

**APPENDIX V. NEMS-BT2 EXTENSION MODELING BEYOND 2025**

**TABLES**

Table V.1 Summary of Active NEMS-BT2 Modules ..... V-2

**FIGURES**

Figure V.1 Modified Residential Delivered Natural Gas Price ..... V-3

## APPENDIX V. NEMS-BT2 EXTENSION MODELING BEYOND 2025

The current forecast horizon of NEMS-BT is 2025; however some aspects of the residential furnace and boiler 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 are tending 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 residential furnace and boiler savings is 2015, only 10 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, called NEMS-BT2, capable of modeling to 2050. The NEMS-BT2 2050 extension model, based on the 2004 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 version. Therefore, the Department used the 2005 version of NEMS-BT to conduct the analysis through 2025 and the 2004 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 NEMS-BT2 extension model to 2050 does not run all modules. Table Z.1 summarizes the active and inactive modules. Because the NEMS-BT2 2050 extension module 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 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 furnace and boiler analysis and were, therefore, not extended. Obviously, the natural gas price forecast is important and yet the oil and natural gas module was not extended, rather a forecast price trajectory is imposed, as explained later in this appendix.

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

- resize the huge data array that holds all the annualized variables,
- extend exogenous inputs,
- extend endogenous variables, and
- change algorithms in the source source code.

Because not all modules run, many endogenous variables need to be modified, and are 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 solves using a previous forecast of commercial floorspace through 2025, creating a new forecast to 2050. But, as there is no previous forecast to 2050 from which to borrow; fixed inputs from 2026 -2050 are created by calculating the average growth from 2000-2025 by building type by region, and making a simple extrapolation. Similar simple extrapolations have been made for numerous variables, especially for macroeconomic quantities.

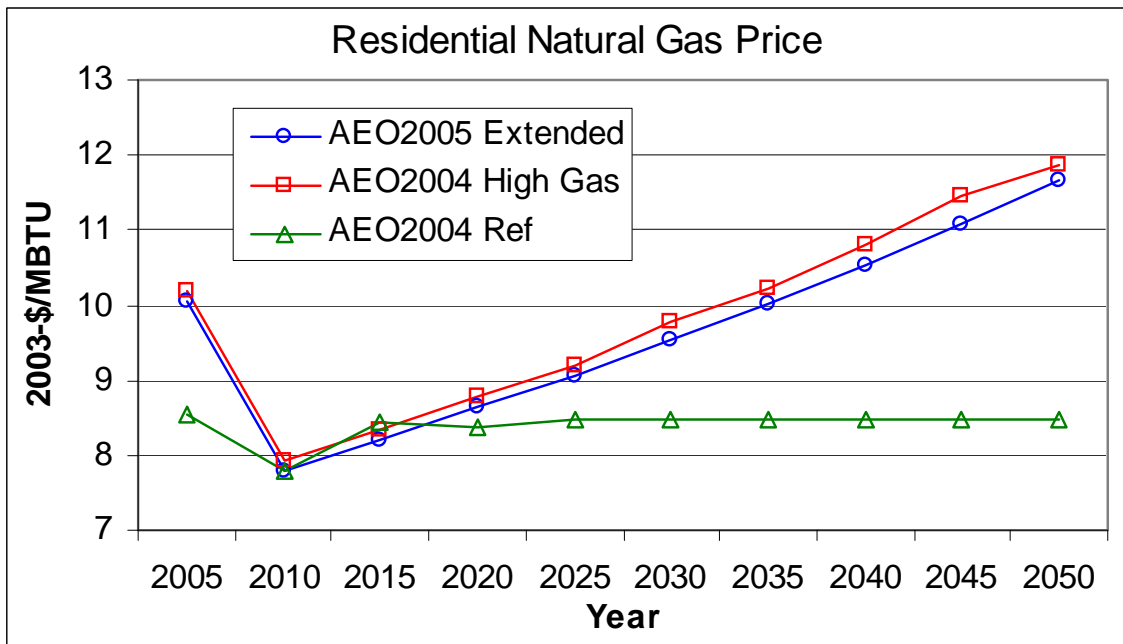
Establishing deviations from EIA’s 20-year ahead estimates and creating a 45-year ahead estimate would be fraught with difficulty, so most of the inputs that describe values that can’t be assumed to grow, for example, the cost and technology characteristics for distributed generation, were extended by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

**Table V.1 Summary of Active 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	OFF

Since the NEMS-BT2 2050 extension model is intended to project the NEMS-BT 2005 version results beyond 2025 as accurately as possible, it was tailored to behave more similarly by modifying the critical residential delivered natural gas price. This gas price forecast is assumed

in other parts of the residential furnace and boiler rulemaking analysis to be the AEO2005 with an extension beyond 2025 based on the growth rate from 2015-2025, so for consistency, this same price trajectory is also assumed in the NEMS–BT2 2050 extension. The 2005 version of NEMS-BT 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 Z.1 shows before and after changes to the modified residential natural gas price. 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 residential furnace and boiler analysis because standards can influence the overall natural gas price, which can in turn could have a significant effect on the generation fuel mix.



**Figure V.1** Modified Residential Delivered Natural Gas Price

As previously mentioned, some techniques were necessary 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. To address this discrepancy, a simple adder was applied to all years 2026-2050 that represents the 2025 difference between the two models. This adder was applied to all results in the utility analysis and environmental assessment. The impacts from each modeled trial standard level are determined using the interpolation method discussed in Appendix U and are reported without further smoothing during the extrapolation period 2026-2050.

Additionally, to be consistent with the AEO2005 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 was not modified to run the High and Low Economic Growth sensitivity cases because it would not be reasonable to extend these trajectories so far out, so extensions to these cases were interpolated from the Reference Case results. The High and Low Economic Growth sensitivities were run for the 2005 NEMS Reference Case with TMY System Load runs for Trial Standard Levels 1-5, yielding results for the 2005-2025 forecast period. However, beyond 2025, High and Low Economic Growth Case results were derived by 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, impacts as the difference from the Reference Case were assumed to be five percent higher or lower than the corresponding Reference Case results for each Trial Standard Level. This adjustment was determined using professional judgement based on previous analyses using the Economic Growth sensitivity cases. All adjustments made to derive the results during the 2026-2050 period were applied both to the utility analysis results as well as to the corresponding environmental assessment impacts.