APPENDIX N. USER INSTRUCTIONS FOR THE LIFE-CYCLE COST ANALYSIS SPREADSHEET

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N.1 USER INSTRUCTIONS

The results obtained in this analysis can be examined and reproduced using the Microsoft Excel® spreadsheets accessible on the Internet from DOE's Furnace and Boiler Rulemaking page: http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html. From that page, follow the links to the final rule and then to the Analytical Tools.

N.1.1 Startup

The Department named the spreadsheets"LCC_XX.xls" where "XX" stands for the product class and subgroup analysis if applicable. The spreadsheets enable users to perform Life-Cycle Cost (LCC) analyses of residential furnace and boilers. A separate spreadsheet exists for each of the product classes and additional spreadsheets exist for subgroup analysis performed on non-weatherized gas furnaces. Table N.1.1 lists all LCC spreadsheets used in this analysis.

Table N.1.1 List of LCC Spreadsheets

Filename	Description
Main Spreadsheets[a]	
LCC_GB.xls	Generates LCC results for Gas Boilers. (Ch. 7 & 8).
LCC_MHF.xls	Generates LCC results for Mobile Home Furnaces (Ch. 7 & 8).
LCC_NWGF.xls	Generates LCC results for Non-Weatherized Gas Furnaces (Ch. 7 & 8).
LCC_OB.xls	Generates LCC results for Oil Boilers. (Ch. 7 & 8).
LCC_OF.xls	Generates LCC results for Oil Furnaces. (Ch. 7 & 8).
LCC_WGF.xls	Generates LCC results for Weatherized Gas Furnaces. (Ch. 7 & 8).
Low Income and Senior Only Subgroup Analysis for Non-weatherized Gas Furnaces	
LCC_NWGF_LowIncome.xls	Generates LCC low income subgroup results for NWGF (Ch. 11).
LCC_NWGF_Senior.xls	Generates LCC senior subgroup results for NWGF (Ch. 11).
Regional Subgroup Analysis (5000 HDD & 6000 HDD) for Non-weatherized Gas Furnaces[a]	
LCC_NWGF_GT5000HDD.xls	Generates LCC north regional subgroup results (HDD5000) (Ch. 11).
LCC_NWGF_LT5000HDD.xls	Generates LCC south regional subgroup results (HDD5000) (Ch. 11).
LCC_NWGF_GT6000HDD.xls	Generates LCC north regional subgroup results (HDD6000) (Ch. 11).
LCC_NWGF_LT6000HDD.xls	Generates LCC south regional subgroup results (HDD6000) (Ch. 11).

[a] LCC Main and Regional Spreadsheets are also used to generate inputs for the National Impact Analysis (Chapter 10).

To examine the spreadsheets, the Department assumes that the user has access to a personal computer (PC) with a hardware configuration capable of running Windows NT/2000/XP. The furnace and boiler LCC spreadsheets require Microsoft Excel® 2000 or later installed under the Windows operating system. Because certain variables inside the spreadsheets are defined as distributions; the user's computer requires a copy of Crystal Ball® from Decisioneering©.

N.1.2 Description of Life-Cycle Cost Worksheets

For each of the six product classes, the Department created one spreadsheet as an Excel® workbook containing a collection of worksheets (referred to as "sheets"). The Department modularized the calculations. Each sheet usually represents a conceptual component within the LCC calculation. To facilitate navigability and identify how the sheets are related, each sheet contains an area on the extreme left that shows the variables which are imported from other sheets and also the variables that are used by other sheets. The LCC spreadsheets consist of the following worksheets:

Simulation Results The Simulation Results contains the LCC and Payback Period simulation results for each design option of the product class.

Simulation Stat The Simulation Stat contains the retail price, installation cost, total installed price, annual gas use, annual electricity use, burner operating hours (steady state for single-stage or high-fire for two-stage and step-modulation), burning operating hours (low-fire for two-stage and step-modulation), household characteristics, annual maintenance cost, annual repair cost, and annual fuel cost results for each design option of the product class.

Summary The Summary contains a user interface to manipulate the *Energy Price Trend* and the *Start Year* and to run a Crystal Ball® simulation. The Department shows results of LCC calculations for different efficiency levels for a single Residential Energy Consumption Survey (RECS) household only. During a Crystal Ball® simulation, the spreadsheet records the LCC and payback periods for every sampled household.

Equipment Price The Equipment Price calculates retail price values used as inputs in the LCC calculations in the Summary sheet. The Department derived the inputs for the Equipment Price sheet from the baseline and incremental manufacturer costs from the Engineering Spreadsheet. DOE applied baseline and incremental markups inputs derived in the Markups sheet to calculate the final retail prices. The Department based the prices on a baseline unit and adjusted for the size of the equipment (and the size of the air handler for furnaces installed in each sampled household.)

Markups The Markups sheet contains distributions of (i) manufacturer markup, (ii) wholesaler markup, (iii) contractor markup, (iv) builder markup for new

homes, and (v) sales tax. The Department use these distributions of markups to calculate the total baseline markup and total incremental markup for every design option. DOE calculated the markups differently for replacement units and new units.

Energy Use

The Energy Use calculates burner operating hours for single-stage and two-stage equipment and the annual gas or oil and electricity use. The annual energy use calculations for each design option are inputs to the Summary sheet to calculate the annual operating cost of the LCC.

Electricity Use

The Electricity Use calculates the electricity use of the air handler. For the electricity use of both permanent split capacitor (PSC) and electronically commutated motor (ECM) air handle motors, the Department calculated separately for both single-stage, two-stage, and step-modulation equipment and for non-condensing and condensing furnaces. The boiler spreadsheets do not contain this sheet because boilers do not have air handlers.

