

## Offsets: IPM Modeling Assumptions

### Overview

A combined offsets supply curve was derived for RGGI IPM modeling, consisting of a supply curve applied in each IPM “run year.” The combined supply curve consists of distinct supply curves for landfill gas (LFG), sulfur hexafluoride (SF<sub>6</sub>), and afforestation, as well as a market price estimate for Clean Development Mechanism (CDM) credits. This memorandum outlines the data sources and assumptions used to develop the supply curves for RGGI modeling of offsets in IPM.

### General Assumptions

RGGI-applicable electric generation units in IPM were allowed to comply with the cap by utilizing offsets beginning in the first year of the 2009 IPM run year (2008), with the exception of afforestation offsets, which could not be used until the first year in the 2012 IPM run year (2011). This temporal limitation was placed on afforestation offsets based on expert input, as a proxy for the time needed to implement afforestation projects and begin sequestering significant amounts of carbon.

CDM credits were assumed to be available at a price of \$6.50/ton of CO<sub>2</sub> equivalent, based on recent project data. A supply curve was not used to estimate the price and supply of CDM credits.

The amount of offsets that could be used for compliance was limited to an annual CO<sub>2</sub> tonnage amount equivalent to 50% of the difference between projected business-as-usual CO<sub>2</sub> emissions (emissions in the applicable IPM reference case) and the cap level in each year under the package scenario (stabilization at 2006 reference case emissions through 2013, with a reduction to 10% below this level in 2020).<sup>1</sup> The CO<sub>2</sub> tonnage amount of allowable offsets in each IPM run year was based on an average of annual allowable amounts under different phases of the cap (stabilization and reduction). For additional details, see “IPM Modeling Results – Offsets Summary,” available at <http://www.rggi.org/documents.htm>.

### Detailed Offsets Assumptions<sup>2</sup>

*Offsets Modeled:*

- Landfill Gas (LFG)

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<sup>1</sup> This cap schedule is a representation of the SWG package proposal. Annual timing of the reduction schedule differs slightly from the package proposal due to the structuring of IPM “run years”.

<sup>2</sup> Note, due to a lack of readily available data, assumptions for natural gas/oil offsets were not used in the IPM modeling. The model therefore functionally assumes that potential offsets supply from this category is not available.

- Sulfur Hexafluoride (SF<sub>6</sub>)
- Afforestation (conversion of land from non-forested to forested state)

### Landfill Gas

Nine-state RGGI region supply curves were derived from national marginal abatement cost curves (MACs). These MACs are for non-NSPS landfills only and do not include transaction costs or incentive costs. The MACs provide available offsets supply (tons CO<sub>2</sub>e) at different price points (\$/ton CO<sub>2</sub>) for temporal points from 2000-2020 (five-year increments). A corresponding RGGI supply curve was applied in the closest applicable IPM “run year”.

RGGI region supply curves were derived from the MACs for the U.S. that were developed by Gallaher et al. (“Region-Specific Marginal Abatement Costs for Methane from Coal, Natural Gas, and Landfills through 2030,” 7th Greenhouse Gas Technology Workshop (GHGT7), July 2004). These MACs are generally consistent with MACs derived by U.S. EPA.<sup>3</sup>

### Determining RGGI Region Offsets Potential

The projected emissions offset potential and national MACs were adjusted based on the population of landfills and MSW generation in the nine-state RGGI region as a percentage of the national population of landfills and national MSW generation.<sup>4</sup>

