Appendix C. Modeling Energy Efficiency Policies

The Blueprint report included a supplemental analysis conducted by the American Council for an Energy Efficient Economy (ACEEE) to account for the costs and energy savings resulting from nine policies and programs aimed at driving the use of energy efficient technologies in the residential, commercial, and industrial sectors. The analysis used the resulting calculations of annual, national-level energy savings to reduce electricity demand and direct fossil fuel use by sector in the Energy Information Administration's (EIA's) NEMS model. The NEMS model then distributed the savings proportionally across different end-use categories (e.g., space heating, water heating, etc.) and North American Electric Reliability Council regions, and determined the effects of the energy demand reductions on electricity generation, fossil fuel use for electricity production, carbon dioxide emissions, energy prices, and energy bills. The Blueprint combines the incremental investment and policy costs resulting from the offline efficiency analysis with consumer energy bill savings from the model to determine net consumer energy expenditures, and with other policy and investment costs to determine net total societal costs.

Table C.1 summarizes the energy savings and program and investment costs from these policies. By 2030, cumulative end-use energy savings grow to a combined 12.1 quadrillion BTUs (quads), a 29 percent reduction in projected residential, commercial, and industrial energy consumption from our Reference case. Annual program expenditures, research and development funding, and incentives needed to encourage investment in energy efficiency reach $7.5 billion in 2020 and increase to $13.4 billion in 2030. These policy costs, in turn, stimulate a total of $64.3 billion of new investment in more energy-efficient technologies and measures in 2020 and $113.6 billion in 2030.

Table C.1. Energy Savings and Costs in Buildings and Industry from Blueprint Policies

Blueprint Policies	Total Energy Savings (in End-Use Quads)		Total Cost (in Billions of 2006 Dollars)			
			2020		2030	
	2020	2030	Program	Investment	Program	Investment
Appliance and Equipment Standards	1.01	1.75	0.40	9.25	0.50	11.45
Energy Efficiency Resource Standard	2.17	3.68	1.11	11.15	1.63	16.26
Energy Efficiency Codes for Buildings	0.76	1.25	1.92	12.87	2.12	14.19
Advanced-Buildings Program	0.46	1.06	1.93	11.53	3.96	21.78
R&D on Energy Efficiency	0.17	1.76	1.78	2.04	4.65	18.50
Combined-Heat-and-Power Systems	0.34	0.58	0.05	15.16	0.06	27.57
Energy-Efficient Industrial Processes	0.89	1.73	0.29	2.06	0.36	2.58
Enhanced Rural Energy Efficiency	0.01	0.01	0.005	0.03	0.003	0.02
Use of Recycled Petroleum Feedstocks	0.16	0.26	0.02	0.18	0.02	0.15
Total Impact	**5.97**	**12.08**	**7.51**	**64.28**	**13.40**	**113.55**

Below we describe each of the policies implemented in the ACEEE analysis, as well as the methodology and assumptions used to determine their costs and energy savings.

Policy and Cost Assumptions

To determine the potential for policy savings, ACEEE relied on a number of internal studies that included recent state assessments completed in 2007 for both Florida (Elliott et al. 2007a) and Texas (Elliott et al. 2007b). In addition, ACEEE reviewed several national energy efficiency potential studies including the UCS *Clean Energy Blueprint* (Clemmer et al. 2001), the 2001 ACEEE report *Smart Energy Policies* (Nadel and Geller 2001), and an assessment of the National Energy Efficiency Resource Standard (Nadel 2006).

ACEEE's analysis generally accounted for several factors that could affect energy savings. These included a combination of existing units (whether appliances, building stock, or combined-heat-and-power generation units), depreciation of that existing capital stock, and expected growth rates appropriate to each category of capital stock. In addition, the analysis determined both existing levels of efficiency and the level of use of each category of capital stock, as well the potential level of improvement in the performance of each major level of technology over time. ACEEE also carefully reviewed the efficiency measures installed under each program and policy and made adjustments to minimize double-counting of savings. For example, modeling a new, higher-efficiency building code requires that voluntary programs promote even higher levels of efficiency, which affects savings, costs, and participation rates. A similar approach was used for new equipment-efficiency standards and other policies. Finally, the efficiency savings were adjusted to account for the efficiency policies included in the 2007 Energy Independence and Security Act.

Energy Efficiency Standards for Appliances and Equipment

The Blueprint assumes that the federal government puts in place new or upgraded efficiency standards for 15 appliances and equipment types—including incandescent lamps, electric motors, refrigerators, and clothes washers—over the next several years. Where rulemakings are required, estimates of future standard levels are based on efficiency levels that minimize life cycle costs, the primary metric the Department of Energy (DOE) uses to determine standard levels.

The primary source for determining the level of achievable energy savings from improved appliance standards is the 2006 ACEEE report *Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards* (Nadel et al. 2006). Based on this report, ACEEE assumed that the average life of all appliances is 15.9 years and that their benefit-cost ratio is 4.5.