Fan Curves

The Fan Curves contains the coefficients of the equations for the fan curves and watt/CFM curves for PSC and ECM air handler motors in non-condensing, condensing, high-fire and low-fire models. The boiler spreadsheets do not contain this sheet because boilers do not have air handlers.

AFUEexisting Lookup

The AFUEexisting Lookup determines the efficiency of the existing equipment in the household at the time of Residential Energy Consumption Survey (RECS) 2001 survey.[1] DOE located the AFUE from tables of the age of the heating equipment and the Heating-Degree-Day (HDD) of the weather for the house. The Department assumed the AFUE of the existing equipment in the household to correlate by rank with HDD.

InputCapacity Lookup

The InputCapacity Lookup determines the input capacity of the existing heating equipment in the house and located the capacity on a table based on the age of the heating equipment and the square-footage of the household. The Department assumes the input capacity correlate by rank with the size of the house.

AirFlow Lookup

The AirFlow Lookup determines the size of the air handler (or maximum air flow) of the heating equipment. If the house has central air conditioning then the size of the air handler, the Department rank ordered the size of the household with size of the units within air conditioner shipments of that vintage. If the house does not have central air conditioning then the Department assumed the size of the air handler to be sized for 800 CFM at 0.5 in.w.g. static pressure. The boiler spreadsheets do not contain this sheet because boilers do not have air handlers.

Generic Model Lookup The Generic Model Lookup maps the input capacity and air handler size to one of the predefined set of generic models.

HDD Dist by Division The HDD Dist by Division looks up the rank of the HDD of the climate of the house within the HDD of all houses. For non-weatherized gas furnaces, the Department rank ordered the HDD within the household's census division.

RECS HH Data The RECS HH Data contains the RECS 2001 household data for each product class. It includes: average and marginal energy prices, annual gas or oil use, size of the house, age of the house, and the age of the existing heating equipment.

AFUE Baseline Lookup The AFUE Baseline Lookup determines the AFUE of the baseline unit which represents the equipment that the household would have purchased in 2015 in the absence of standards. DOE rank order correlated the AFUE with the HDD of the house. For non-weatherized gas furnaces, DOE performed this rank correlation within the division to which the house belongs. For all other product classes, the Department rank correlated all houses within the sample.

Installation Cost The Installation Cost provides the weighted average installation cost for each design option. It is an input to the Summary sheet to calculate the total installed prices of the design options.

Maintenance Cost The Maintenance Cost provides the maintenance cost for each design option. It is an input to the Summary sheet to be part of the operating costs of the design options.

Energy Price Trends The Energy Price Trends provides the price trends of the different heating fuels; these trends represent the growth rate of energy prices relative to the energy prices in 2001. DOE took energy price data and forecasts from the EIA's Annual Energy Outlook 2007[2] for the period until 2030; and then extrapolated beyond 2030.

Discount Rate The Discount Rate contains the distributions of discount rates for replacement and new units.

Lifetime The Lifetime contains the distribution of lifetimes for equipment of that product class.

Labels The Labels contains labels and variables that are used for the user interface in the Summary sheet.

N.1.3 Basic Instructions for Operating the Life-Cycle Cost Spreadsheets

Basic instructions for operating the LCC spreadsheet are as follows:

1. Once the LCC spreadsheet file has been downloaded from the Web, open the file using Excel®. Click "Enable Macro" when prompted and then click on the tab for the worksheet Summary.
2. Use Excel's® View/Zoom commands at the top menu bar to change the size of the display to fit your monitor.
3. The user can change the parameters listed under USER OPTIONS. There are three drop-down boxes and one command button. The default parameters are:
    a. Energy Price Trend: Set to "AEO 2007 - Reference Case". To change values use the drop-down arrow and select the desired energy price trend (Reference, Low or High).

    b. Start Year: Set to 2015. To change the value use the drop-down arrow and select the desired year (2015, 2011, 2012, 2013 or 2014).

    c. # of Trials: Set to 10,000. To change this value use the drop-down arrow and select the desired number of trials (10,000, 1,000, 2,000, 3,000 or 5,000).

    d. Material Price Scenarios: Set to "Average". To change this value use the drop-down arrow and select the desired scenario (Average, High, or Low).

    e. Rebound Effect: Set to "none". To change this value use the drop-down arrow and select the desired value (none or 15%).

    f. Weatherized Gas Furnace Stainless Steel Heat Exchanger Cost Option: Set to "Low". To change this value use the drop-down arrow and select the desired cost option (Low or High).

    g. Gas Boiler Draft Inducer Cost Option: Set to "Low". To change this value use the drop-down arrow and select the desired cost option (Low or High).

4. To run the Crystal Ball simulation, click the "run" button (you must re-run after changing the parameters). The spreadsheet will then be minimized. You can monitor the progress of the simulation by watching the count of iterations at the left bottom corner. When the simulation is finished, a sheet named Simulation Results will appear with the results.

REFERENCES

1. U.S. Department of Energy - Energy Information Administration, *Residential Energy Consumption Survey (RECS): Household Energy Consumption and Expenditures 2001,* 2001. (Last accessed May 18, 2005.) <http://www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html>

2. U.S. Department of Energy - Energy Information Administration, *Annual Energy Outlook 2007: With Projections Through 2030,* February, 2007. Washington, DC. Report No. DOE/EIA-0383(2007). <http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2007).pdf>