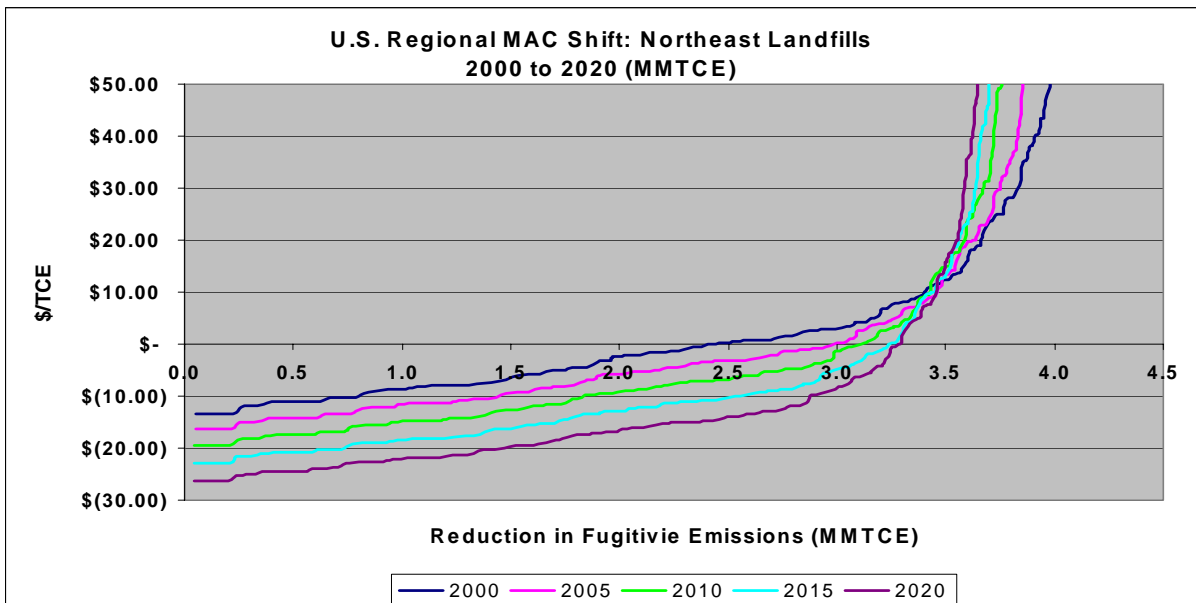


Figure 1. Landfill Gas Regional Marginal Abatement Curve (Prior to SWG Adjustments)

<sup>3</sup> See U.S. EPA, *U.S. Methane Emissions 1990-2020: Inventories, Projections, and Opportunities for Reductions*, 1999 (EPA 430-R-99-013); U.S. EPA, *Addendum to the U.S. Methane Emissions 1990-2020: 2001 Update for Inventories, Projections, and Opportunities for Reductions*, 2001.

<sup>4</sup> See Kaufman, Scott, et al., “The State of Garbage in America,” *Biocycle* 45, 1 (2004): 31.

Additional RGGI SWG Adjustments:

- RGGI region MACs assume all projects have an EGU component or supply methane directly to industrial users. Available tonnage was reduced by 0.50 as a rough additionality proxy (to account for the fact that a portion of potential projects may be unavailable due to participation in a RPS market, dependent on additionality provisions ultimately included in the RGGI Model Rule, TBD).<sup>5</sup>
- All supply curves begin at \$1.00/ton CO<sub>2</sub>. A \$1.00/ton adder was applied to account for transaction costs and incentive costs (payments to landfill owner to encourage development of LFG capture project). Research for the Canadian offsets program estimated LFG transaction costs in the \$0.05/ton – \$0.11/ton (Canadian) range.<sup>6</sup>
- Tonnage was converted from carbon equivalent to CO<sub>2</sub> equivalent.
- Tonnage was converted from metric tons to short tons.

Table 1. Projected Annual Landfill Gas Offsets Supply (2015)

Break-Even Price (\$/ton CO <sub>2</sub> e)	MMTCO <sub>2</sub> e (short tons)	Adjusted Price (\$/ton CO <sub>2</sub> e w/ transaction/incentive costs)
(0.12)	6.54	1.00
0.18	6.57	1.18
0.24	6.60	1.24
0.40	6.61	1.40
1.69	6.64	2.69
2.35	6.67	3.35
3.09	6.68	4.09
4.13	6.71	5.13
4.18	6.73	5.18
4.81	6.76	5.81
4.88	6.79	5.88
6.51	6.80	7.51

**Sulfur Hexafluoride (SF<sub>6</sub>)**

Nine-state RGGI region supply curves were derived from national marginal abatement cost curves (MACs). The available emissions offset potential in the RGGI region was adjusted based on the transmission and distribution (T&D) infrastructure in the nine-state RGGI region as a percentage of national (T&D) infrastructure. The RGGI supply curves also consider utility-specific infrastructure issues when estimating available supply. In estimating emissions reduction potential, the MACs take into account emissions reductions already

<sup>5</sup> Note that eligible LFG projects could theoretically receive RGGI offset credits for methane capture and also participate in a RPS market if they met an additionality standard that demonstrated that they were not viable solely on the basis of REC revenue. Potential interaction of LFG projects and RPS markets is under discussion at the SWG level, and is recognized as an additionality issue that must be satisfactorily addressed.

