



Carbon Tax Assessment Model

User’s Manual

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# INTRODUCTION

The Carbon Tax Assessment Model (CTAM) is an open-source model that quantifies the greenhouse gas (GHG) and fiscal impacts of a carbon tax on the five primary energy sectors and helps provide policy recommendations for Washington State based on the model’s results. In 2011, Keibun Mori developed CTAM at the request of the Washington State Energy Office (WSEO) and to fulfill graduate school requirements at the University of Washington.

Since its development, the model has been maintained and enhanced by WSEO staff within the Washington State Department of Commerce (Commerce). The March 2015 update was undertaken by Mori, Hammerschlag & Co., and WSEO staff. It is the most extensive update yet.

The following new features have been added to CTAM 3.0. In general, these are optional and variable features reflecting potential complementary policy measures to a carbon tax:

* The price elasticity of demand and proration tables for fuels in CTAM have been updated.
* Industrial process emissions can now be included in the model.
* Electricity sector emissions are now consumption based instead of generation based.
* Optional and variable reductions to any of the five primary energy consuming sectors reflecting complementary GHG reduction policies that are not part of the carbon tax.
* Optional supplemental fuel tax, reflecting a variable increase in state or federal transportation fuel taxes.
* Optional Low Carbon Fuel Standard (LCFS) can be added as a complementary policy, similar in design to the California LCFS.
* Optional early and variable shutdown of out-of state coal-fired electricity generation.
* Optional and variable increase in electric vehicle market penetration rate.

The graphics and tables on the dashboard tab have been enhanced. The newest version is designated CTAM 3.0. The model is currently using the [Energy Information Administration’s 2014 Annual Energy Outlook (AEO)](http://www.eia.gov/forecasts/aeo/)[[1]](#footnote-1) reference case as the basis for forecasting future Washington State energy consumption. CTAM 3.0 will be updated with the EIA’s 2015 AEO reference case when it becomes available during the spring of 2015. CTAM is setup for the state of Washington, but it can easily be adapted for other states.

Because CTAM has become more complex, two sub-sections of the original model have been separated from the updated model and now reside in separate spreadsheets: CTAM 2015 WA Energy Forecast and CTAM 2015 Price Elasticity. The Energy Office has developed a short CTAM user’s manual, which briefly describes key features of CTAM 3.0a and the two supporting spreadsheets.

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# CTAM 3.0a

The primary modeling spreadsheet is designated CTAM 3.0a and contains all the commonly used features of CTAM. A number of new features have been added relative to previous version, CTAM 2.5.

## COVER TAB

The cover tab provides the contact information for the version 3.0a model. On this page is a table of contents with active links to other worksheets (tabs). Finally, located towards the bottom is a style key and brief methodology notes.

## DASHBOARD TAB

CTAM users will spend most of their time on the dashboard tab. It controls most of the variable inputs for the model. The key sections of this tab are:

### Subsection 1: Defining the carbon tax

The user input cells allow for setting the carbon tax start date, initial tax rate, annual incremental increase in the tax (referred to as the ramp rate), and the maximum tax rate. Default values are located in column C.

### Subsection 2: Fate of carbon tax revenue

CTAM assumes carbon tax revenue neutrality, which means the collected revenue offsets existing taxes or is returned to consumers as a cash rebate. The user can assign the distribution of the carbon tax revenue. Choices include: property tax, sales tax offset, B&O tax offset, cash rebate, state general fund, and a Clean Energy Trust fund. Default values are in column C.

### Subsection 3: Model behavior

In this section the user can select from three baseline forecast options. CTAM will eventually be loaded with the Energy Information Administration’s (EIA) 2015 Annual Energy Outlook (AEO) Pacific region reference case, and the AEO high price energy case, and AEO low price energy case as alternatives. The user may choose to substitute one of the other 2015 AEO forecast cases using the separate spreadsheet “CTAM 2015 WA Energy Forecast”, which is described on page 8.

