CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

Overview and Introduction to Solid Waste Emissions Estimation Tool (SWEET) v3.0

Abt Associates on behalf of the U.S. EPA

Overview

- Background
- SWEET Overview
- Illustrative Examples
- Concluding Thoughts

Background

Short-lived Climate Pollutants (SLCPs)

- Subset of greenhouse gases and aerosols that
  - Contribute to global warming
  - Remain in the atmosphere for shorter periods compared to long-lived GHGs
  - Have detrimental impacts on human health, agriculture, ecosystems
- UNEP study: Near-term reductions in SLCPs could result in
  - 0.6^{o} C in avoided warming in 2050
  - 2.4 million avoided premature deaths from reduced pollution in 2030
  - 52 million metric tons of avoided annual staple crop losses in 2030

More information: http://ccacoalition.org/en/science-resources

SLCPs from the Waste Sector

Black Carbon

- A component of particulate matter
- Formed by incomplete combustion of fossil fuels, biofuels, and biomass
- Atmospheric lifetime: Days/weeks
- Significant climate forcer
  - GWP_{100}: Variable (global avg ~910*)
- Contributes to same health impacts as fine particulate matter

** Bond et al. 2013. Bounding the Role of Black Carbon in the Climate System: A Scientific Assessment*

SLCPs from the Waste Sector

Methane

- Produced by anaerobic decomposition of organic material
- Key drivers:
  - Amount of organic waste deposited
  - Extent of anaerobic decomposition
  - Waste cover properties
  - Methane oxidation rates
- Atmospheric lifetime: 12 years
- Significant climate forcer
  - GWP_{100}: 28-36*
- Contributes to the formation of tropospheric ozone, an air pollutant

** IPCC AR5*

Challenges to Estimating SLCPs from the MSW Sector

- Lack of activity data
  - Waste generated and disposed or burned
  - Waste composition
  - Fuel consumed or miles driven by waste collection vehicles
- Lack of emissions factors for certain MSW sector sources
  - E.g., high variability in emissions factors for garbage burning
- Disposal site methane generation and emission rates are not measured, creating large uncertainties
- Calculations can be complex, especially for landfills

Summary

- MSW sector is a key sources of SLCP emissions
- These emissions have significant impacts on human health and climate
- Understanding the magnitude of these emissions is necessary for identifying appropriate mitigation solutions
- But estimating emissions can be complicated and burdensome

Tool History

- SWEET 1.0 (May - October 2017)
  - Original release of SWEET was in May 2017.
  - SWEET was then updated in October 2017 to address some bugs after receiving user feedback.
- SWEET 2.0 (February 2018)
  - Tool revised so that the user interface and input sheets are easier to understand.
  - More information provided to user on waste burning.
  - Additional bug fixes identified in SWEET v1.0 addressed.
  - SWEET User Manual published.
- SWEET 2.1 (May 2018)
  - Additional bug fixes identified in SWEET v2.0 addressed.
  - Adjustments and fixes made to a number of default assumptions.
  - SWEET v2.1 Example, Portuguese, and Spanish versions published.
- SWEET 3.0 (May 2019)
  - Temporal component added to waste burning allowing user to edit open burning assumptions with time.
  - Additional bug fixes identified and fixed.
  - Default assumptions about methane correction factors adjusted to reflect more accurately realistic conditions in dumpsites and landfills.
  - Users allowed to enter alternative scenarios start years to enhance model accuracy

SWEET Overview

Solid Waste Emissions Estimation Tool (SWEET) - Overview

- Developed by the U.S. EPA on behalf of the CCAC Waste Initiative
- Excel-based tool for quantifying pollutant emissions from sources across the waste sector
    - Project-, source-, or system-level emissions estimates
    - Baseline scenario and up to four alternative scenarios

Emissions Sources and Example Required Inputs

Source	Examples of Required Inputs
General Information	• Waste generation/collection rates • Population • Waste composition
Landfills and Dumpsites (up to four disposal sites under each scenario)	• Waste quantity • Waste composition • Depth • Open and closure years • Gas collection system
Waste Collection and Transport	• Number of trucks of different types (gasoline vs. diesel)
Waste Burning	• % of waste burned in the open or at landfills/dumpsites
Waste Handling	• Number of bulldozers and other large equipment (etc.)
Organics Management Facilities	• Waste quantity • Waste composition • Discard rate
Waste Combustion	• Waste quantity • Reject rate

SWEET Outputs

- Emissions are presented in terms of metric tons and metric tons of carbon dioxide equivalent (CO_2e)
- Estimates are presented for each individual source and for entire waste sector
- Pollutants include: Black Carbon, CH_4, CO_2, NOx, SOx, $PM_{2.5}$, PM_{10}, Organic Carbon

