Adipic Acid Production Protocol V1.0

Public Comment Webinar
August 12, 2020
Housekeeping

• All attendees are in listen-only mode
• Please submit any questions in the GoToWebinar question box
  – We will take questions at the end of the session (time permitting)
  – We will follow up via email to answer questions not addressed during the meeting
• The slides and a recording of the presentation will be posted online
Agenda

I. Introductions
II. Process Overview
III. Background
IV. Protocol Overview
V. Next Steps
INTRODUCTIONS
Introductions

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PROCESS OVERVIEW
Process Overview

1. Internal research and scoping (*Summer 2019 – Winter 2020*)
2. Scoping meeting (*Sep 17, 2019*)
3. Issue paper (*Oct 4, 2019*)
4. Workgroup process (*Sep – Nov 2019*)
   - Formation (*Sep – Oct 2019*)
   - Meeting 1 (*October 8, 2019*)
   - Meeting 2 (*November 13, 2019*)
   - Meeting 3 (June 30, 2020)
5. Revisions based on workgroup feedback (*Nov 2019 – Aug 2020*)
6. 30-day public comment period (*Jul – Aug 2020*)
7. Revisions based on public comments (*Aug – Sep 2020*)
8. Presented to Board for adoption (*Sep 30, 2020*)
Background

• Among the top 50 synthetic chemicals annually produced in the U.S. – largest use is in the manufacture of nylon 6,6
  - Nitrous oxide (N₂O) is generated and emitted as an unavoidable & unwanted byproduct

• Adipic acid N₂O abatement or control technology can be installed downstream of where the reaction occurs to treat the facility’s off gas

• Currently 2 AAPs operating in U.S. – both U.S. AAPs are fitted with some N₂O abatement technology – though only 1 of the 2 U.S. AAPs is legally required to abate N₂O, based on facility-specific conditions
  - Significant potential exists to voluntarily abate further N₂O
  - Significant costs associated with voluntary abatement and little to no incentives
Clean Development Mechanism (CDM): *Baseline Methodology for decomposition of N\textsubscript{2}O from existing adipic acid production plants* (**CDM AM0021**)

- Projects install a catalytic or thermal N\textsubscript{2}O destruction facility at an existing AAP

- **ISSUES:** Caused production-shifting (i.e., “leakage”), leading to over-crediting and the generation of credits that were not real or additional
  - Set the baseline N\textsubscript{2}O abatement emissions level at 0% (i.e., assumed no historical or current abatement), leading to high volume of credits (“CERs”) as all abatement was credited
  - The value of the CERs exceeded the value of the adipic acid itself, creating perverse incentives to overproduce the product
  - Caused a substantial shift in worldwide adipic acid production, from non-CDM AAPs to CDM projects, resulting in an estimated 20% non-additional CERs

- Led the EU to ban the use of these offsets from its carbon market
International Offset Projects History

Lessons Learned*,**:

• Most straightforward and efficient way to effectively reduce the risk for leakage is to set a baseline emission benchmark (i.e., emissions per adipic acid production)
  – Only emission reductions beyond the benchmark would be credited, i.e., multiply the amount of adipic acid production eligible for crediting with a baseline emission factor
  – Still provide considerable incentives for the industry to abate N\textsubscript{2}O emissions (e.g., JI projects)

• JI projects show that very high levels of N\textsubscript{2}O abatement can be, and have been, achieved by implementing additional abatement measures
  – Possibly even enable the elimination of nearly all N\textsubscript{2}O emissions

• The carbon market provided incentives to innovate and implement highly effective N\textsubscript{2}O abatement solutions

*Stockholm Environment Institute (2010). *Industrial N\textsubscript{2}O Projects Under the CDM: Adipic Acid – A Case of Carbon Leakage?*
**Öko-Institut (2016). *How additional is the Clean Development Mechanism?***
PROTOCOL OVERVIEW
Project Definition

1. The installation and operation of a new, previously uninstalled N$_2$O abatement technology; and/or

2. The enhancement of an existing control technology at a single adipic acid plant (AAP) …

that results in the reduction of N$_2$O emissions that would otherwise have been vented to the atmosphere

Enhancement

• The implementation of a capital investment to improve the N$_2$O abatement efficiency of an existing control technology compared to historical N$_2$O abatement efficiency levels

Projects may only be implemented at existing, relocated, or upgraded AAPs
### Approved N₂O Control Technologies

