# Energy Efficiency and Conservation (EEC)
# Quantification Memorandum

**To:** Iowa Climate Change Advisory Council

**From:** The Center for Climate Strategies (CCS)

**Subject:** Brief overview of the proposed approach for the quantification of greenhouse gas (GHG) emissions reductions associated with energy efficiency and conservation policy options in Iowa

**Date:** June 3, 2008

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This memo outlines key elements of the approach that CCS is using to quantify the GHG impacts and costs for those EEC Subcommittee policy options that are considered amenable to quantification. The Subcommittee is encouraged to suggest modifications and additions. The list of topics addressed in the memo are

A. Underlying Premises and Methodology
B. Outputs
C. Data Sources
D. Cost Inclusion
E. Using the Models To Test Varying Parameters

## A. Underlying Premises and Methodology

There are a number of key premises upon which the analysis will be based, as briefly outlined below.

- *CCS role*—Unless a member of the Subcommittee offers to undertake an analysis of any of the options, we assume that we (i.e., CCS) will undertake the analysis of the options. If a Subcommittee member does offer to undertake the analysis of one or more options, we will provide analytical support (e.g., review and technical feedback) as needed.
- *Transparency*—Data sources, methods, key assumptions, and key uncertainties are clearly indicated. The document of priority policy options, as well as the Excel workbooks quantifying each policy's impacts, clearly explains the assumptions that were used in the quantification process for each option.

- *Analytical approach*—We adopt the general analytical approach of cost-effectiveness and net present value, as widely applied to GHG mitigation policy options.[1] We include direct economic costs from the perspective of the state as a whole (e.g., avoided costs of electricity rather than consumer electricity prices).
- *Bottom-up analysis*—We adopt a bottom-up approach that is amenable to transparency and is capable of reflecting the costs (and cost savings) associated with individual policy options, in contrast to macroeconomic analysis, which aims to capture flows and interactions across all sectors of the economy. Potential macroeconomic impacts, costs, or benefits that fall disproportionately on specific groups or actors, as well as external costs and benefits, are noted qualitatively where studies or other information are available.

As much as possible, the analysis will proceed using simple spreadsheet modeling techniques in which assumptions are transparent and readily accessible to any Subcommittee member for review and adjustment. To ensure consistent results across options, common factors and assumptions will be used for the following items:

- *Independent and integrated analyses*—Each option will first be analyzed individually and then addressed as part of an overall integrated analysis.
- *Fuel costs and projected escalation*—Fuel cost estimates will be based on common sources wherever possible. For example, fossil fuel price escalation will be indexed to the U.S. Department of Energy (DOE) projections as indicated in their most recent Annual Energy Outlook (AEO).
- *Consumption-based approach*—The analysis uses a consumption-based approach where emissions are calculated on the basis of the electricity sources used to deliver electricity to Iowa consumers, as opposed to a production-based approach, which considers the emissions from Iowa power plants, regardless of where the electricity is used.
- *Full fuel cycle approach*—Where studies are sufficient to enable estimation, a fuel cycle analysis is applied when an activity has emissions impacts upstream (e.g., production and extraction) or downstream (e.g., waste disposal) that constitute a significant fraction of a policy option's emissions impacts.
- *Overlap with other Subcommittees*—Where EEC options overlap with options being considered in the Clean and Renewable Energy (CRE) Subcommittee, the analysis for these options will be conducted in close coordination with the assumptions and other inputs used in the CRE analysis.

## B. Outputs

The analysis of mitigation options produces the following results:

- *Net GHG reduction potential* in million metric tons of carbon dioxide equivalent ($MMtCO_2e$) is calculated from the 100-year global warming potentials used by the Intergovernmental

[1] See, for example, Section 2.4 of the IPCC Fourth Assessment Report, Working Group III, for more discussion of various economic analysis approaches, available at: http://www.mnp.nl/ipcc/pages_media/AR4-chapters.html

Panel on Climate Change (IPCC). The GHG reductions are calculated on an annual basis as well as cumulatively. Where significant additional GHG reductions or costs occur beyond the project period as a direct result of actions taken during the project period, these will be indicated as appropriate. Positive numbers represent GHG reductions.

- *Net present value* (NPV) *cost* (or cost savings) is calculated in 2005 constant dollars, using a 5% real discount rate, for a range of periods from project launch through 2012, 2020 and 2050.[2] Positive numbers represent options with net costs; negative numbers represent options with net cost savings.
- *Costs per* $tCO_2e$ emissions reduced (or avoided) are given in units of dollars per metric ton of carbon dioxide equivalent ($/$tCO_2e$). This figure represents the NPV cost divided by the cumulative emission reductions, and it is calculated for each year as well as cumulatively.

## C. Data Sources

Subcommittee members are often in a good position to obtain and provide data sources that are specific to Iowa, and these will be used as much as possible. The success of this approach depends on such information being provided to the CCS analysis team as early in the process as possible. Where Iowa-specific information cannot be readily obtained from the Subcommittee, the analysis relies on published data from the DOE, national laboratories, and other state climate change processes.

### 1. Baseline Energy Consumption By Sector (billion British thermal units [BBtu])

Historical energy consumption in the state, by sector, is from the DOE Energy Information Administration (EIA) State Energy Data available at http://www.eia.doe.gov/emeu/states/_seds.html. To calculate future projected energy consumption, growth factors were applied to the historical 2005 data to calculate projections through 2030. The growth factors are based on a combination of two parameters. One factor accounts for growth within the residential, commercial, and industrial (RCI) sectors, with growth factors for the residential sector based on projected population growth (from http://data.iowadatacenter.org/datatables/State/stpopest19002007.xls and http://data.iowadatacenter.org/browse/projections.html); growth in the commercial sector is based on non-manufacturing employment growth projections; and growth in the industrial sector is based on manufacturing employment. Employment projections were taken from the Iowa Workforce Information Network, Iowa Industry Projections, 2004–2014 (http://iwin.iwd.state.ia.us/pubs/statewide/indprojstatewide.pdf). The other factor is growth in electricity sales, which was calculated on the basis of historical retail sales from 1990 to 2005 obtained from the EIA state electricity profile, in gigawatt-hours (GWh), available from Table 8 at: http://www.eia.doe.gov/cneaf/electricity/st_profiles/iowa.html.