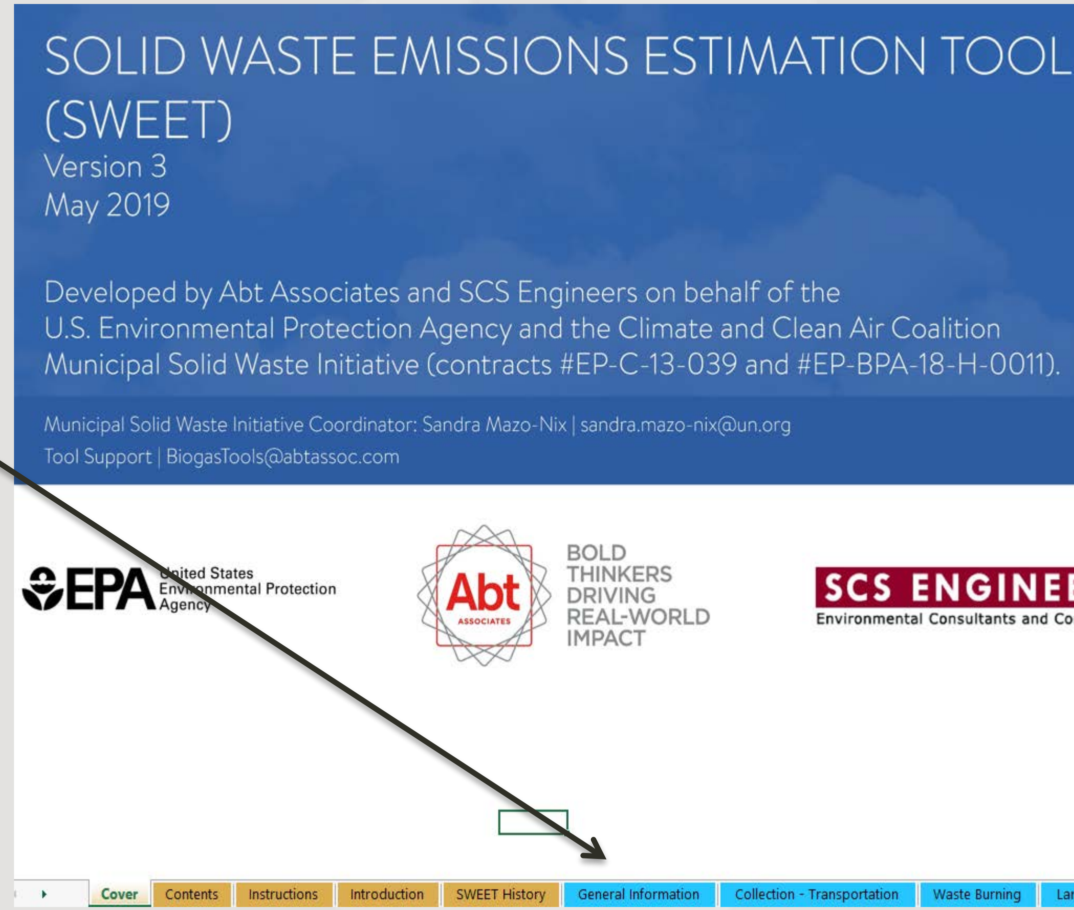
Tool Overview

- Generates estimates of city-level emissions
- Pollutants include: CO_2, CH_4, NO_x, SO_x, PM_{10}, $PM_{2.5}$, Organic Carbon, and Black Carbon
- Emissions sources
  - Waste collection and transportation
  - Open burning (at landfills/dumps and away from disposal sites)
  - Landfills and open dumps
  - Organic waste management facilities (e.g., composting facilities)
  - Waste handling equipment (e.g., forklifts, bulldozers)
  - Waste combustion equipment (e.g., waste-to-energy facilities)
- Calculations
  - For most sources, annual emissions calculated based on annual activity data
  - For landfills and open dumps, tool uses disposal site data to calculate annual methane emissions into the future (i.e., to 2050)

Using SWEET

SWEET is organized as follows:

- **BROWN** tabs provide instructions, notes, assumptions, default values references, and additional information
- **BLUE** tabs are for users to enter data.
- **BLACK** tabs provide tables and charts that summarize the tool's outputs
- **GRAY** tabs provide more detailed emissions results from the baseline and alternative scenarios



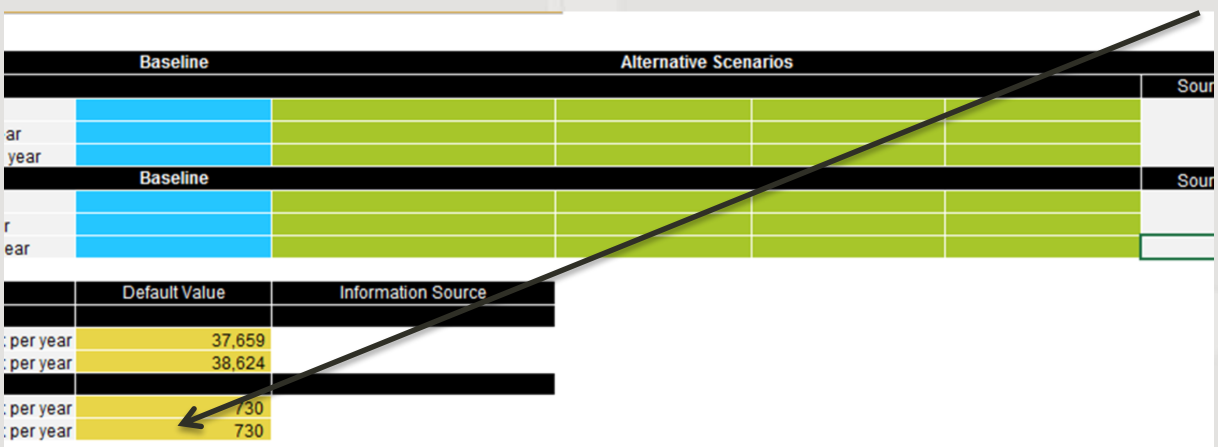
Using SWEET

In the **BLUE** tabs:

- Users **must** enter data in every cell that is shaded **BLUE**. This information will be used to generate baseline emissions estimates.
  - o Users must enter data in every **BLUE** cell in every **BLUE** tab before the tool will produce results.

- Users **can** enter data for up to four alternative scenarios in cells that are shaded **GREEN**.

- Users **can** override default values and assumptions in **YELLOW** cells if local data is available.