<table>
<thead>
<tr>
<th>Abatement Type</th>
<th>Description</th>
<th>Example</th>
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</thead>
<tbody>
<tr>
<td><strong>Catalytic Destruction</strong></td>
<td>Destroy N₂O using a catalyst – selective catalytic reduction (SCR) or non-selective catalytic reduction (NSCR)</td>
<td>Noble or precious metal catalysts</td>
</tr>
<tr>
<td><strong>Thermal Destruction</strong></td>
<td>Destroy N₂O using flame burners with pre-mixed CH₄ or natural gas</td>
<td>Thermal Reduction Units (TRUs)</td>
</tr>
<tr>
<td><strong>Recycle to Nitric Acid</strong></td>
<td>Recycle N₂O to create nitric acid by burning the gas at high temperatures with steam</td>
<td>Nitrogen recycling adiabatic reactor</td>
</tr>
<tr>
<td><strong>Recycling / Utilization Technologies</strong></td>
<td>Utilize N₂O as a reactant or input to produce other products</td>
<td>Using N₂O off gas as an oxidant to produce phenol from benzene</td>
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Other control technologies may also be permissible, pending review by and approval from the Reserve
## Eligibility Rules

<table>
<thead>
<tr>
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<th>LOCATION</th>
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<tbody>
<tr>
<td>I</td>
<td>• U.S. and its tribal lands and territories</td>
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<th>START DATE</th>
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| II | • Date on which production first commences after the installation and/or enhancement of specific N₂O control technology  
  • No more than 12 months prior to project submission |

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<tr>
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<th>CREDITING PERIOD</th>
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<tr>
<td>III</td>
<td>• Ten years, with possible 2nd crediting period</td>
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<tr>
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<th>ADDITIONALITY</th>
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<tr>
<td>IV</td>
<td>• Meet performance standard <em>and</em> exceed legal requirements</td>
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<th>REGULATORY COMPLIANCE</th>
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<td>V</td>
<td>• Comply with all applicable laws</td>
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Performance Standard Test

Technology-specific threshold:

- Projects automatically pass the performance standard test by either installing a new approved N\textsubscript{2}O control technology not previously installed at the AAP and/or enhancing an existing one to improve levels of N\textsubscript{2}O abatement efficiency
- Both the installation of a technology completely new to the AAP and/or the installation of a redundant technology (e.g., a second TRU) are eligible
- e.g., Catalytic destruction, thermal destruction; recycling/utilization technologies

Financial barriers:

- New investments cost ~10.6 - 17.25 million USD*
- Increased operating costs ~1.33 to 2 million USD per year*

* Schneider et al., 2010. Industrial N\textsubscript{2}O Projects Under the CDM: Adipic Acid – A Case of Carbon Leakage? Stockholm Environment Institute. October 9, 2010; All currencies were converted from EURs to 2010 U.S. Dollars (USD) with an annual average conversion factor of 1.33.
Legal Requirement Test

Projects pass the LRT when there are no legally binding mandates requiring the abatement of N₂O at the AAP project site

- The Reserve could identify *no existing* federal, state or local regulations that obligate *all* AAPs to abate N₂O emissions

**Clean Air Act (CAA) Prevention of Significant Deterioration (PSD) and Title V Greenhouse Gas Tailoring Rule (“Tailoring Rule”)**

- When necessary, PSD permits for GHG emissions require an assessment of “best available control technology” (BACT), with the permitting authority ultimately mandating installation of a selected BACT
- If future PSD permits require installation of the same abatement technologies that are voluntarily deployed as part of this protocol, emissions may be reported (i.e., CRTs may be earned) up until *the date* that N₂O is legally required to be abated
SSR 1
- N$_2$O emissions created and lost during adipic acid production

SSR 3
- CO$_2$ and/or CH$_4$ emissions from hydrocarbon use to enhance efficiency of the N$_2$O abatement system (if applicable)

SSR 5
- Emissions from steam export, off gas utilization and heating, and fossil fuel/electricity use (if applicable)
Quantifying Baseline GHG Emissions

Baseline GHG emissions are quantified using AAP-specific N$_2$O abatement efficiency (AE$_{BL}$) levels based on the quantity of N$_2$O in the off gas remaining after baseline voluntary N$_2$O abatement

- Ensures the baseline is conservative and representative of only the incremental emissions reduced beyond baseline voluntary abatement levels

For added flexibility, this protocol provides project developers with two options for setting the AAP-specific baseline N$_2$O AE$_{BL}$:

1. Static baseline N$_2$O AE$_{BL}$ – or –

2. Dynamic baseline N$_2$O AE$_{BL}$ that changes each reporting period based on historical maximum and minimum AEs, historical maximum and minimum adipic acid production levels, and current adipic acid production levels
Static Baseline Approach

**Static Baseline Abatement Efficiency ($AE_{BL,S}$)**

- Calculate average annual AE over the static baseline look-back period
  - First calculate annual AE value for each baseline year, using all available data
  - Then calculate mean AE value over entire baseline period using annual AE values
  - Then introduce conservative bias eliminating any annual AE value beyond -2SD of mean over baseline period – replacing each removed annual AE with single highest annual AE from baseline period
  - Last, recalculate mean AE value over entire baseline period, using annual AE values

**Baseline Look-Back Period**

- The most recent calendar years of operation prior to project start date – dating back to 2015
  - Using data prior to 2015 is inappropriate due to significant structural changes in US adipic acid production industry in 2015
  - If start project in 2020, will be 5 years of baseline data
  - If start project in 2021, will be 6 years of baseline data, *etc*
Static Baseline Approach

Annual Baseline AE

• Percent of the AAP’s $N_2O$ emissions destroyed by the $N_2O$ emission control unit in a given historical year within the static baseline look-back period

• Calculated by dividing the amount of $N_2O$ reduced in a historical year ($RE_{N_2O}$) by the total amount of $N_2O$ emissions generated in the same historical year ($TE_{N_2O}$)

Relies on direct historical measurements using CEMS data
Quantifying Baseline GHG Emissions

Equation 5.2

\[ BE = \left[ (TE_{RP,N_2O} \times (1 - AE_{BL})) + (HNO_3 \text{Ratio} \times AA_{RP} \times 0.0025) \right] \times GWP_{N_2O} \times (1 - ld) \]

Where,

- \( BE \) = Baseline emissions in reporting period
- \( TE_{RP,N_2O} \) = Total \( N_2O \) emissions in reporting period before any abatement
- \( AE_{BL} \) = Baseline \( N_2O \) abatement efficiency
- \( HNO_3 \text{Ratio} \) = Ratio of nitric acid (HNO\(_3\)) to adipic acid
- \( AA_{RP} \) = Adipic acid produced in reporting period
- 0.0025 = IPPC emission factor for \( N_2O \) emissions per HNO\(_3\) produced
- \( GWPN_{N_2O} \) = Global warming potential for \( N_2O \) (i.e., 298)
- \( ld \) = Proportion of adipic acid production in reporting period due to leakage
Dynamic Baseline

In order for the baseline to be dynamically tied to the amount of actual \( \text{N}_2\text{O} \) emissions created by an AAP in a project reporting period, the AAP-specific baseline abatement efficiency \( (\text{AE}_{\text{BL},D}) \) must be multiplied by total \( \text{N}_2\text{O} \) emissions in a given reporting period prior to any abatement \( (\text{TE}_{\text{RP},\text{N}_2\text{O}}) \)

\( \text{AE}_{\text{BL},D} \) is dependent on:

- Maximum and minimum baseline \( \text{N}_2\text{O} \) abatement efficiencies \( (\text{AE}_{t,\text{MAX}} \text{ and } \text{AE}_{t,\text{MIN}}, \text{respectively}) \) over the dynamic baseline look-back period;
- Maximum and minimum baseline amounts of adipic production \( (\text{AA}_{t,\text{MAX}} \text{ and } \text{AA}_{t,\text{MIN}}, \text{respectively}) \) over the dynamic baseline look-back period; and
- The amount of adipic acid production in a project reporting period \( (\text{AA}_{\text{RP}}) \)

Dynamic baseline look-back period set using data back to 2015, same as static alternative (i.e. at least 5 years of baseline data starting in 2015)

Must demonstrate appropriate statistical correlation (i.e. \( \text{min } r^2 \) of 0.8)
Nitric Acid (HNO$_3$) Recovery Ratio

HNO$_3$ recovery is a function of N$_2$O conversion to NO, which is then converted to HNO$_3$ in the downstream process.

Applies to recycling technologies that convert a portion of the N$_2$O in the exhaust to beneficial byproducts rather than simply oxidizing the N$_2$O to nitrogen (N$_2$) and oxygen (O$_2$) (conventional technology).

The calculation establishes a baseline average and project ratio of HNO$_3$ to adipic acid.

