Climate Action Planning Tool Formulas and Assumptions

The Climate Action Planning Tool calculations use the following formulas and assumptions to generate the business-as-usual scenario and the greenhouse gas emissions reduction goals for the technology options.

Business-as-Usual Scenario

All Scope 1 (gas, oil, coal, fleet, and electricity) and Scope 2 calculations increase at a rate equal to the building growth rate. Scope 3 calculations (commuters and business travel) increase at a rate equal to the population growth rate.

Assumptions

- New buildings will consume energy at the same rate (energy use intensity) as existing campus buildings.
- Fleet operations will be proportional to total building area.

Technology Options

People and Policy

Space Planning and Use

Savings are calculated for growth reduction (priority) and new construction standards (secondary). The benefit is represented in the buildings energy sector. The energy reduction rate is applied to the new growth of Scope 1 and Scope 2 impacts. The building growth rate for the base case is reduced by a specified percentage. This growth reduction would be in response to a campus policy decision to actively manage existing space and reduce the need for new building area. This reduction is on all Scope 1 and Scope 2 impacts. This calculation also applies to the new buildings design technology option below.

Formula

Gas (Reduced Growth) = Gas (initial) × (1+ Growth rate × Growth rate reduction × New Buildings Design.

Assumptions

- New buildings will consume energy at the same rate (energy use intensity) as existing campus buildings.
- Reduction in building growth and new buildings design go into effect in year 1.

Energy Conservation

Energy conservation represents savings due to energy reduction in existing buildings. Only the initial scope impacts are used to calculate energy conservation savings on Scope 1 fuels (gas, oil, and coal) as well as Scope 2 purchased power. This action is in the buildings energy sector.

Formulas

- For each year of the energy conservation plan:

  Gas(Energy Conservation) = Gas(Initial) × (Energy Conservation %/Years of plan) × Year

- After Years of the Plan is complete the savings is a constant:

  Gas (Energy Conservation) = Gas(Initial) × Energy Conservation %.

Assumptions

- All fuels are burned centrally, and all purchased electric power is consumed in buildings or is a parasitic result of building usage such as distribution and boiler plant losses. This assumes that percentage energy reductions in buildings will result in equal percentage savings in parasitic loads.
- The energy conservation plan begins at year 1. An energy conservation plan is implemented over a specific number of "Years of the Plan" with reductions uniform over the term of the plan. At the end of the specified number of Years of the Plan, the reduction goal has been fully achieved.

Buildings
New Buildings Design
Calculations and formulas for new buildings design are the same as those listed above for space planning and use.

Assumption

- New buildings will consume energy at the same rate (energy use intensity) as existing campus buildings.

Transportation
Fleet Management
Carbon reductions due to fleet management are calculated as reducing the fleet impact to a specified fleet management percentage goal by a specified year. A fleet management plan is implemented over a specific number of Years of the Plan with reductions uniform over the term of the plan. At the end of the specified number of Years of the Plan, the reduction goal has been fully achieved and the fleet impact of new growth has been reduced by the reduction goal. The benefit will appear in the Transportation category.

Formulas

- For each year of fleet management plan:

> Fleet (Fleet Mgmt) = Fleet (Fleet Mgmt (Year-1)) - Fleet(initial) × Fleet Mgmt % / Years of Plan × Year.

- After years of the plan is complete:

> Fleet (Fleet Mgmt) = Fleet (Fleet Mgmt (Year-1)) × (1+Building Growth rate %).

Assumption

- Fleet growth is eliminated over the term of the plan.

Commuter Programs

Carbon reductions due to commuter programs are calculated as reducing the commuter impact to a specified commuter percentage goal by a specified year. A commuter program is implemented over a specific number of Years of the Plan with reductions uniform over the term of the plan. At the end of the specified number of Years of the Plan, the reduction goal has been fully achieved and the fleet impact of new growth has been reduced by the reduction goal. The benefit will appear in the Transportation category.

Formulas

- For each year of commuter plan:

> Commuters (Commuter) = Commuters (Commuter (Year-1)) − Commuters (initial) × Commuter plan % / Years of Plan × Year.

- After Years of the plan is complete:

> Commuters (Commuter) = Commuters (Commuter (Year-1)) × (1+Commuter
> Growth rate %).

Assumption

- Commuter growth is eliminated over the term of the plan.

Business Travel

Carbon reductions due to business travel changes are calculated as reducing the business impact to a specified business travel percentage goal by a specified year. Business change is implemented over a specific number of Years of the Plan with reductions uniform over the term of the plan. At the end of the specified number of Years of the Plan, the reduction goal has been fully achieved and the fleet impact of new growth has been reduced by the reduction goal. The benefit will appear in the transportation energy sector.

Formulas

- For each year of Business travel change plan:

> Business (Busn Chng) = Business (Busn Chng (Year-1)) − Business (initial) × Business change plan % / Years of Plan × Year.

- After Years of the plan is complete:

> Business (Busn Chng) = Business (Busn Chng (Year-1)) × (1+Commuter Growth
> rate %).

Assumptions

- Business travel growth is eliminated over the term of the plan.
- The baseline growth of business travel impact is proportional to the increase in campus population (i.e., commuter growth rate).