Energy Efficiency Resource Standard

The Blueprint assumes that an energy efficiency resource standard (EERS) is adopted at the federal level covering both the electricity and natural gas sectors. The electricity target ramps up gradually (in annual increments increasing from 0.25 to 1 percent) to achieve total savings of 10 percent by 2020 and 20 percent by 2030. The natural gas targets increase more gradually (annual increments grow to a maximum of 0.5 percent) reaching 5 percent by 2020 and 10 percent by 2030.[1] These target levels are consistent with—or, in some cases, exceeded by—standards in leading states such as Minnesota and Illinois (Nadel 2007).

The investment and policy costs associated with implementing the EERS are based on 2006 ACEEE analysis (Nadel 2006). The analysis calculates investment costs using a levelized cost of 3 cents per kilowatt-hour (kWh) for the electricity target, and 30 cents per therm for the natural gas target, assuming a 13-year product life and 7 percent discount rate.[2] Utilities were assumed to cover one-third of the investment cost, with consumers paying for the remainder. Based on experience with state programs, the assumption for EERS policy costs is 10 percent of investment costs.

Energy Efficiency Codes for Buildings

Under the Blueprint, ACEEE assumes that new building codes achieve 15 percent energy savings in new residential and commercial construction through 2020, and 20 percent beyond that through 2030. These savings reflect modest improvements over current building codes and are well within the energy savings goals recently established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers; American Institute of Architects; and the DOE. To evaluate the savings from these targets, the cumulative percentage of total energy consumption from new construction in the residential and commercial sectors was based on an ACEEE analysis of building code potential in Texas (Elliott et al. 2007b).

Advanced-Buildings Program

An advanced-buildings program combines training and technical assistance on new design and construction techniques for architects, engineers, and builders with educational outreach to purchasers on the benefits of energy efficiency. The Blueprint assumes that a targeted advanced-buildings program could gradually ramp up to achieve a 15 percent reduction in total new residential and commercial building energy consumption by 2023, with savings continuing at that level through 2030. This savings potential for advanced buildings is based on an ACEEE analysis of this policy in Texas (Elliott et al. 2007b), but is also consistent with other studies (e.g., Sachs et al. 2004).

Investment costs draw from the Texas analysis, assuming first-year costs for advanced building technologies of $0.83 per kWh initially, and declining to $0.58 per kWh by 2030. Also based on the Texas analysis, the ACEEE analysis assumes program costs of $0.12 per first-year kWh savings (Elliott et al. 2007b).

R&D on Energy Efficiency

Energy savings from R&D is based on an ACEEE study of potential savings from investment in Florida (Elliott et al. 2007b). These savings are scaled proportionally to the

[1] ACEEE did not include any contribution for combined heat and power or recycled energy under the EERS, but rather addressed them in separate policies.
[2] Our analysis used a 7 percent discount rate to be consistent with what the EIA assumes in its use of the NEMS model as required by the U.S. Office of Management and Budget (Circular No. A-94 Revised).

national level, and we assume that a concerted national effort could double them. As a result of these R&D investments, U.S. energy use is reduced 4.4 percent by 2030, accounting for about 15 percent of the total efficiency policy savings, including combined heat and power (CHP).

They also adapt estimates from a 1997 report by the President's Committee of Advisors on Science and Technology (PCAST) and other studies, and assume that $80 in R&D spending (in 2005 dollars over a five-year period) would be required to develop a technology that eventually delivers 1 million BTU of energy savings once it first enters the market (PCAST 1997). The first year that R&D technologies appear in the market is 2013, with an initial nine-year payback for implementation costs. By 2030, the payback period decreases to five years due to economies of scale and learning-by-doing. As a result, the Blueprint projects annual R&D program costs reach $4.6 billion in 2030, stimulating $18.5 billion in private-sector investments.

Combined-Heat-and-Power Systems

Reducing the barriers to widespread adoption of CHP will require establishing consistent national standards for permitting and interconnection practices; equitable interconnection fees and standby, supplemental, and buy-back power tariffs; uniform tax treatment; and fair access to electricity consumers. The Blueprint assumes these policies are adopted and incorporate annual spending on federal and state CHP programs such as the successful CHP Regional Application Centers coordinated by the DOE and the Environmental Protection Agency. This program facilitates deployment of CHP systems through education programs, coordination, and direct project support such as site assessments and feasibility studies (Brooks, Elswick, and Elliot 2006). The annual amortized policy costs reach $48 million in 2020, and grow to $59 million in 2030.

As a result of these policies and investments, the Blueprint assumes an average annual addition of 4,000 megawatts to the total installed CHP capacity through 2030 in the NEMS model. This rate is consistent with increases experienced this decade in states with effective CHP policies such as Texas, where CHP accounted for more than 21 percent of electric power generation in 2005—a 29 percent increase over 1999 levels (Elliott et al. 2007a).