Users may choose to include or exclude industrial process emissions (non-energy GHG emissions) in the tax program.

Users may also choose whether to exempt jet fuel, marine fuel or “transition coal” from the carbon tax. Jet and marine fuels are primarily combusted outside of state boundaries by out-of-state entities and are frequently exempted from carbon taxes. Transition coal refers to GHG emissions from the Trans Alta Centralia power plant which because of an earlier agreement with the state of Washington could be shielded from a carbon tax. Default settings for all model behavior inputs are denoted in column C.

### Subsection 4: Optional - exogenous reductions to specific energy sectors

The user may specify exogenous (outside the carbon tax program) reductions to these sectors: residential, commercial, industrial, and transportation. Reductions in fuel consumption outside of the carbon tax are often referred to complementary policies. Only the largest two or three fuel categories within each section can be addressed in this section.

For this and subsequent complementary policies described below, the user must specify three parameters.

1. The user must first determine the percent reduction in a specific fuel use that is to be expected from the complementary policy. For example a reduction of 10% of natural gas consumption in the residential sector.
2. Next, the sure selects a target year for achieving the percent reduction.
3. Finally the user specifies the ramp period which is the number of years from initiation of the complementary policy to full effectiveness.

### Subsection 5: Optional - exogenous reductions to industrial process emissions

Similar to subsection 4, the user can specify emission reductions to industrial process emissions, outside the carbon tax system.

The structure of this optional section is the same as the previous section. The user must specify a percentage reduction in emissions, target year, and ramp length.

### Subsection 6: Optional - supplemental fuel tax

A supplemental fuel tax may be added to the model. This represents a possible increase in federal or state (road) fuel taxes for gasoline and/or diesel. These taxes are generally not considered a complementary policy, but will influence the price of gasoline and diesel and therefore the consumption of these fuels.

### Subsection 7: Optional - invoke a low carbon fuel standard

An optional low carbon fuel standard program can be added to the model. This is another type of complementary greenhouse gas reduction strategy often considered by states. The user must specify the LCFFS reduction in average fuel carbon intensity (AFCI) as well as a target year for full implementation and a ramping period.

### Subsection 8: Optional – shut down Colstrip power plant

The coal-fired Colstrip power plant in Montana supplies a significant amount of Washington states imported electricity. This policy allows the users to specify a phase-out of electric power production at the Colstrip facility. A portion or the entire output of Colstrip may be specified. Variables in this subsection include shutdown date and percent replacement by natural gas fired electric power generation.

### Subsection 9: Optional – increase penetration rate of EVs

Measures to increase the rate of electric vehicle (EV) penetration represent another complementary policy. For this measure the key variable is the percent of gasoline displaced by increased market penetration of EVs. Variables establishing the target year and ramp period must be provided. The user should exercise caution using this option since EVs are also typically part of LCFS programs thus creating the potential to double count this policy option. If the LCFS option described above is not selected then double counting of GHG emission reductions from a complementary policy promoting EVs will not be a problem.

## DASHBOARD MODEL OUTPUT

After all the input variables are finalized, entered in the dashboard and pass the logic tests in column F, the model run is complete.

Model output includes:

1. A figure illustrating carbon dioxide equivalent emissions for 2005 through 2040. The light blue line represents the reference case, while the green line represents the emissions for the case with a carbon tax and any optional complementary or non-carbon tax policies that the user has selected. The state’s 2020 and 2035 GHG targets are also displayed in the figure.
2. There are five tables below the emissions figure. The first presents baseline and adjusted emissions (after carbon tax) for 2020 and 2035 for the residential, commercial, industrial, and transportation sectors.
3. The second and third tables summarize the carbon tax revenue in 2020 and 2035, expressed in 2012 dollars and effects of the revenue expressed as percent offsets of existing taxes (recall that CTAM assumes revenue neutrality).
4. The fourth table presents gross energy expenditures for the baseline and adjusted cases in 2020 and 2035, expressed in constant 2012 dollars.
5. The fifth table summarizes baseline and adjusted scenario unit energy prices for common fuels (gasoline, diesel, natural gas, residual fuel, and electricity) in the years 2020 and 2035.