Using SWEET

- SWEET relies on a number of assumptions and default values
  - Default values can be overridden and reset
- Except for landfills and open dumps, inputs are fairly limited
- Landfills and open dumps require more inputs
  - Largest SLCP emissions source
  - Considerable variability depending on site-specific details

Modeling Simple Open Burning Scenario in SWEET 3.0

Assuming open burning rates fall from 10 percent to 5 percent in 2020

Open Burning Rates (I.)	Business-as-Usual	Alternative Scenario 1
Business-as-Usual/Alternative Scenario Start Year	2018	2020
Percentage of uncollected waste that is burned in the open by residents living outside formal collection zones	10%	5%
Percentage of uncollected waste that is burned in the open by residents living inside formal collection zones	10%	5%
Percentage of waste disposed at landfills or dumpsites that is ultimately burned at the landfill or dumpsite	10%	5%
Open Burning Rates (II.)	**Business-as-Usual**	**0**
Do you wish to model a change in open burning rates under one or multiple of the scenarios identified above (e.g., a phased reduction in open burning rates)?		No
Business-as-Usual/Alternative Scenario Start Year	2018	
Percentage of uncollected waste that is burned in the open by residents living outside formal collection zones		
Percentage of uncollected waste that is burned in the open by residents living inside formal collection zones		
Percentage of waste disposed at landfills or dumpsites that is ultimately burned at the landfill or dumpsite		

Modeling Complex Open Burning Scenario in SWEET 3.0

Assuming open burning rates fall from 10 percent to 5 percent in 2020. Then in 2030, open burning rate falls to 2 percent.

Open Burning Rates (I.)	Business-as-Usual	Alternative Scenario 1
Business-as-Usual/Alternative Scenario Start Year	2018	2020
Percentage of uncollected waste that is burned in the open by residents living outside formal collection zones	10%	5%
Percentage of uncollected waste that is burned in the open by residents living inside formal collection zones	10%	5%
Percentage of waste disposed at landfills or dumpsites that is ultimately burned at the landfill or dumpsite	10%	5%
Open Burning Rates (II.)	**Business-as-Usual**	**0**
Do you wish to model a change in open burning rates under one or multiple of the scenarios identified above (e.g., a phased reduction in open burning rates)?		Yes
Business-as-Usual/Alternative Scenario Start Year	2018	2030
Percentage of uncollected waste that is burned in the open by residents living outside formal collection zones		2%
Percentage of uncollected waste that is burned in the open by residents living inside formal collection zones		2%
Percentage of waste disposed at landfills or dumpsites that is ultimately burned at the landfill or dumpsite		2%

Modeling Complex Open Burning Scenario in SWEET 3.0 (continued)

Test two scenarios, one where open burning is controlled at landfills and dumpsites versus reducing open burning from residents living inside collection zones.

Open Burning Rates (I.)	Business-as-Usual	Alternative Sc Alternative Scenario 1	Alternative Scenario 2
Business-as-Usual/Alternative Scenario Start Year	2018	2020	2020
Percentage of uncollected waste that is burned in the open by residents living <u>outside</u> formal collection zones	10%	10%	10%
Percentage of uncollected waste that is burned in the open by residents living <u>inside</u> formal collection zones	10%	5%	10%
Percentage of waste disposed at landfills or dumpsites that is ultimately burned <u>at the landfill or dumpsite</u>	10%	10%	5%
Open Burning Rates (II.)	**Business-as-Usual**	**Alternative Sc 0**	**0**
Do you wish to model a change in open burning rates under one or multiple of the scenarios identified above (e.g., a phased reduction in open burning rates)?		Yes	Yes
Business-as-Usual/Alternative Scenario Start Year	2018	2030	2030
Percentage of uncollected waste that is burned in the open by residents living <u>outside</u> formal collection zones		10%	10%
Percentage of uncollected waste that is burned in the open by residents living <u>inside</u> formal collection zones		2%	10%
Percentage of waste disposed at landfills or dumpsites that is ultimately burned <u>at the landfill or dumpsite</u>		10%	2%

Examples of Inputs

- Waste Collection and Transport
  - Number of trucks of different types (gasoline vs. diesel)
- Open Burning
  - % of uncollected waste that is burned in the open
- Waste Handling
  - Number of bulldozers (etc.)
- Organic Waste Management Facilities
  - Waste composition
  - Discard rate
- Waste Combustion
  - Reject rate
- Landfill Gas Collection
  - Depth
  - Open and closure year
  - Gas collection system

SWEET Outputs

Emissions are presented in terms of:

- Metric tons
- Metric tons of carbon dioxide equivalent

Estimates are presented for each individual source and for entire waste sector

- Tables
- Graphs

Figure 10. Future Landfill Emissions by Scenario

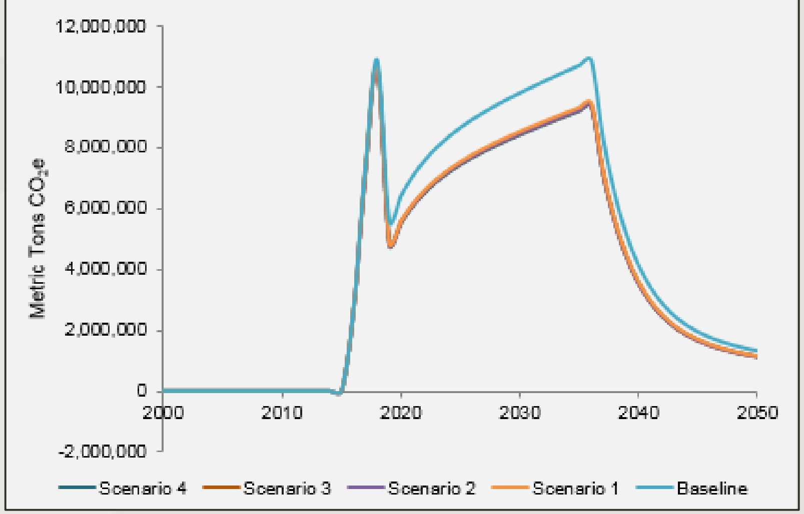
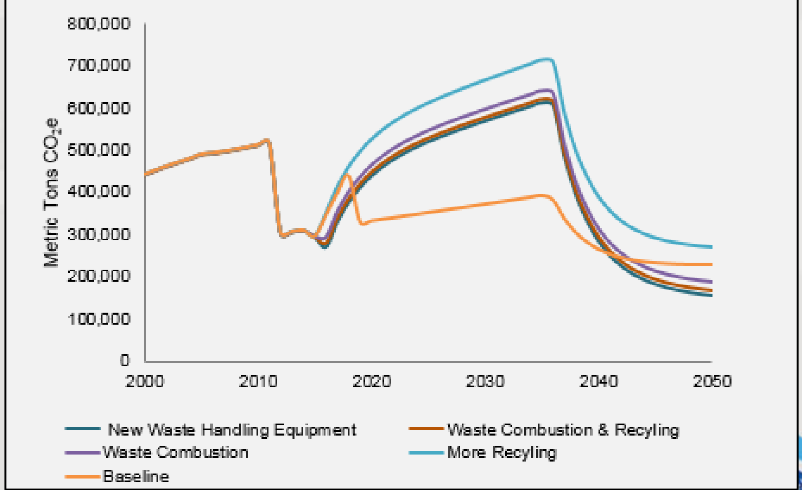


