TECHNICAL NOTE: METHODS FOR ESTIMATING ENERGY CONSUMPTION IN BUILDINGS

Previous authors have used a number of approaches to estimate the impact of climate change on energy use in U.S. buildings. Many of the researchers translate changes in average temperature change on a daily, seasonal, or annual basis into heating and cooling degree days, which are then used in building energy simulation models to project demand for space heating and space cooling (e.g., Rosenthal et al. 1995, Belzer et al. 1996, and Amato et al. 2005). Building energy simulation is often done directly with average climate changes used to modify daily temperature profiles at modeled locations (Scott et al. 2005, and Huang 2006). (See Box A.1 on heating and cooling degree-days.)

Building energy simulation models such as CALPAS3 (Atkinson et al. 1981), DOE-2 (Winkelmann et al. 1993), or FEDS and BEAMS (PNNL 2002, Elliott et al. 2004) have been used to analyze the impact of climate warming on the demand for energy in individual commercial buildings only (Scott et al. 1994) and in groups of commercial and residential buildings in a variety of locations (Loveland and Brown 1990, Rosenthal et al. 1995, Scott et al. 2005, and Huang 2006).

Other researchers have used econometrics and statistical analysis techniques (most notably the various Mendelsohn papers discussed in Chapter 2, but also the Belzer et al. 1996 study using the CBECS microdata, and Sailor and Muñoz 1997, Sailor 2001, Amato et al. 2005, Ruth and Lin 2006, and Franco and Sanstad 2006, using various state-level time series.) A subcategory of the econometric technique is cross-sectional analysis. For example, Mendelsohn performed cross-sectional econometric analysis of the RECS and CBECS microdata sets to determine how energy use in the residential and commercial building stock relates to climate (Morrison and Mendelsohn 1999; Mendelsohn 2001), and then used the resulting equations to estimate the future impact of warmer temperatures on energy consumption in residential and commercial buildings. Mendelsohn 2003 and Mansur et al. 2005 subsequently elaborated the approach into a complete and separate set of discrete-continuous choice models of energy demand in residential and commercial buildings.

Finally, Hadley et al. 2004, 2006, directly incorporated changes in heating degree-days and cooling degree-days expected as a result of climate change into the residential and commercial building modules of the Energy Information Administration's National Energy Modeling System, so that their results incorporated U.S. demographic trends, changes in building stock and energy-using equipment, and (at least some) consumer reactions to energy prices and climate at a regional level. Hadley et al. translated temperatures from a single climate scenario of the Parallel Climate Model

BOX A.1 Heating and Cooling Degree-Days and Building Energy Use

Energy analysts often refer to concepts called heating and cooling degree-days when calculating the impact of outdoor temperature on energy use in buildings. Buildings are considered to have a minimum energy use temperature where the building is neither heated nor cooled, and all energy use is considered to be nonclimate sensitive. This is called the "balance point" for the building. Each degree deviation from that balance point temperature results in heating (if the temperature is below the balance point) or cooling (if the temperature is above the balance point). For example, if the balance point for a building is 60°F and the average outdoor temperature for a 30-d period is 55°F, then there are 5 x 30 heating degree days for that period. Energy demand is usually considered to increase or decrease proportionately with increases in either heating degree-days or cooling degree-days.

Balance points by default are usually considered to be 65°F because many weather datasets come with degree-days already computed on that basis (See Amato et al 2005). However, empirical research on regional datasets and on the RECS and CBECS microdata sets suggests that regional variations are common. In Massachusetts, for example, Amato et al. found a balance point temperature for electricity in the residential sector of 60°F and 55°F for the residential sector. Belzer et al. (1996) found that the newer commercial buildings have even lower balance point temperatures, probably because of tighter construction and the dominance of lighting and other interior loads that both aid with heating and make cooling more of a challenge.

into changes in heating degree days (HDDs) and cooling degree-days (CDDs) that are population-averaged in each of the nine U.S. Census divisions (on a 65º F base –against the findings of Rosenthal et al., Belzer et al., and Mansur et al. 2005, all of which projected a lower balance point temperature for cooling and a variation in the balance point across the country). They then compared these values with 1971-2000 average HDDs and CDDs from the National Climate Data Center for the same regions. The changes in HDD and CDD were then used to drive changes in a special version (DD-NEMS) of the National Energy Modeling System (NEMS) of the U.S. Energy Information Administration, generally used to provide official energy consumption forecasts for the Annual Energy Outlook (EIA 2006). Table A.1 contains a summary of methods used in the various studies employed in this chapter.

Table A.1 Methods Used in U.S. Studies of the Effects of Climate Change on Engergy Demand in Buildings

Authors	Methods	Comments
National Studies		
Linder-Inglis 1989	Electric utility planning model	Electricity only. Results available for 47 state and substate service areas. Calculates peak demand.
Rosenthal et al. 1995	Reanalysis of building energy consumption in EIA Annual Energy Outlook	Energy-weighted national averages of census division-level data
Belzer et al. 1996	Econometrics on CBECS commercial sector microdata	Used HDD and CDD and estimated energy balance points
Mendelsohn 2001	Econometric analysis of RECS and CBECS microdata	Takes into account energy price forecasts, market penetration of air conditioning. Precipitation increases 7%.
Scott et al. 2005	Building models (FEDS and BEAMS)	Varies by region. Allows for growth in residential and commercial building stock, but not increased adoption of air conditioning in response to warming
Mansur et al. 2005	Econometric analysis of RECS and CBECS microdata	Takes into account energy price forecasts, market penetration of air conditioning. Precipitation increases 7%. Affects both fuel choice and use.
Hadley et al. 2004; 2006	NEMS energy model, modified for changes in degree-days	Primary energy, residential and commercial combined. Allows for growth in residential and commercial building stock.
Huang et al. 2006	DOE-2 building energy model	Impacts vary by region, building type.
Regional Studies		
Loveland and Brown 1990	CALPAS3 Building Energy Model	Single family detached house, commercial building, 6 individual cities
Baxter and Calandri 1992	Building energy model	Electricity only, California.
Scott et al. 1994	DOE-2 building energy model	Small office building, 4 specific cities
Sailor 2001	Econometric on state time series	Total electricity per capita in 7 out of 8 energy-intensive states; one state (Washington) used electricity for space heating
Sailor and Pavlova 2003	Econometric on state-level time series	Four states. Includes increased market saturation of air conditioning
Mendelsohn 2003	Econometric on national cross sectional data on RECS and CBECS data	Impacts for California only. Residential and commercial. Expenditures on energy.
Amato et al. 2005	Time series econometric on state data	Massachusetts (North), Winter monthly residential capita consumption, commercial monthly per employee consumption
Ruth and Lin 2006	Time series econometric on state data	Maryland (borderline North-South), residential natural gas, heating oil, electricity expenditures
Franco and Sanstad 2006	Regression of electricity demand in California Independent System Operator with average daily temperature anddaily consumption in the CalISO area in 2004, and the relationship between peak demand and average daily maximum temperature over the period 1961–1990	Electricity only