## PARAMETERS TAB

This tab contains fixed parameters used in CTAM. Values in C21, which controls the share of Centralia generation that is sold to WA utilities, and C108-110, which controls the range of allowed start (2016) and stop years (2040), can be adjusted.

## ELASTICITIES TAB

The price elasticity (of demand) table is a key operational element of CTAM. The default values in the table are the product of an extensive literature search of fuel and sector specific price elasticity of demand values. The literature search and averaging methodology are summarized in the spreadsheet “CTAM 2015 Price Elasticity”, which is discussed on page 9.

The user has the option of inserting their own values in the price elasticity of demand values into column D of the table in place of the default values.

The table also has a “stickiness” parameter which can be thought of as the ramp or phase-in time required for 100 percent of the price elasticity to be fully realized. This “stickiness” reflects the response time necessary for consumers to replace a piece of equipment (vehicles, furnaces, boilers, etc.) after they face higher energy costs. Users may add their own “stickiness” values in column G of the table.

## RAMPS TAB

This tab contains the ramp rates for many parameters used in CTAM calculations. The ramp rates are derived from ramp values input by the user in the Dashboard tab. An example is the carbon tax ramp default value of $5 per year in cell C7 of the Dashboard tab. No direct user input is needed in the tab.

## PRICE SCENARIO TABS A, B, and C

CTAM will eventually contain three AEO 2015 Pacific region price scenarios one of which can be selected by the users on the Dashboard tab (cell D22) as the baseline for the model. The default setting is scenario A. The price scenario tabs are shaded green in CTAM.

* Scenario A represents the AEO 2015 Pacific region reference case.
* Scenario B represents the AEO 2015 Pacific region high energy cost case.
* Scenario C represents the AEO 2015 Pacific region low energy cost case.

Users may substitute other AEO scenarios, or their own price scenarios in these tabs: see description of spreadsheet “CTAM 2015 WA Energy Forecast” on page 8. Careful attention should be given to the order of the fuel pricing in the original AEO spreadsheet when copying and pasting into the price scenario tabs.

## CONSUMPTION SCENARIOS TABS A, B, and C

The consumption scenario tabs A, B, and C is associated with a similarly named price scenario tab. From the Dashboard tab the CTAM user will select one of the scenarios as the baseline for the model. The scenarios are derived from the AEO 2015 Pacific region consumption forecast spreadsheets: reference, high energy cost, and low energy cost cases. Theses tabs are also shaded green.

The consumption scenario data in the CTAM 3.0a as posted on the Commerce website does not need to be modified. If the CTAM user prefers to use different price and consumption scenarios than those already loaded into CTAM then the spreadsheet “CTAM 2015 WA Energy Forecast” must be used. See description on page 8.

## BASELINE TAB

Baseline energy prices, consumption, emissions, and expenditures represent the situation where there is no carbon tax. They contain calculated or extracted data and should not be altered by the user. These tabs are shaded yellow in CTAM.

## PRICE CHANGE TAB

This tab presents the change in the price of a specific fuel due to the imposition of a carbon tax, presented as a percent (increase) for the fuel in a given year.

Price change (%) = Carbon tax rate

 Baseline price

## ADJUSTED PRICE TAB

The adjusted tabs (six tabs: price change, energy prices, consumption, emissions, expenditures and revenue) are shaded light blue in CTAM and represent the case where the carbon tax is applied to the carbon content of the fuels. The adjusted price is the product of the baseline price (by fuel, by year) times one, plus the percent price change (see previous tab).

Adjusted price = Baseline price x (1 + price change)

## ADJUSTED CONSUMPTION TAB

Consumers adjust their consumption of fuels because of the higher cost created by the carbon tax.

