Estimation of Carbon Dioxide Emissions in the Short-Term Energy Outlook

Introduction

Energy-related carbon dioxide (CO₂) emissions account for about 98 percent of U.S. CO₂ emissions (EIA, Emissions of Greenhouse Gases Report). The vast majority of CO₂ emissions come from fossil fuel combustion (coal, natural gas, and petroleum), with small amounts from the nonfuel use of energy inputs, and emissions from electricity generation using non-biogenic municipal solid waste and geothermal energy. Other sources include emissions from industrial processes, such as cement and limestone production.¹

The EIA Short-Term Energy Outlook (STEO) is a monthly forecast of energy supply, consumption, and prices that looks forward from 12 to 24 months (every January the outlook is extended through December of the following year). The STEO provides a history and forecast of CO₂ emissions from the consumption of the three fossil fuels: coal, natural gas, and petroleum. The historical and projected CO₂ emissions are available as monthly, quarterly, and annual data series from either the STEO Table 9a, U.S. Energy Indicators or from the STEO Custom Table Builder². Long-term forecasts of CO₂ emissions are available in the EIA Annual Energy Outlook. The short-term forecasts for CO₂ emissions are calculated from the STEO projections of fossil fuel consumption and estimated conversion factors of CO₂ emissions per unit of fuel consumed calculated from the historical Monthly Energy Review (MER) database and the Emissions of Greenhouse Gases Report.

Forecast Procedures

STEO CO₂ emission projections are based on STEO projections of fossil fuel consumed (in quadrillion Btu) and calculated CO₂ emissions factors (million metric tons CO₂ emissions per quadrillion Btu fuel consumed). The calculated CO₂ emissions factors are based on historical emissions and consumption reported in the

² The historical monthly CO₂ emissions in the STEO database are from the EIA Monthly Energy Review (MER). The monthly MER data are benchmarked to the annual Emissions of Greenhouse Gases report. The MER will begin publishing monthly emissions in August 2009.
The historical MER data, in turn, are benchmarked to the annual *Emissions of Greenhouse Gases* report.

The *STEO* may not exactly reproduce the MER energy consumption and CO₂ emissions history because *STEO* projects some fuel consumption at a more aggregated level and can not account for differences in nonfuel use. For example, the *STEO* does not disaggregate total petrochemical feedstock into naphtha feedstock and gas oil feedstock, which is necessary for accurate CO₂ emissions accounting. Consequently a benchmarking procedure is used to scale forecast CO₂ emissions calculated by the *STEO* model up or down based on a benchmark factor calculated from the most recent 12 months of CO₂ emissions history published in the MER, by dividing the MER emissions by the *STEO* calculated emissions. A summary of annual average CO₂ emission benchmarking factors is provided in Table 1.

### Table 1. STEO CO₂ Emission Benchmarking Factors

<table>
<thead>
<tr>
<th></th>
<th>Natural Gas</th>
<th>Petroleum</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>1.0053</td>
<td>1.0009</td>
<td>0.9980</td>
</tr>
<tr>
<td>1995</td>
<td>1.0069</td>
<td>1.0009</td>
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<td>1996</td>
<td>1.0077</td>
<td>1.0009</td>
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<td>1997</td>
<td>1.0110</td>
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<td>1.0002</td>
</tr>
<tr>
<td>1998</td>
<td>1.0078</td>
<td>1.0009</td>
<td>0.9990</td>
</tr>
<tr>
<td>1999</td>
<td>1.0050</td>
<td>1.0009</td>
<td>0.9973</td>
</tr>
<tr>
<td>2000</td>
<td>0.9985</td>
<td>1.0009</td>
<td>1.0039</td>
</tr>
<tr>
<td>2001</td>
<td>1.0011</td>
<td>1.0009</td>
<td>1.0049</td>
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<tr>
<td>2002</td>
<td>1.0104</td>
<td>1.0009</td>
<td>1.0081</td>
</tr>
<tr>
<td>2003</td>
<td>1.0121</td>
<td>1.0009</td>
<td>1.0074</td>
</tr>
<tr>
<td>2004</td>
<td>0.9967</td>
<td>1.0009</td>
<td>1.0081</td>
</tr>
<tr>
<td>2005</td>
<td>1.0027</td>
<td>1.0009</td>
<td>1.0001</td>
</tr>
<tr>
<td>2006</td>
<td>0.9988</td>
<td>1.0006</td>
<td>1.0046</td>
</tr>
<tr>
<td>2007</td>
<td>1.0015</td>
<td>1.0007</td>
<td>1.0036</td>
</tr>
</tbody>
</table>