CHP is different from most other energy efficiency measures in that it satisfies two or more different service demands—e.g., power, heating, cooling—with a single system. As a result, our analysis needs to account for both the displaced onsite thermal energy use and the displaced purchased electricity. First, we allocate the fuel use that would be required for a conventional thermal system to the thermal output of the CHP system. The remaining fuel use is attributable to the power output—in this case assumed to be electricity (see Elliott and Spurr 1998 for more detailed discussion). The net incremental heat rate—onsite fuel used by the CHP system over and above that required to meet the thermal requirements using a separate thermal system—is assumed to be 4,100 BTU per kWh. This value is consistently used by ACEEE and other analysts based on surveys of operating CHP facilities.

In addition, with the installation of new CHP facilities there is likely to be a net increase in the average operating thermal efficiency of the existing boiler inventory from 65 percent to up to 80 percent.[3] Therefore, our analysis includes a credit against the incremental natural gas used for power generation for the reduced thermal natural gas consumption resulting from increased thermal efficiency.

The additional CHP resulting from the Blueprint is projected to produce 453 billion kWh of electric output and an increase in on-site natural gas consumption of 1.816 quads. This increased natural gas use for CHP is more than offset by the avoided natural gas and other fossil fuel consumption in conventional electricity generation. Two-thirds of the CHP electricity generation is assumed to come from industrial facilities and one-third from commercial/institutional facilities.

To project the non-fuel costs associated with the additional CHP investment, ACEEE used the capital, non-capital, and operations and maintenance (O&M) costs presented in Table C.2, which are based on estimates developed by Energy and Environmental Analysis for ACEEE's 2007 Texas analysis (Elliott et al. 2007b). These assumptions result in an average annual CHP investment of $6.3 billion.

Table C.2. Costs Associated with Investment in CHP Systems

CHP Costs	Investment ($/kW)			O&M ($/kWh)
	Total	Capital	Installation	
Commercial	$1,875	$1,313	$562	$0.01
Industrial	$1,275	$893	$382	$0.01

Energy-Efficient Industrial Processes

Significant potential for low-cost efficiency improvements exist in all parts of the industrial sector. Opportunities primarily center on how technologies are integrated into industrial processes, rather than the efficiency of the equipment. As a result, the key to realizing energy savings comes from process optimization that is industry- and site-specific (Shipley and Elliott 2006).

ACEEE's assumption of industrial energy efficiency savings is based on a series of presentations published in 2007 on the DOE's Industrial Assessment Centers and recent Save Energy Now programs. These programs focus on opportunity identification and technical assistance. Key to realizing the industrial efficiency opportunities is the expansion of efforts similar to these, in combination with local programs that support the more effective implementation at the plant. The Blueprint assumes that these programs lead to reductions in industrial fuel use (not otherwise affected by either the EERS or CHP policies) that gradually reach 10 percent by 2030. This is consistent with the cost-effective savings recently identified in DOE evaluations of more than 13,000 typical in-plant assessments conducted since 1980 (Shipley and Elliott 2006).

[3] These assumptions are based on an unpublished ACEEE analysis of savings that could be achieved from replacement of the existing boiler inventory with state–of-the-art thermal systems.

Although detailed cost data are generally lacking for the newer Save Energy Now program, initial results support the assumption that program costs should be about 15 percent of total capital investment cost. This is consistent with the Industrial Assessment Centers program and some of the leading state and utility industrial energy efficiency programs.

Enhanced Rural Energy Efficiency

Robust rural energy efficiency programs emerged in the 1970s to respond to the impact of increasing energy costs on this particularly energy-intensive sector of the economy. With subsequent drops in electricity prices and restructuring of electricity markets in many areas, many of those efforts were abandoned in the early 1990s. It was only with the 2002 Farm Bill that rural energy efficiency programs began to reappear (Brown, Elliot, and Nadel 2005).

The Blueprint includes a continuation the Farm Bill's Section 9006, which mandates annual granting of $35 million—upward of 40,000 individual grants—for renewable energy and energy efficiency technical assistance programs, resulting in a 10 to 30 percent energy savings for farmers.

Use of Recycled Petroleum Feedstocks

The Blueprint builds on existing recycling mandates for plastics and other petrochemical products, and additional research into recycled-stream production processes to increase the use of recycled feedstocks. The estimate of the available savings is drawn from an ACEEE study, *Reducing Oil Use through Energy Efficiency: Opportunities beyond Light Cars and Trucks* (Elliott, Langer, and Nadel 2006). Based on this analysis, we assume reductions in industrial petroleum feedstock use gradually reach 12 percent by 2020, and increase to 20 percent by 2030. This level of savings is consistent with the impacts of mandated plastic recycling efforts in Germany (Elliott, Langer, and Nadel 2006).

The initial cost of recycling petroleum feedstock is assumed to be approximately $64 per barrel saved. In addition, we estimate that the cost of market transformation (i.e., program costs) is about $5 per barrel (Elliott, Langer, and Nadel 2006).

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