Adjusted consumption = Baseline consumption x price change x price elasticity + baseline consumption

Note: price elasticity is a negative value, so adjusted consumption is always less than baseline consumption.

## ADJUSTED EMISSIONS TAB

Adjusted emissions are the product of adjusted consumption and an emission factor for a specific fuel.

 Adjusted emissions = adjusted consumption x emission factor

## ADJUSTED EXPENDITURES TAB

Adjusted expenditures are the product of adjusted price and adjusted consumption for a specific fuel.

 Adjusted expenditures = adjusted price x adjusted consumption

## REVENUE TAB

Revenue is the product of adjusted consumption and the carbon tax rate.

Revenue ($ millions) = adjusted consumption (quadrillion Btu) x 1000 x carbon tax ($/MMBtu)

## VERSIONS TAB

This tab contains the version history of CTAM as modifications have been made to the spreadsheet.

## UNITS TAB

This tab contains conversion factors for physical units.

# CTAM 2015 WA ENERGY FORECAST

If the user of the Carbon Tax Assessment Model (CTAM) wants to utilize an energy price and consumption forecast other than the three forecast data pairs (price and consumption) that are pre-loaded in the primary CTAM 3.0a spreadsheet, then the CTAM 2015 WA Energy Forecast (EF) spreadsheet must be used.

The EF spreadsheet converts the Energy Information Administration’s (EIA) Annual Energy Outlook (AEO) Pacific region energy price and consumption forecasts into Washington State specific price and consumption forecasts, which can then be transferred into the primary CTAM modeling spreadsheet (CTAM 3.0a).

To prepare the Washington State specific price and consumption forecasts CTAM user will first need to transfer the desired alternative AEO Pacific region forecasts (EIA prepares multiple alternative scenarios for each AEO release) to the pages designated “AEO regional price” and “AEO regional consumption”. The EF spreadsheet prorates the AEO Pacific region consumption data to represent Washington energy consumption using the factors in the page labelled “AEO proration”. The proration factors are derived from sets of Washington state and Pacific region historical data derived from the EIA State Energy Data System (SEDS).

The worksheet in the tab labelled “electricity” converts the AEO Pacific region electricity price data to a Washington state level electricity price forecast. In addition, a Washington state electricity fuel mix forecast is created in this tab. An industrial process emission forecast is created on the page labelled “process emissions”. The forecast relies on historical data and the state forecast of personal income growth.

The “price forecast” page in the EF spreadsheet is the resulting Washington state energy price forecast, and can be transferred to the desired “price scenario” tab in the primary CTAM 3.0a spreadsheet. The “consumption forecast” page is the Washington state energy consumption forecast and can be transferred to the desired “consumption scenario” tab in CTAM 3.0a. Care should be taken when transferring the AEO data into the EF spreadsheet. Fuel type labels in the source spreadsheet must align exactly with those in the EF. The same care must be shown when transferring the resulting Washington state energy price and consumption data into the CTAM 3.0a spreadsheet.

# CTAM 2015 PRICE ELASTICITY

This spreadsheet contains the latest review of price elasticity of demand literature. The tab labeled “Elasticities” illustrates which studies were used to establish fuel specific price elasticity values that are found in the primary spreadsheet CTAM 3.0a. The stickiness values used to phase in the fuel specific price elasticity values are also shown on the “Elasticities” tab. The tabs “New Literature” and “New Estimate” contain additional study details. The user can review the price elasticity information, remove studies that they feel are not representative, or add their own elasticity studies, and compute new values which can be used in the primary CTAM spreadsheet tab designated “Elasticities”.

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# CTAM AEO 2014 POLICIES and PROGRAMS

This spreadsheet provides a review of the policies and programs that have been incorporated and those that have not been incorporated into Annual Energy Outlook (AEO) 2014.

1. <http://www.eia.gov/forecasts/aeo/> [↑](#footnote-ref-1)