The HNO$_3$ Ratio is the average of HNO$_3$ to an average of adipic acid over the baseline look-back period less the ratio of HNO$_3$ to adipic acid in the reporting period:

$$HNO_3\text{Ratio} = \frac{HNO_3\text{avg}}{AA\text{avg}} - \frac{HNO_3\text{RP}}{AA\text{RP}}$$
Mitigating Leakage

What do we mean by leakage?

• If greater production shifts to the project adipic acid facility, due to offset revenues, that can be considered leakage, and risks us crediting for N\textsubscript{2}O destruction that would have occurred anyway at the facility from which such production shifted

3 Alternative approaches given to address leakage

• 1) Leakage assessment focusing on shifting production within corporate group
• 2) Leakage assessment focusing on shifting production when no corporate group
• 3) Production cap
Mitigating Leakage

1) Leakage assessment for corporate groups with multiple adipic acid producing facilities

- For project facility that’s part of corporate group with multiple adipic acid production facilities
- Assess average annual factory loading of project AAP (% of facility-specific total production capacity being used) during baseline period relative to during each reporting period
- In any given reporting period, if factory loading decreases at other AAP controlled by group and increases at project AAP (or remaining steady at project AAP whilst dropping elsewhere) – by a statistically significant amount = leakage
- Reduce total baseline emissions in Equation 5.2 by % of increased production of adipic acid attributed to leakage
Mitigating Leakage

2) Leakage assessment for AAP not part of corporate group with multiple AAPs

- Seek Reserve approval for method to demonstrate no leakage occurred
- Method must be based on assessment of publicly available market data and a *reasonable explanation* – ie based on study of adipic acid demand in the U.S.
- Acceptance of such an alternative leakage assessment in one reporting period does not necessitate acceptance in any other future reporting period
- In any given reporting period, if adipic acid production increases – by a statistically significant amount – and Reserve does not accept explanation provided = leakage
- Reduce total baseline emissions in Equation 5.2 by % of increased production of adipic acid attributed to leakage
3) Production cap

- In any given reporting period, if adipic acid production increases – by a statistically significant amount – and first two options cannot be used = leakage

- Reduce total baseline emissions in Equation 5.2 to be no greater than CAA Title V permitted adipic acid production levels as at the project start date
Quantifying Project Emissions

Equation 5.11

\[ PE = PE_{N_2O} + PE_{HC} + PE_{EE} \]

Where,

PE = Total project emissions in reporting period

PE_{N_2O} = Measured N\textsubscript{2}O emissions in the off gas to project N\textsubscript{2}O control units during the reporting period

PE_{HC} = GHG emissions from the use of hydrocarbons as a reducing agent or to reheat off gas during the reporting period (if applicable)
  - CO\textsubscript{2} or CH\textsubscript{4} emissions

PE_{EE} = GHG emissions from external energy used to reheat the off gas during the reporting period (if applicable)
  - E.g., steam export, off gas heating, fossil fuel/electricity use
Project Monitoring

Monitoring Plan
• Covers all aspects of monitoring and reporting; serves as the basis for verification

Initial Monitoring Requirements (6.1)
• Include CEMS installation and initial certification report in monitoring plan
  – Required per 40 CFR Appendix A to Part 75

Quality Assurance / Quality Control (QA/QC) (6.2)
• Implement and include CEMS QA/QC program written plan (e.g., testing frequency requirements) in monitoring plan
  – Required per 40 CFR Appendix B to Part 75

Missing Data Substitution (6.3)
• Follow the procedures for NO\textsubscript{X} CEMS found in section 75.33 of 40 CFR Part 75

Monitoring Parameters (6.4)
• Table 6.1 contains the parameters necessary to calculate baseline and project emissions
Reporting Period and Verification Cycle

**Reporting Period (RP)**
- The length of time over which GHG emission reductions are periodically quantified and reported to the Reserve.
- **An RP may exceed 12 months** – this is the only case where more than 12 months of emission reductions may be verified.
- RPs must be contiguous; there must be no time gaps in reporting during the crediting period of a project once the initial RP has commenced.

**Verification Period**
- The length of time over which GHG emission reductions are verified.
- Projects must be verified **each reporting period**
  - Verified emission reduction reports on a sub-annual basis are acceptable.
- One site visit to the AAP is required annually at a minimum.
NEXT STEPS
Next Steps

1. Submit public comments by Aug 31, 2020
   Email comments, preferably in Word format, to policy@climateactionreserve.org

2. Revisions based on public comments (Aug – Sep 2020)

3. Board adoption (Sep 30, 2020) TBD
Key Contact

For questions about protocol development, the public comment process, or general assistance, please contact us at:

Policy@climateactionreserve.org