Figure 4. Total Emissions by Scenario including CO_2, NOx, BC, CH_4, Organic Carbon



Output Uses

Cities can use this information for multiple purposes:

- Establishing a city-level baseline
- Comparing city-level baseline scenarios to as many as four alternative scenarios
- Analyzing specific projects for potential emissions reductions
- Estimating the contribution of activities in the waste sector to overall city emissions reduction goals
- Tracking progress over time

Key Sources and Assumptions

- Emissions factors and other assumptions and default values are from EPA Guidelines or peer-reviewed studies
- Emissions calculations are based on established methods
  - E.g., Intergovernmental Panel on Climate Change and numerous tools developed by the EPA and the Global Methane Initiative
- Numerous other assumptions and sources, fully document in the tool

Uses

- Analyzing air quality and climate change impacts/benefits of projects or policies
  - E.g., analyzing the benefits of an anaerobic digestion project in Naucalpan, Mexico
- Comparing alternative waste management scenarios/practices
- Informing decisions about capital investments (e.g., when to install landfill gas capture equipment)
- Tracking performance
- Consistent benchmarking across cities (important for the CCAC Waste Initiative)

Caveats

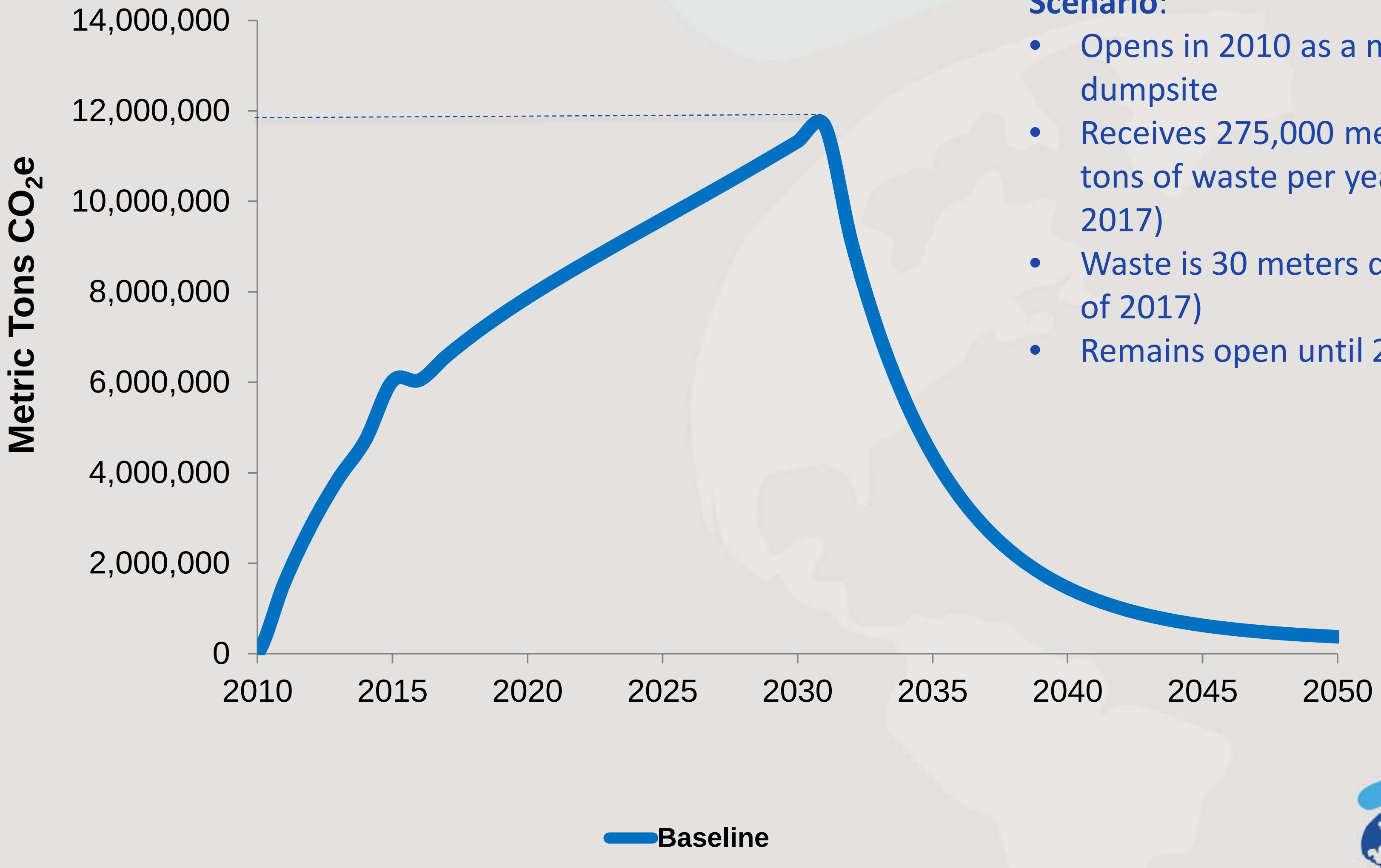
- Uses information from EPA studies and guidelines, peer-reviewed studies, and other credible sources
- Calculations based on established methods (e.g., IPCC)
- Yet, estimates should be considered preliminary
  - Even best estimates have high degree of uncertainty
  - Default values may not be applicable to all cities