[2] Capital investments with lifetimes longer than 2030 are represented in terms of levelized or amortized costs to avoid "end effects."

**2. Baseline Power Station Electricity Generation (GWh) and Fuel Use (BBtu)**

Gross generation for 2005 was obtained from the EIA database (EIA-906/920) on fuel stocks at all electricity sector power generating facilities, broken down by fuel type. Data for later years were projected from the 2005 figure based on projections of growth in generation for the Mid-Continent Area Power Pool (MAPP) region. The projected regional consumption and generation data are from the EIA AEO and can be accessed by downloading the "Electric Generation & Renewable Resource" file at http://www.eia.doe.gov/oiaf/aeo/supplement/index.html. On-site usage was subtracted from all generation figures.

**3. Heat Rates (Btu/kWh)**

Heat rates indicate how much fuel is used (Btu) to generate a given amount of electricity (kilowatt-hours [kWh]), and they vary greatly depending on the type of power stations and the fuel used. Heat rates are used to convert figures for electricity into figures for fuel use so the fuel use can be converted into GHG emissions using GHG emission factors. Heat rates for 2005 for each type of generation and fuel were calculated from 2005 fuel use (in billion British thermal units [BBtu]) divided by 2005 generation (GWh). Projections for 2006 and beyond are based on annual combustion efficiency growth rates for the MAPP region. Combustion efficiency for a given year is calculated for each fuel type as the fuel use (in quadrillion Btu) divided by the electricity generated (in billion kWh), and the combustion efficiency growth rate applied to this value is based on the change in combustion efficiency from the previous year.

**4. Baseline GHG Emissions Associated With End-Use Consumption (by Sector)**

Historical carbon dioxide ($CO_2$) data by sector (and further broken down by fuel type) were calculated by two U.S. Environmental Protection Agency (EPA) State Greenhouse Gas Inventory Tool (SIT) software modules: the Fossil Fuel Combustion Module and the SIT module for industry (for emissions from industrial sources). Methane ($CH_4$) and nitrous oxide ($N_2O$) emissions were calculated by the Stationary Combustion Module and—for emissions from industrial sources—the SIT module for industry.

Projected emissions through 2030 were based on the 2005 data with growth factors compounded from year to year as discussed above in (A) for energy consumption.

**5. Baseline GHG Emissions Associated With Electricity Generation From Different Technologies and Fuels**

The projected baseline data for each GHG was calculated for each fuel and generation type (e.g., non-lignite coal in a steam plant) as a direct product of the projected generation data (in GWh) described above in C.2. Metric tons of $CO_2$ are calculated from generation as

$$\text{tons } CO_2 = \text{GWh} \times (\text{Btu/kWh}) \times (\text{tons } CO_2/\text{MMBtu}) \times (\text{\% of that fuel in the fuel mix})$$

where (Btu/kWh) is the heat rate and (tons $CO_2$/MMBtu) is the $CO_2$ emission factor [MMBtu = million British thermal units]. Similarly for $CH_4$ and $N_2O$, which are then converted to $CO_2$ equivalents ($CO_2$e) using global warming potentials (GWPs) of 21 for

$CH_4$ and 310 for $N_2O$. The emission factors used for each GHG were the same as those used in the SIT software modules.

6. **Costs Associated With Electricity Generation**

The costs in the United States to produce electricity using different types of technologies are from the AEO 2007 and are based on an analysis of energy supply, demand, and prices in the United States using the EIA National Energy Modeling System. See Table 39 in the "Electricity Market Module" available at: http://www.eia.doe.gov/oiaf/archive/aeo07/assumption/index.html.

7. **Energy Price Projections through 2030**

Energy prices by region are from the EIA Supplemental Tables to the AEO 2007, with projections through 2030. Download "Consumption & Prices by Sector & Census Division," available at: http://www.eia.doe.gov/oiaf/aeo/supplement/. Energy prices by region begin with Table 11.

## D. Cost Inclusion

The analytical models being used can incorporate a wide variety of costs, depending on the availability of cost state. Fuel costs are incorporated into all analyses where relevant. Other types of costs will be explicitly considered in the analysis if they can be readily estimated. Types of costs that are incorporated include

- Capital costs levelized (amortized);
- Labor costs, such as operations and maintenance; and
- Administrative costs.

Types of costs that are not incorporated include

- External costs, such as the monetized environmental or social benefits and impacts (e.g., the cost of damage by air pollutants on structures and crops), quality-of-life improvements, and health impacts and benefits (e.g., improved road safety);
- Energy security benefits; and
- Macroeconomic impacts related to reduced or increased consumer spending, and shifting of cost and benefits among different sectors of the economy.

## E. Using the Models To Test Varying Parameters

Although all assumptions used in the calculations of estimated emissions reductions can be altered as needed by the Subcommittee, all analyses include a set of assumptions specifically programmed so that the impacts of modifying them can be tested. These parameters are identified in the "Assumptions" tab of each spreadsheet by cells that are shaded in yellow and bordered in blue. The values in these cells are embedded in formulas throughout the analysis so that changes to them are instantly reflected in the results. Subcommittee members are invited to make use of this facility to test the impacts of different assumptions.