<sup>6</sup> *Administration and Transaction Cost Estimates for a Greenhouse Gas Offset System*, consultant report to Agriculture and Agri-Food Canada, 2004.

being achieved through current U.S. EPA voluntary SF<sub>6</sub> Emission Reduction Partnership for Electric Power Systems (Partnership) activities.

The MACs provide available offsets supply (tons CO<sub>2</sub>e) at different price points (\$/ton CO<sub>2</sub>) for temporal points from 2000-2020 (five-year increments).<sup>7</sup> A corresponding RGGI supply curve was applied in the closest applicable IPM “run year”.

The supply projections and the MACs are based on the supply projections and the MACs for the U.S. that were developed for the EMF-21 study (Schaefer, D. O., D. Godwin, and J. Harnisch, "Estimating Future Emissions and Potential Reductions of HFCs, PFCs, and SF<sub>6</sub>." *Energy Journal* (forthcoming).) U.S. SF<sub>6</sub> emissions from transmission and distribution were assumed to remain constant at 3.89 MMTCE from 2000 through 2020.

#### Determining RGGI Regional Offsets Potential

The draft U.S. Greenhouse Gas Inventory estimate of SF<sub>6</sub> emissions from electrical transmission and distribution for 2003 was used as a starting point for determining the state-level emissions of SF<sub>6</sub>.<sup>8</sup> Emissions of SF<sub>6</sub> in 2003 are estimated at 3.66 MMTCE.

Estimated emissions of SF<sub>6</sub> from electrical transmission and distribution equipment in the RGGI region was divided into the following: (1) those reported to U.S. EPA by participants (Partners) in the U.S. EPA SF<sub>6</sub> Partnership; and (2) those estimated by U.S. EPA based on the length of transmission lines controlled by non-reporting utilities. Partner emissions first allocated to individual companies based on Partner reports. If a Partner company was located in several states, reported emissions were apportioned to each state based on the transmission mileage of the Partner in each state. Non-Reporting utility emissions were allocated based on transmission mileage in each state. Transmission mileage was obtained from the 2004 UDI Directory of Electric Power Producers and Distributors.

#### Additional RGGI SWG Adjustments:

- Only 25% of Consolidated Edison emissions reduction potential was assumed available. Discussion with experts indicated that Consolidated Edison is not fully representative of SF<sub>6</sub> emissions mitigation opportunities, due to vintage and underground location of a majority of T&D infrastructure.
- For non-Consolidated Edison T&D infrastructure, 100% of emissions reduction potential is assumed available.
- All supply curves begin at \$1.00/ton. A \$1.00/ton adder was applied to account for transaction costs and incentive costs (payments to T&D owner to encourage implementation of a SF<sub>6</sub> management program or expansion of an

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<sup>7</sup> The supply curves for each temporal point are identical for this offsets category.

<sup>8</sup> See U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003*, 2005 (EPA 430-R-05-003)

existing management program). Transaction costs for monitoring and reporting SF<sub>6</sub> emissions were roughly estimated on the basis of the 1999 U.S. EPA Information Collection Request and the 2003 reductions of the U.S. EPA SF<sub>6</sub> Partnership. To participate in the Partnership, electric utilities are required to do the following: (1) review and sign a Memorandum of Understanding with U.S. EPA; (2) develop an estimate of SF<sub>6</sub> emissions in a baseline year; (3) develop an SF<sub>6</sub> emission reduction goal; and (4) track and submit a report on SF<sub>6</sub> emissions annually. Current transaction costs based on U.S. EPA Partner inventories average \$0.22/ton. Based on this estimate, a \$1.00/ton minimum offset price adder is assumed to be sufficient to account for transaction costs and provide incentives to stimulate offsets activities.