Energy Sources

Fuel Sources: Coal to Gas

Calculates carbon reduction based on conversion of coal fuel to natural gas. On an energy basis the carbon impact of coal is twice that of natural gas (227 lb carbon dioxide [CO_2]/MMBtu vs. 117 lb CO_2/MMBtu). The conversion is made in terms of a percent of the coal use being converted to natural gas in a specific year. This is consistent with the installation of a new gas boiler coming on line with a step change in fuels. The benefit will appear in the energy sources energy sector.

Formulas

- After the specified year of the fuel change the coal impact is reduced to:

> Coal (Coal-gas) = Coal (Busn Chng) × (1− % Coal-Gas).

- After the specified year of the fuel change the gas impact is increased to:

Gas (Coal-gas) = Gas (Busn Chng) + (Coal (Busn Chng) × % Coal-Gas/2).

Assumptions

- Conversion from coal to natural gas will cut carbon impact in half. This assumes combustion and distribution efficiencies are equal for the two fuels.
- After a fuel change is made in a specified year, that change will be consistent for all subsequent years at the specified percentage.
- The impact of gas is increased by half the amount of the coal decrease consistent with the 2:1 carbon impact of coal as compared to gas.

Fuel Sources: Coal to Wood

Calculates carbon reduction based on conversion of coal fuel to wood or other climate neutral biomass. Wood is considered a climate neutral fuel and the carbon impact of the coal is reduced by the percentage of wood substitution. The conversion is made in terms of a percent of the coal use being converted to wood in a specific year. The benefit will appear in the energy sources energy sector.

Formula

- After the specified year of the fuel change the coal impact is reduced to:

Coal (Coal-wood) = Coal (Coal-gas) × (1− % Coal-Wood).

Assumptions

- Conversion from coal to wood eliminates the coal carbon impact with the assumption that the wood is a climate neutral fuel.
- After a fuel change is made in a specified year, that change will be consistent for all subsequent years at the specified percentage.

Combined Heat and Power (CHP)

Calculates the reduced impact resulting from gas-fired combined heat and power (CHP). There is no target goal within the calculation for CHP, only a year of implementation. In the year specified, CHP will be introduced at a capacity that is limited by either the gas consumption or the electric use in that year. The benefit will appear in the energy sources energy sector.

Formulas

- After the year of CHP implementation:

Convert electric and gas to MWh to determine which is limiting factor:
Electric MWh = Electric CO_2/ Electric CO_2 factor × 2204 lb/Ton
(MWh) TonCO_2 lbsCO_2/MWh lbs/Ton

- Convert gas impact prior to CHP implementation to its capacity to generate power:

Electric MWh = Gas CO_2 × 1.5
MWh Ton CO_2 MWh/Ton CO_2

- If the electric use is lower, this is the limiting factor and the electric impact is reduced to 0 (Zero) meaning all electric use is a by-product of CHP.
- If the gas use is the limiting factor the electric impact is reduced to:

Electric (CHP) = Electric (Coal-wood) − Gas (Coal-wood) × .33 × Electric carbon factor (Inputs)/500

- Gas impact must be increased to correspond to increase gas use for CHP.
- If the electric use is the limiting factor and the gas impact is increased to:

Gas(CHP) = Gas(Coal-wood) + Electric(Coal-wood) × 500 / Electric carbon factor
(Inputs)

- If the gas use is the limiting factor the gas impact is increased to:

Gas(CHP) = Gas(Coal-wood) × 1.33

Assumptions

- The calculation of the amount of energy generated is limited by either the gas used for heating or the purchased electricity, which is how most campuses use CHP.
- This is consistent with operation of the system such that it will not dump excess heat or export electric power. Gas factor = 117 lb CO_2/MMBtu.
- Heat to power ratio = 3 units of thermal heat to each unit of electric power.
- System efficiency is .80 and equal to the efficiency of the gas heating system.
- With these assumptions the amount of electric power produced per Tonnes of CO_2 equivalent (T CO_2e) of original gas is 1.47 MWh/T CO_2e gas which has been rounded to 1.5.

- Also at these factors CHP generates electric power with a CO_2 factor of 499 $lbCO_2/MWh$ which has been rounded to 500.
- All of the climate benefit of CHP has been shown in the Source 2 Purchased Electricity calculation rather than being pro-rated between gas and electric use.

Renewable Electricity

Calculates the benefit of purchased renewable electric power. In terms of carbon impacts, it does not matter whether the power is wind or solar, owner installed or via a Power Purchase Agreement. The user specifies a percentage of renewable electric purchase to begin in a specific year. Beginning in that year the electric impact is reduced by that percentage for all subsequent years. The benefit will appear in the energy sources energy sector.

Formula

- After the year renewable purchase begins:

Electric (renewable) = Electric (CHP) (1− Renewable %).

Assumption

- If CHP is in place, the electric impact reduction from that has been taken, and the remaining electric impact is all that will be considered for renewable purchase.

Carbon Offsets and Certificates

After all the technology option reduction goals have been entered and their total impact calculated, the tool calculates carbon offsets and certificates as a percentage of the remaining carbon impact. Beginning in the year after the entered plan year, the carbon impact is reduced by that percentage for all subsequent years. The benefit will appear in the offsets and certificates energy sector.

Formula

- After the plan year carbon offsets begin:

Carbon Offset = Total Carbon (1− Carbon Offset %).

Assumption

- Beginning in the year after the entered plan year, the carbon impact is reduced by that percentage for all subsequent years.