Illustrative Examples

Hypothetical City

- Population: 4 million
- Average temperature: 16° C
- Average precipitation: 1,000 mm
- Waste generation rate: 0.45 kg/capita/day
- Waste collection rate: 80%
- Waste composition: 65% organic

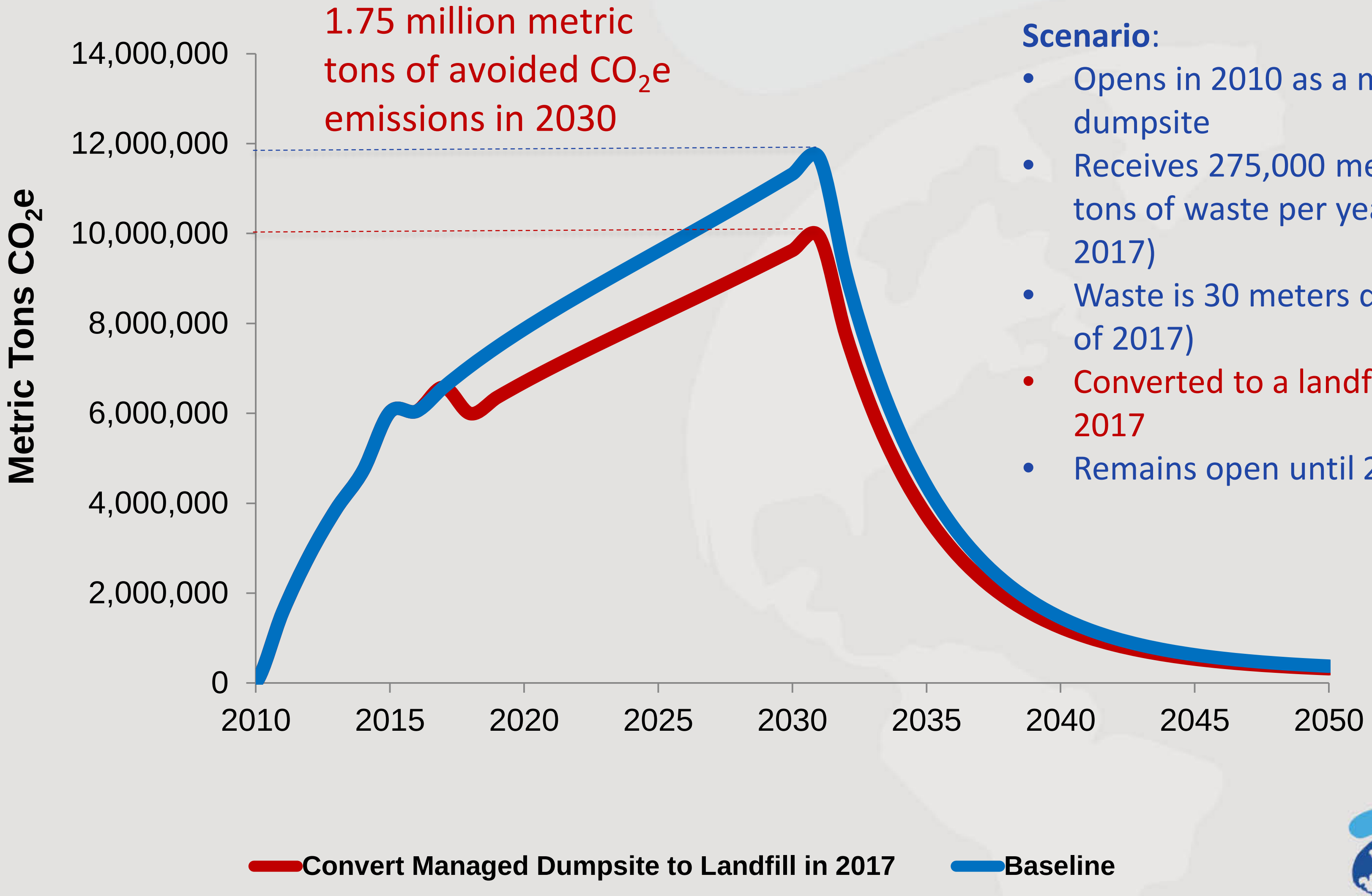
Example 1 – Upgrading Dumpsite



Scenario:

- Opens in 2010 as a managed dumpsite
- Receives 275,000 metric tons of waste per year (as of 2017)
- Waste is 30 meters deep (as of 2017)
- Remains open until 2030

