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| Case Western Reserve University |
| Documentation of Key BAU Assumptions |
| Case Western Reserve University Climate Action Plan Model |
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| **Prepared by:****Energy Strategies, LLC****Robert McKenna****801-355-4365****rmckenna@energystrat.com** |
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| The purpose of this document is to outline the key assumptions and sources of information used in the development of the Climate Action Plan Model (CAP Model) business-as-usual reference case (BAU) and familiarize the user with the intended use of the various sections of the CAP Model. The CAP Model is a Microsoft Excel based model that was used in the development of the Case Western Reserve University (CWRU) Climate Action Plan (CAP).  |

[1 Overview 1](#_Toc288111172)

[2 Business-as-usual reference case 2](#_Toc288111173)

[2.1 2009 GHG Inventory 2](#_Toc288111174)

[2.2 Population Growth 3](#_Toc288111175)

[2.3 Campus Area Forecast 3](#_Toc288111176)

[2.4 Utility Demand 6](#_Toc288111177)

[2.5 Commodity Price Assumptions 7](#_Toc288111178)

[2.6 GHG Emissions Forecast 7](#_Toc288111179)

[2.7 GHG Regulatory Financial Exposure 8](#_Toc288111180)

[3 Valuation of GHG Mitigation Actions 10](#_Toc288111181)

[4 Portfolio Development 10](#_Toc288111182)

[5 Other Factors 10](#_Toc288111183)

# Overview

 The purpose of this document is to outline the key assumptions and sources of information used in the development of the Climate Action Plan Model (CAP Model) business-as-usual reference case (BAU) and familiarize the user with the intended use of the various sections of the CAP Model. The CAP Model is a Microsoft Excel based model that was used in the development of the Case Western Reserve University (CWRU) Climate Action Plan (CAP). Below is a screen capture of the "Home" screen of the CAP Model. The blue underlined text found in the "Sheet" column of the Home screen of the CAP Model is a hyperlink. Clicking on each link will take you to that specific section of the CAP Model. As noted, each section of the CAP Model will then have a green "Home" button that will return you to this home screen. This key assumptions document is organized according to the same flow and topics of information that are available in the CAP Model.

# Business-as-usual reference case

The business-as-usual reference case (BAU) is intended to establish the forecast for GHG emissions at CWRU from the baseline year (FYE 2009) through 2050. This is necessary in order to understand, not only the currently GHG emissions that need to be mitigated, but also the forecasted volume of GHG emissions that need to be addressed as part of this and future GHG mitigation efforts. This section of the document describes the baseline year GHG emissions and the key assumptions used to forecast future emissions.

## 2009 GHG Inventory

CWRU, led by Gene Matthews (ecm4@case.edu), conducted a GHG inventory for the University operations ending June 2009 (FYE 2009). Gene and his team utilized the Clean Air Cool Planet (CA-CP) inventory tool to conduct their analysis. Their analysis showed that the FYE 2009 GHG inventory for CWRU was roughly 263,000 metric tons of carbon dioxide equivalent (MTCO2e). The components of the inventory are shown below and are also found by following the 2009 GHG Inventory link on the CAP Model home screen. These values are the starting values used in the CAP Model BAU GHG forecast. The "Forecast Drivers" identified in the table below identify the key assumptions that are used in forecasting each type of GHG emission through 2050. The key assumptions are discussed below.



## Population Growth

The table below shows the historical campus population broken out by Total Enrollment and Total Faculty and Staff. For the purposes of the BAU forecast it is assumed that the Total Enrollment grows to 10,500 students by 2050 and that the Total Faculty/Staff essentially remains constant, growing to 5,100 by 2050. These assumptions were provided by Steve Campbell.



## Campus Area Forecast

Campus Area refers to the amount of building space found in the building inventory at the University. The campus area is the primary driver of GHG emissions at the University. The figure below represents the 2009 GHG inventory with the blue shaded slices representing emissions associated with building energy. Building energy related emissions account for roughly 82% of the 2009 GHG inventory.