*Source: EIA, Short-Term Energy Outlook, August 2009.*

### Detailed Methodology

A flow chart of the *STEO* procedure for calculating CO₂ emissions is shown in Figure 1, followed by details of the calculation procedures.
1. Download two variables (fuel consumption and CO₂ emissions) for each of 23 fuels from the historical MER database:

\[ xx\text{TCCO}_2\text{MER} = \text{CO}_2 \text{ emissions from fuel } xx, \text{ million metric tons per month} \]
\[ xx\text{TCBUS}\text{MER} = \text{Fuel } xx \text{ consumed, quadrillion Btu per month} \]

where \( xx \) is:

- AB = Aviation gasoline blending components
- AR = Asphalt and road oil
- AV = Aviation gasoline blend components
- BD = Biodiesel
- CL = Coal
- DF = Distillate fuel oil
- EO = Fuel ethanol
- FE = Petrochemical feedstocks
- JF = Jet fuel
- KS = Kerosene
- LG = Liquefied petroleum gas
- LU = Lubricating oil
- MB = Motor gasoline blending components
- MG = Finished motor gasoline
- MS = Miscellaneous petroleum products
- NG = Natural gas
- PC = Petroleum coke
- PP = Pentanes plus
- RF = Residual fuel oil
- SG = Still gas
- SN = Special naphthas
- UO = Unfinished oils
- WX = Waxes
2. Calculate historical CO₂ emission conversion factors\(^3\) by dividing monthly total CO₂ emissions (million metric tons) by total product consumption (quadrillion Btu) reported in the MER.

\[
\text{xxTCCO2\_FAC} = \text{xxTCCO2\_MER} / \text{xxTCBUS\_MER}
\]

\text{xxTCCO2\_FAC} = \text{annual average CO₂ emission factor for fuel xx, million metric tons CO₂/quadrillion Btu fuel consumed}

The CO₂ emission conversion factors from the most recent full year of historical data are used through the forecast.

3. Estimate historical CO₂ emissions from the STEO database using the calculated historical CO₂ emission conversion factors and STEO estimates of total fuel consumed:

\[
\text{xxTCCO2} = \text{xxTCBUS} \times \text{xxTCCO2\_FAC}
\]

\text{xxTCCO2} = \text{STEO estimate of CO₂ emissions from fuel xx, million metric tons per month}

4. Calculate MER-to-STEØ CO₂ emission benchmark factors (shown through 2007 in Table 1), which are equal to the CO₂ emission reported by the MER divided by the CO₂ emissions estimated from the STEO model:

\[
\text{xxTCCO2\_BNCH} = \text{xxTCCO2\_MER} / \text{xxTCCO2}
\]

\text{xxTCCO2\_BNCH} = \text{MER-to-STEØ CO₂ emission benchmark factor for fuel xx}

5. Extend the historical MER-to-STEØ CO₂ emission benchmark factors over the forecast period using a 12-month moving average:

\[
\text{xxTCCO2\_BNCH} = \text{MOVAV(}xxTCCO2\_BNCH, 12\text{)}
\]

\text{xxTCCO2\_BNCH} = \text{forecast of MER-to-STEØ CO₂ emission benchmark factor for fuel xx}

\text{MOVAV(}...\text{)} = \text{moving average of previous 12 months}

6. Replace the estimated historical CO₂ emissions in the STEO database with values reported in the MER:

\[
\text{xxTCCO2} = \text{xxTCCO2\_MER}
\]

7. Forecast CO₂ emissions based on STEO forecasts of fuel consumption, the CO₂ emission conversion factors, and the MER-to-STEØ CO₂ emission benchmark factors:

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\(^3\) The calculated STEØ CO₂ emission conversion factors are not the same as carbon or CO₂ emissions coefficients. The calculated STEØ factors may include an adjustment for non-fuel use depending on the fuel.
\[
xxTCCO2 = (xxTCBUS \times xxTCCO2\_FAC) \times xxTCCO2\_BNCH
\]

- \(xxTCCO2\) = STEO estimate of \(\text{CO}_2\) emissions from fuel \(xx\), million metric tons
- \(xxTCBUS\) = STEO estimate of total fuel \(xx\) consumed, quadrillion Btu
- \(xxTCCO2\_FAC\) = \(\text{CO}_2\) emission factor for fuel \(xx\), million metric tons \(\text{CO}_2\)/quadrillion Btu fuel
- \(xxTCCO2\_BNCH\) = MER-to-STEO emission benchmark factor for fuel \(xx\)

Total petroleum emissions are calculated as the sum of the individual petroleum fuels.