 forecast period. However, beyond 2025, it derived High and Low Economic Growth Case results using fixed adders to the 2026–2050 results, representing the 2025 economic growth rate above or below the Reference Case. For the High (Low) Growth Cases, the fixed adder represents an 11 percent increase (decrease) over the Reference Case results for total electricity consumption, generation, and capacity. This adder represents the 2025 growth rate difference between the High and Low Growth Cases relative to the Reference Case. To estimate the High and Low Growth results, DOE reported impacts as the difference from the Reference Case, and assumed them to be five percent higher or lower than the corresponding Reference Case results for each trial standard level. It determined this adjustment using professional judgment based on previous analyses using the Economic Growth sensitivity cases. The Department applied all adjustments it made to derive the results during the 2026–2050 period both to the utility analysis results and to the corresponding environmental assessment impacts.

## REFERENCES

1. U.S. Department of Energy - Energy Information Administration. *Annual Energy Outlook 2004: With Projections Through 2025*. January, 2004. Washington, DC. Report No. DOE/EIA-0383(2004). <<http://www.eia.doe.gov/oiaf/aeo>>
2. U.S. Department of Energy - Energy Information Administration. *Annual Energy Outlook 2005: With Projections Through 2025*. January, 2005. Washington, DC. Report No. DOE/EIA-0383(2005). <<http://www.eia.doe.gov/oiaf/aeo/index.html>>