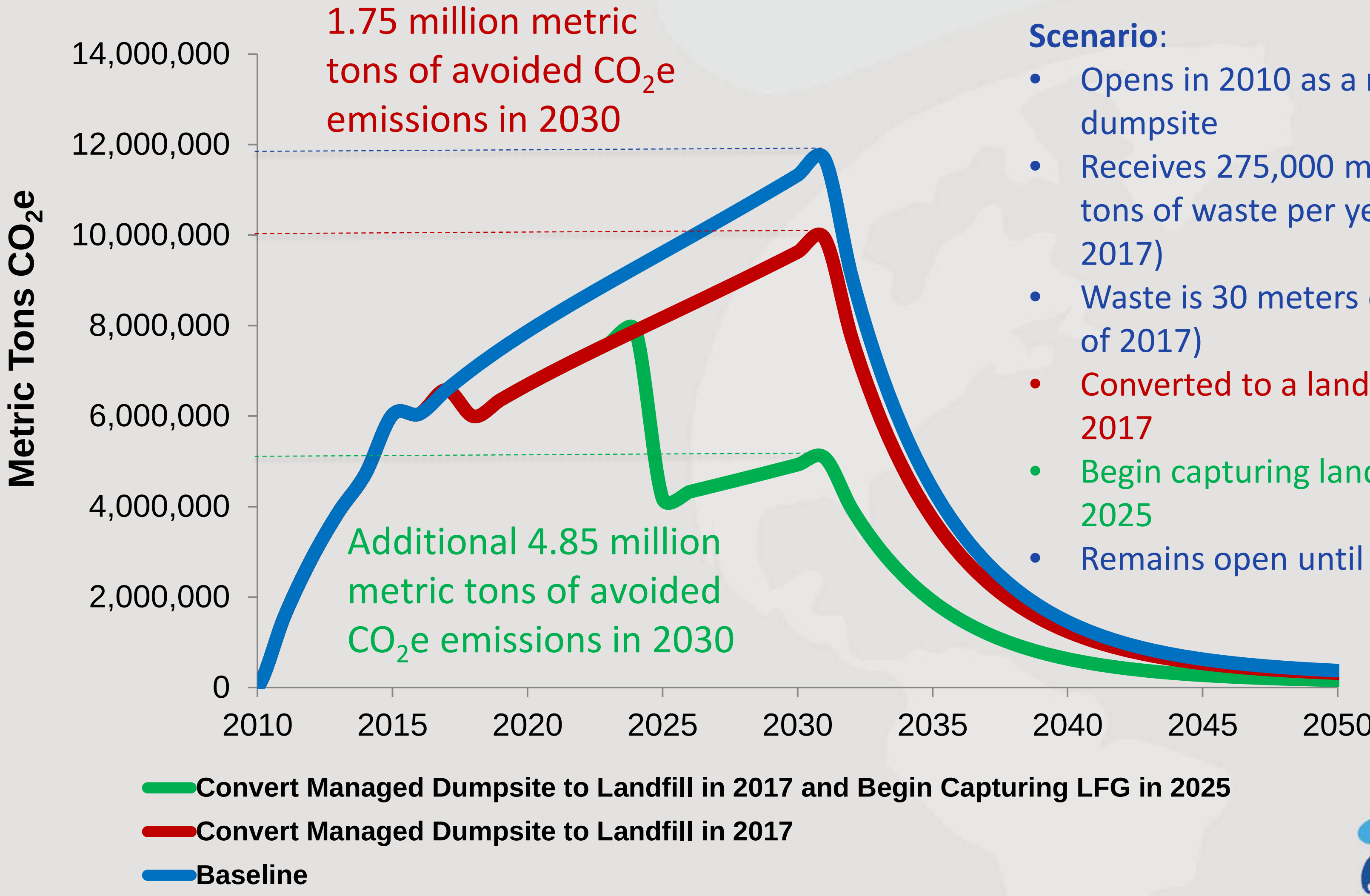
Example 1 – Upgrading Dumpsite



Scenario:

- Opens in 2010 as a managed dumpsite
- Receives 275,000 metric tons of waste per year (as of 2017)
- Waste is 30 meters deep (as of 2017)
- Converted to a landfill in 2017
- Remains open until 2030