Since 1980, CWRU has grown, on average, more than 87,000 gross square feet (GSF) per year if the farms and garages are not included in the total (see Appendix A). If this average growth rate continues, the University will add nearly 3.6 million GSF by the end of the CAP Model forecast period; expanding the campus area from 6.6 million GSF to nearly 10.2 million GSF. For the purposes of the BAU forecast it is assumed that the University continues to grow at this rate, on average, through 2050. Some may argue that it is not reasonable to assume that the University will continue to grow at this same rate in a business-as-usual world given the recent times of relative economic scarcity and uncertainty. While a slower growth rate may be reasonable to assume for the short-term, the 30-year historical average includes both periods of economic prosperity and periods of constrained economic growth. The figure below shows the historical University growth from 1980 through 2010. As is shown in this figure, the 30-year historical average includes a period of time from 1980 through the early 1990's, another period of constrained growth in the economy, where very little growth took place on the campus. According to this figure, another period of constrained growth has been experienced since 2005. Nearly 85% of the growth in campus area was experienced between 1990 and 2005, a period of rapid economic growth and relative abundance. Given the long forecast period of the CAP Model it was decided to use this historical growth rate for the future annual growth rate.

In the near-term, some specific building projects were identified to include in the BAU campus area projections. The specific projects identified and included are:



Beyond these near term projects, there are some specific types of space that have been anticipated will be added to the campus and have been included in the CAP Model (see table below). This space is added as an average addition per year so that the total space added over through 2050 totals the amount in the table below.



These specific additions equal 620,000 GSF by 2050. This leaves nearly 3 million GSF, or 82,000 GSF per year, of unidentified space that has been included in the BAU forecast model.

The other key assumption is renovations. Historically, the University has renovated 20,000 to 30,000 GSF per year, on average. The BAU forecast assumes that 22,000 GSF is renovated each year. The table and graph below illustrate this BAU campus growth scenario.





## Utility Demand

According to the information developed by Gene Matthews and his team in the CA-CP GHG inventory tool, the average campus-wide energy use intensity (EUI) for FYE 2009 was 195,000 BTU per GSF or 195 KBTU/GSF. The components of the historical demand are shown in the table below, broken down by Electricity, Steam and Cooling purchased from the Med Center Company (MCCo).



The BAU utility demand forecast assumes that existing space that is not renovated over the forecast period continues to consume utilities at the historical average EUI. It is assumed that new space that is added has an EUI that equivalent that of the existing space and that any space that is renovated has an increase in utility demand associated with the addition of cooling in buildings that historically have had none (see table below).



These EUI intensity factors multiplied by the campus area growth values described above result in an increase in purchased utilities from the 1.29 quadrillion BTU's experienced in FYE 2009 to 2.0 quadrillion BTU's by 2050, a 55% increase over 41 years. The components of utility demand growth are illustrated in the table and graph below.





## Commodity Price Assumptions

The commodity price assumptions section of the CAP Model actually includes commodity prices as well as purchased utilities pricing for utilities purchased from MCCo. The starting values for FYE 2010 purchased utilities were provided by Gene Matthews and are assumed to be $85/MWh for purchased electricity, $13.00 per klb for purchased steam and $0.23 per ton-hr for purchased cooling. A starting price of $7.00 per MMBTU is used for natural gas purchased from the local distribution company (LDC).

A variety of approaches can be used to forecast these prices going forward, but to simplify the forecast process and make the assumptions easily transparent a simple straight-line growth rate of 0.5% per year was used for the BAU forecast period. These same values are used when valuing GHG abatement options and the associated reductions in purchased utilities. The annual values for the forecast period are available in Attachment B.

## GHG Emissions Forecast

The GHG emissions are forecasted based on the forecast drivers assumption identified in the table in section 2.1 above. Many of the values are forecasted by growing the starting value at the same growth rate as the forecast driver. For example, refrigerants will simply grow at the same rate as the building area. Alternatively, the purchased utilities and natural gas forecasts have an emission factor that is uses in the forecast calculations. The emission factors used, based on the CA-CP inventory, are:

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| Emission Factors for Purchased Utilities and Commodities (MTCO2e/MMBTU) |
| **Purchased Electricity** | **Purchased Steam** | **Purchased Cooling** | **Natural Gas** |
| 0.2080 (0.7098/MWh) | 0.1078 | 0.1188 | 0.0530 |

## GHG Regulatory Financial Exposure

For starters, it should be understood that our approach attempts to simplify a very complex regulatory framework. We understand the complexities go beyond the simplifications represented here, but we feel that this simplified model generally captures, in concept, what the average member of the economy may be subject to under a cap-and-trade scenario. Carbon Tax and rulemaking by the EPA are two additional concepts that are not specifically captured in this model, but are assumed to be within the uncertainty ranges provided.

In the CAP Model "GHG Compliance Costs" are a function of the GHG emissions, which portion of those emissions would have been subject to a compliance cost in the reference case and the cost per MTCO2e for GHG emissions.