- Tonnage was converted from carbon equivalent to CO<sub>2</sub> equivalent.
- Tonnage was converted from metric tons to short tons.

Table 2. Projected Annual SF<sub>6</sub> Offsets Supply

Break-Even Price (\$/ton CO <sub>2</sub> e)	MMTCO <sub>2</sub> e (short tons)	Adjusted Price (\$/ton CO <sub>2</sub> e) (w/ transaction/incentive costs)
\$0.08	0.283	\$1.08
\$0.54	0.447	\$1.54

### Afforestation

Afforestation supply curves for the nine-state RGGI region were derived from research conducted by Sampson Group, Inc. (*Potential for Agricultural and Forestry Carbon Sequestration in the RGGI Region*, October, 2004.). Use of afforestation offsets was not allowed prior to years falling within the IPM 2012 run year (afforestation offsets are assumed available beginning in 2011), as a proxy for temporal delay in implementing projects and achievement of significant sequestration of carbon.

The MACs provide available offsets supply (tons CO<sub>2</sub>e) at different price points (\$/ton CO<sub>2</sub>) for temporal points from 2000-2020 (five-year increments).<sup>9</sup> A corresponding RGGI supply curve was applied in the closest applicable IPM “run year”.

### Additional SWG Adjustments:

- Available offsets supply at price points between \$10/ton CO<sub>2</sub> and \$20/ton CO<sub>2</sub> was interpolated based on the estimated sequestration potential at a “Likely Application Percentage” of between 1% and 5%, which represents the rate of project adoption of by landowners in relation to total sequestration potential, assuming rate of adoption at a specific CO<sub>2</sub> offset price).<sup>10</sup>

<sup>9</sup> The supply curves for each temporal point are identical for this offsets category.

<sup>10</sup> Sampson Group, Inc., *Potential for Agricultural and Carbon Sequestration*, Table A6.

- A median “offset impact” (tCO<sub>2</sub>e/ac/yr) of 5 tons CO<sub>2</sub>e/ac/yr was applied, representing the assumed median carbon sequestration potential for afforestation projects.<sup>11</sup>
- Metric tons were converted to short tons.

Table 3. Projected Annual Afforestation Offsets Supply

Tons CO <sub>2</sub> /yr (short tons)	Price (\$/ton CO <sub>2</sub> )
165,347	\$10.00
248,020	\$11.25
330,693	\$12.50
413,367	\$13.75
496,040	\$15.00
578,713	\$16.25
661,387	\$17.50
744,060	\$18.75
826,734	\$20.00

### Clean Development Mechanism (CDM)

A price of \$6.50/ton CO<sub>2</sub> (U.S.) was assumed going forward (no post-2012 limitation). This price estimate was based on the average of the current market index price for CDM projects (\$6.80/ton U.S. for 2005-2007 from *Argus EU Emissions Markets*, Issue 05-52, March 16, 2005) and the price of surveyed projects in the World Bank’s *State and Trends of the Carbon Market 2004* report for projects where the seller assumes the project registration risk (\$6.18/ton U.S.).<sup>12</sup> Prices were converted to U.S. dollars based on the current exchange rate at the time (3/24/05). There is no assumed limit on the availability of CDM CERs.

Prices for CDM credits are reported in metric tons, whereas IPM reports emissions in short tons. The prices for CDM credits were not adjusted on a \$/short ton basis. It was assumed that the price relationship may not be linear, given fixed project development and transaction costs and the price component of assumed project registration risk for CDM credits. Not adjusting the price to reflect short tons was considered an added measure of conservatism in the assumptions.

As mentioned above, the CDM assumptions employed assume that CDM credits are available post 2012. Price projections post 2012 are problematic due to the current uncertainty surrounding future international cap targets, timing, and participants. The assumptions employed assume that a robust international market in emissions offsets will develop to meet increasing demand due to future international regulatory regimes.

<sup>11</sup> Ibid.

<sup>12</sup> World Bank, Development Economics Research Group, *State and Trends of the Carbon Market 2004*, June 2004.