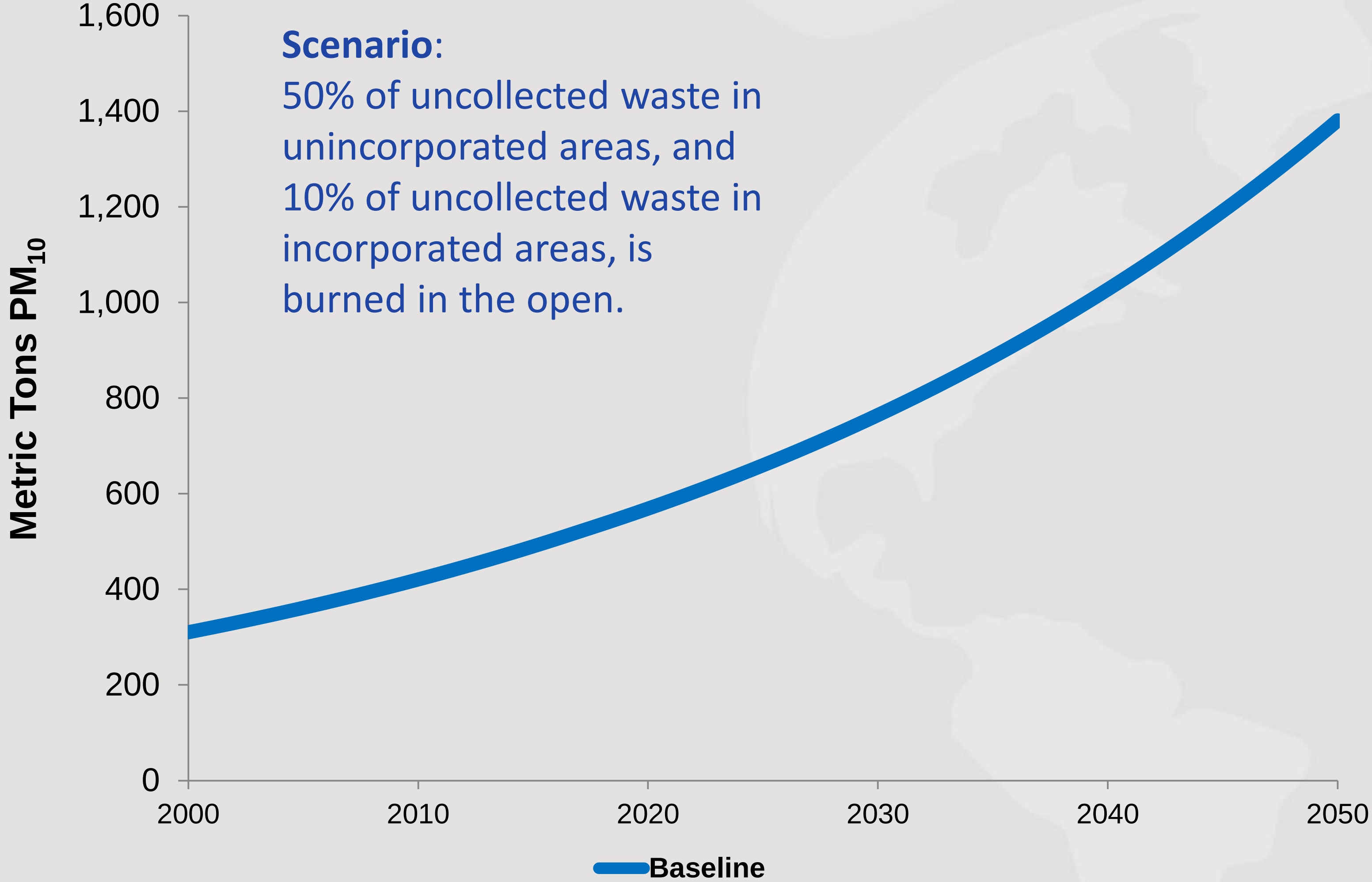
Example 1 – Upgrading Dumpsite



Scenario:

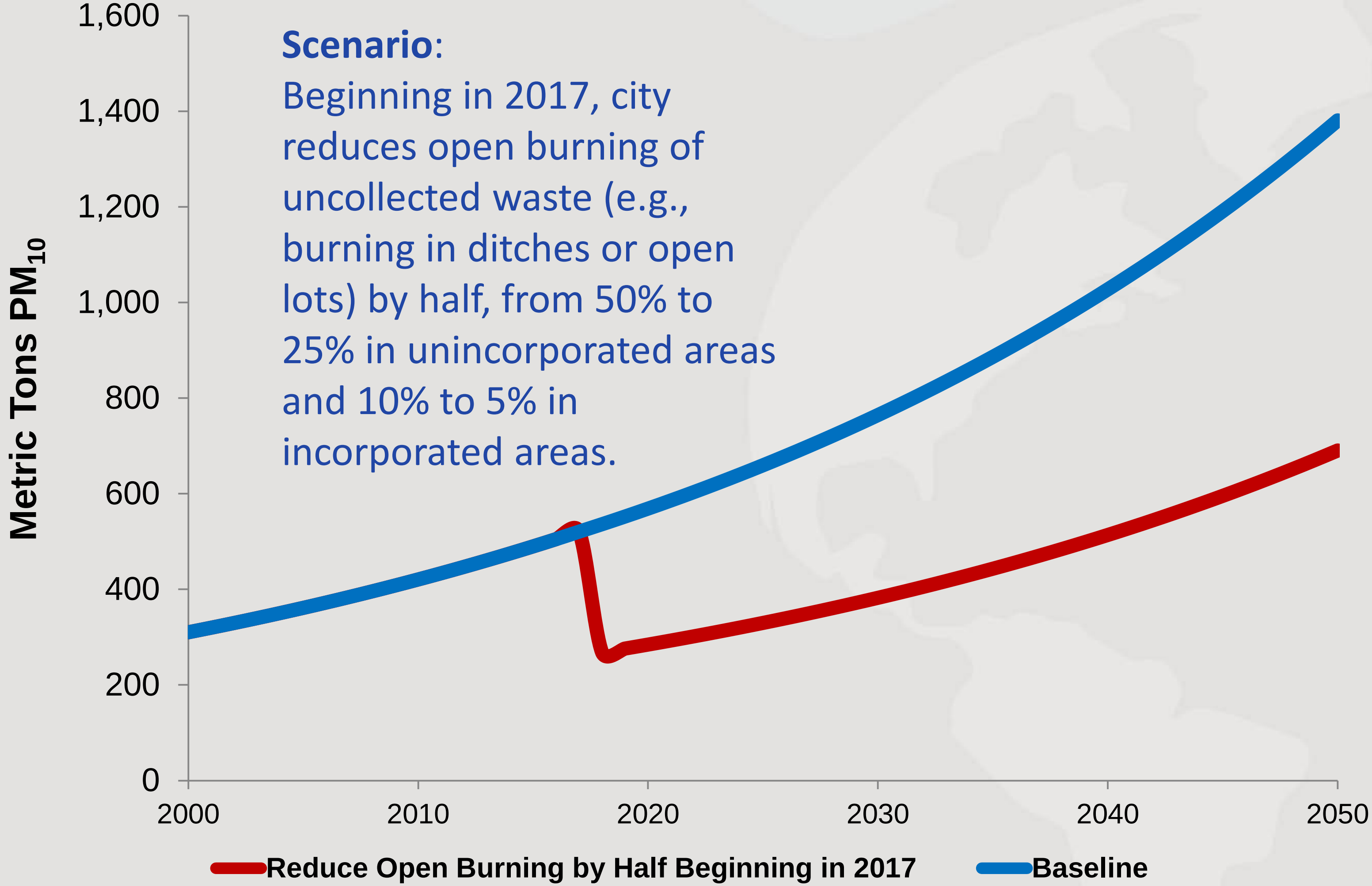
- Opens in 2010 as a managed dumpsite
- Receives 275,000 metric tons of waste per year (as of 2017)
- Waste is 30 meters deep (as of 2017)
- Converted to a landfill in 2017
- Begin capturing landfill gas in 2025
- Remains open until 2030