The first important concept is that it is not assumed that CWRU will necessarily be subject to a "direct" compliance obligation. The University may or may not be, depending on how final legislative and/or regulatory scenarios play out. The important concept is that the University, as an average member of the economy, will be subject to the incremental costs that will flow through the economy as a result of a price being assigned to GHG emissions as a result a cap-and-trade, carbon tax or command-and-control scenario. For example, as a consumer of purchased electricity from the local utility CWRU will pay an incremental cost for purchased electricity as a result a price on GHG emissions. Not that CWRU will be required to meet any specific direct obligation, but that the local utility will and will pass the incremental costs through to customers.

The second important concept is how it is estimated which portion of the economy-wide emissions will be subject to a compliance cost. The graphic in Appendix C is adapted from an analysis performed by the Pew Center on the American Clean Energy and Security Act of 2009. The dotted red line represents the "Cap" on GHG emissions according to this specific legislative scenario. In this cap-and-trade scenario, all emissions above the Cap need to abated since no emissions allowances will be available above the Cap. The bottom two areas on the graph, "Free" and "Auction", represent the GHG emissions allowances that will be available in the economy and how the emissions allowances under the Cap will be allocated to members of the economy. This means that a certain portion of the allowances under the Cap will be freely awarded and the "Auction" portion of the allowances will need to be purchased. The total "emissions subject to a compliance cost", as has been defined in the CAP Model, is the sum of the "economy-wide emissions above the cap" and the "Auction" portion underneath the cap. This means that all GHG emissions that do not have a free allowance available for them will be subject to the cost of the market price for one metric ton of GHG emission allowance denominated in dollars per metric ton of carbon dioxide equivalent or $/MTCO2e.

The legislative scenarios that are used in the CWRU CAP Model do not represent a specific legislative scenario, e.g. Waxman-Markey, but are a composite of scenarios. The composite was developed by Energy Strategies, LLC to capture the major elements of the prevailing scenarios that are being debated in Washington, D.C. We referenced many policy analyses performed by the Pew Center, the Congressional Budget Office, the Nicholas Institute and other policy analysis groups. For example, below is a link to a similar analysis performed by the Pew Center regarding the Dingell-Boucher bill. Additional sources can be provided if necessary.

http://www.pewclimate.org/docUploads/Dingell-BoucherSummary.pdf

The final major assumption is the cost assigned to each unit of GHG emissions subject to a compliance cost. The price assumptions are provided here as Appendix D. The forecast is a composite of 3rd-party forecasts. These are the same values used in the CAP Model. Sources can be provided as necessary.

Using this methodology it is estimated that CWRU has a present value of GHG financial exposure of $161 million, with the compliance costs flowing through to the University starting in 2015. The darker blue section below shows the portion of the BAU GHG emissions that are assumed will be subject to either direct or indirect financial exposure.



The sources of the compliance costs are broken out in the table below.



# Valuation of GHG Mitigation Actions

This portion of the CAP Model is used to value and compare the various mitigation actions considered. The detailed assumptions for each action are documented in the model, in the metric briefs provided on the documentation website and in the CAP document.

# Portfolio Development

This portion of the CAP Model was used to create and compare a variety of portfolios for consideration as part of the CAP portfolio development process. The outcome of this process is documented in the CAP document and on the documentation website.

# Other Factors

The "Other Factors" section of the model includes a variety of conversion and other factors used in the model. The primary factors I will highlight here are inflation and the discount rate used in present value calculations. It should be noted that all dollar values in the model are "real" dollars, meaning they are denominated in 2010 $ and not inflated. The discount rate discussion below will also discuss the derivation of the "real" discount rate that was used.

First, inflation. The assumed inflation rate is 1.9% and is based on a GDP Chain-type Price Index. The GDP Chain-type Price Index is an index published by the Bureau of Economic Analysis (BEA) and is used to convert between real and nominal dollars. The base year for the index is 2000 where the index is equal to 1.0. The reference used for this information is the 2010 Annual Energy Outlook (AEO) published by the Energy Information Administration. The specific location of the information is row 31 in the Excel file found at the following location: <http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_20.xls>. This file is Table 20 from the AEO's reference case. Table 20 describes the Macroeconomic Indicators used in the AEO. The full AEO can be found at <http://www.eia.doe.gov/oiaf/aeo/index.html>.

The next topic is the discount rate used in the present value calculations. In an e-mail dated December 2, 2010, Jim Gross explained that the discount rate used for the calculation of present values at the University is 7.5%. It was explained that this assumes inflation is included. For the purposes of the CAP Model a "real" discount rate is used for present value calculations. The "real" discount rate is assumed to be 5.6% (7.5% minus 1.9% for inflation).