Example 2 – Reducing Open Burning



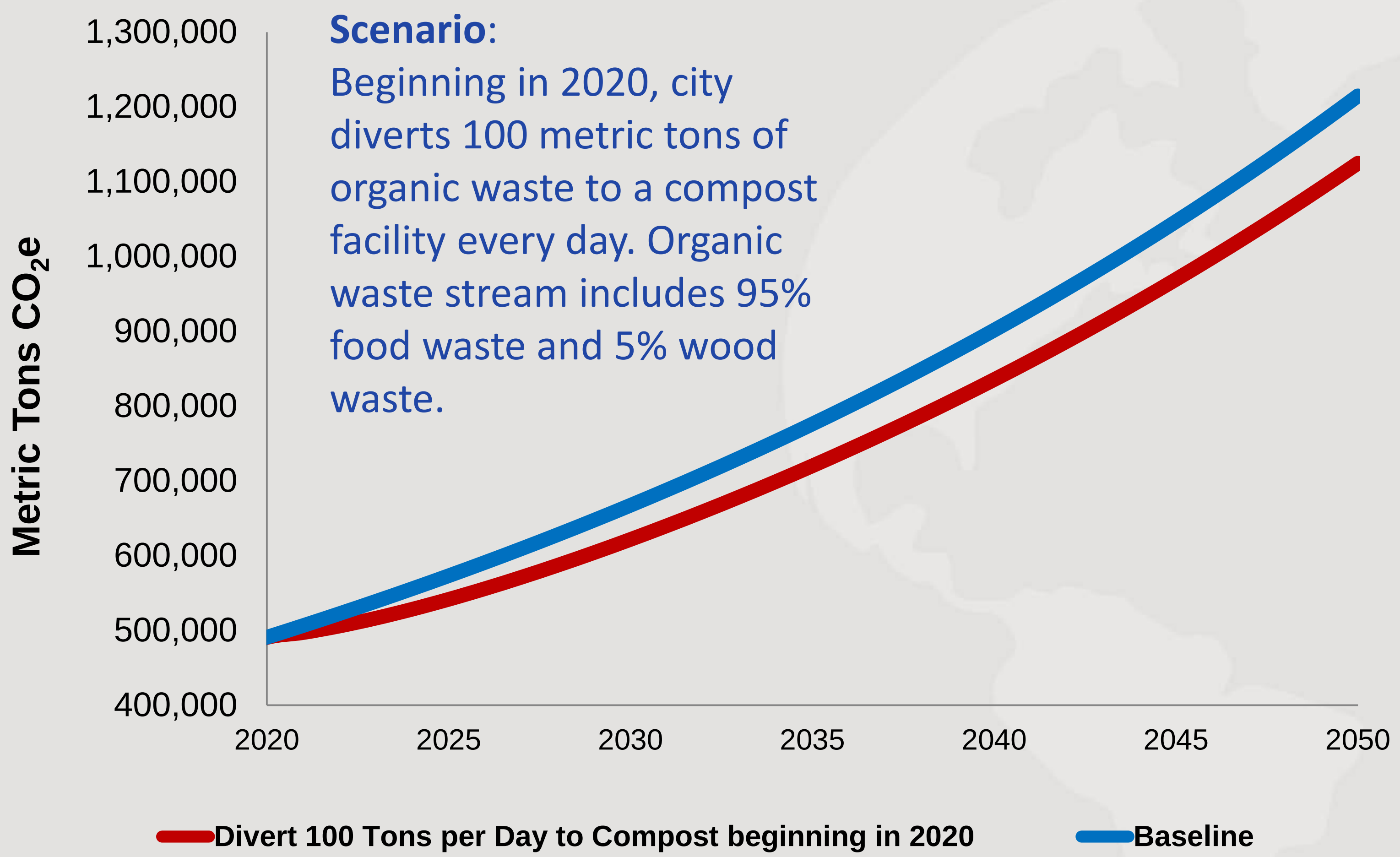
Scenario:
50% of uncollected waste in unincorporated areas, and 10% of uncollected waste in incorporated areas, is burned in the open.

Example 2 – Reducing Open Burning



700 metric tons of avoided PM_{10} emissions in 2050

Example 3 – Diverting Organic Waste



100,000 metric tons of avoided CO_2e emissions in 2050

Concluding Thoughts

Summary

- MSW sector is an important source of SLCP emissions
- Quantifying SLCP emissions from the waste sector is challenging
- SWEET is designed to help address these challenges
- SWEET assists cities in prioritizing potential SLCP reduction measures and serves a wide range of other uses

Frequently Asked Questions

Q: Where can I access the tool?
A: The tool will be available on the CCAC Waste Initiative Knowledge Platform: http://www.waste.ccacoalition.org/tool

Q: Is there a user guide or manual for the tool?
A: There is no user guide or manual at this time. Additional guidance may be prepared for a subsequent Version 2, which will likely be available in 2018.

Q: How accurate should I consider the results?
A: Users should consider the results to be a preliminary, first-order estimate. Many of the default emissions factors are for the U.S. waste sector. Adding country specific information (e.g., by overriding default values) will improve the accuracy of the tools emission estimates.

Q: In what ways does the tool allow my municipality to evaluate potential projects or policies?
A: The user can compare emissions reductions from up to four alternative scenarios. These scenarios can incorporate difference practices and technologies, such as diverting organic waste to composting or anaerobic digestion projects; banning open burning; capturing and using landfill gas; implementing high-BTU gas-to-energy projects; changing transportation fuels; and upgrading dumpsites.

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- Joe Donahue, Abt Associates (Project Coordinator)

Resources

CCAC Waste Initiative Website:
http://www.ccacoalition.org/en/initiatives/waste

CCAC Waste Initiative Knowledge Platform:
http://www.waste.ccacoalition.org/tool

Thank you! Questions?

Access SWEET:

https://www.waste.ccacoalition.org/document/solid-waste-emissions-estimation-tool-sweet-version-30

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